IEEE 1588 Evolution

latest amendments, protocol evolution

Rodney Cummings

Affiliation: Keysight
Vice Chair, IEEE Precise Networked Clock Synchronization (PNCS) Working Group
(also known as IEEE 1588 Working Group)

IEEE 802

ITU

Agenda

- 1588-2019 (PTP) overview
- Published amendments
- Pending amendment (P1588f)
- Future projects
- IEEE Industry Connection (IC) on Timing in Data Centers

Precision Time Protocol (PTP)

- PTP precisely syncs time among devices in a local network
  - Ethernet, but also OTN, Wi-Fi and 5G
  - Precision: Hardware timestamp PTP messages on receive / transmit
- 1588-2019 is latest revision
  - Relative to previous 1588-2008:
    backward compatible (v2.1),
    new optional features,
    architectural clarifications

Applications Using PTP

- Cars, planes, telecom, TV studios, factories, financial, CERN, …
  - Referenced by over 20 specifications
  - PTP Profile: Formal spec selects options to enable interoperation
    - https://sagroups.ieee.org/1588/ptp-profiles/
- Usage can be transitive
  - 1588 → IEEE 802.1AS → IEC/IEEE 60802 (industrial automation)
  - 1588 → ITU-T G.8275.1 → O-RAN (5G fronthaul)

PTP

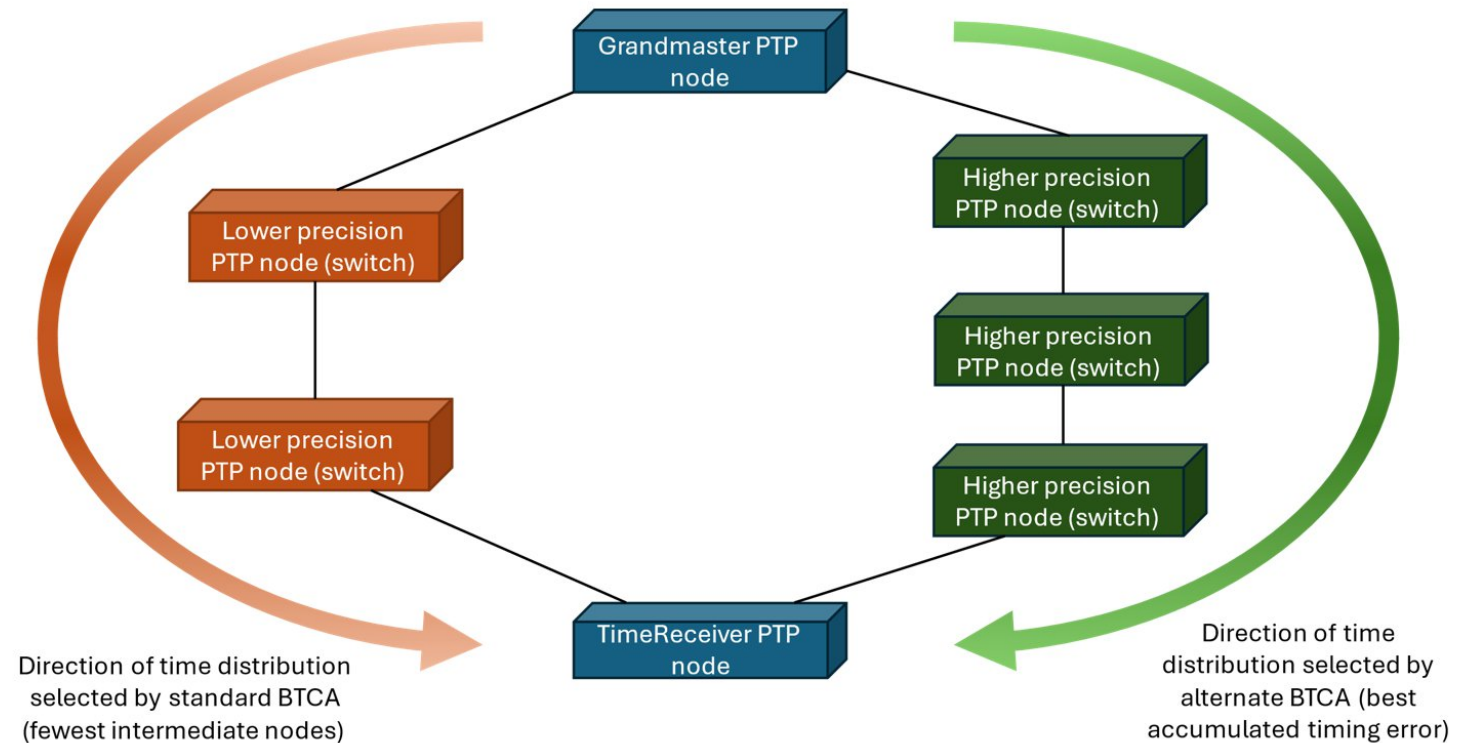IEEE 802

ITU
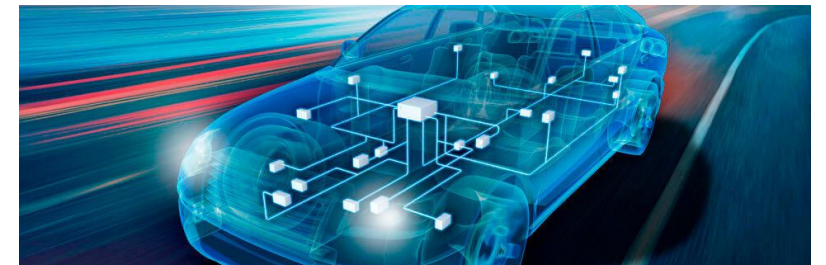
Published amendments

2022

- 1588b-2022: Mapping for Optical Transport Network (OTN)
  - Formalizes encoding of PTP messages on OTN
  - Used by ITU-T
- 1588g-2022: Master/slave optional alternative terminology
  - 1588-2019 uses master/slave for each side of PTP exchange
  - For organizations that want alternate terms, consistency is important
  - 1588g specifies timeTransmitter/timeReceiver as alternates
    - ITU-T and IEEE 802.1 use these terms
  - Grandmaster (source of time) same

1588a-2023: Enhancements for BMCA

- PTP's Best TimeTransmitter Clock Algorithm (BTCA) finds the best grandmaster and paths
  - Paths by hop count
- 1588-2019: Enhanced Accuracy Metrics TLV
  - Propagates accuracy down paths
- 1588a-2023: annex on alternate BTCA that uses TLV
- ITU-T contributions on potential use

Direction of time distribution selected by standard BTCA (fewest intermediate nodes)

Direction of time distribution selected by alternate BTCA (best accumulated timing error)

1588d-2023: GDOI Key Management

- 1588-2019 specifies an Authentication TLV which may be used for 1588-specific security
- Power distribution standards in IEC use GDOI (IETF RFC 6407) for key management
- 1588d-2023 adds an informative annex to help with integration of IEC, IETF, and 1588 Auth TLV security features

1588e-2024: MIB and YANG

- Remote network management is a critical need for configuration and monitoring of network equipment
  - Including with PTP
- 1588e specifies MIB and YANG [modules](#) for PTP
- 1588e YANG can be imported for augment
  - IEEE P802.1ASdn YANG in-progress
  - ITU-T G.7721.1 YANG in-progress
    - O-RAN WG9 YANG in-progress (transitive)
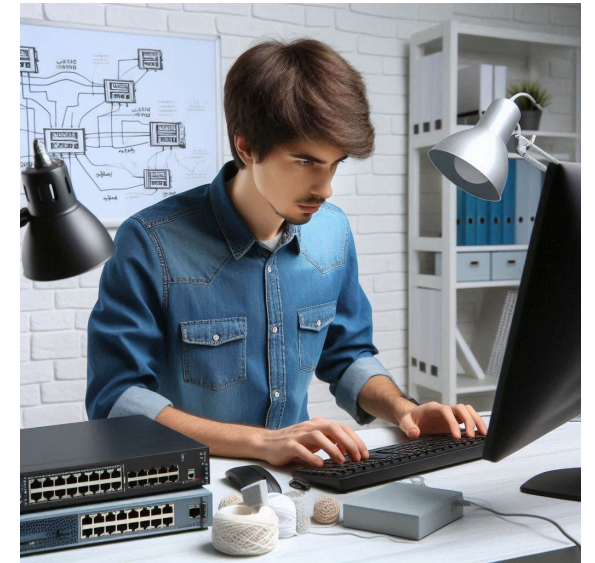
P1588c: Clarification of Terminology

- Clarifies how PTP messages transfer through switches/routers
  - E.g., Rules for how Type-Length-Value (TLV) suffixes transfer
- Clarifies "timescale ARB" (arbitrary epoch)
- Done with balloting
- Submitted for formal IEEE approval (RevCom & SASB)
  - Hopefully 1588c-2024

Pending amendment (P1588f)

P1588f: Latency and Asymmetry Calibration

- Work split into three parts

- Part A: Absolute calibration
  - 1588-2019 supports calibration of ingress/egressLatency
    - Difference between hardware timestamp and real point on medium
  - P1588f adds ingress/egressPluggableTransceiverLatency
    - Distinct calibration for SFP module, and layers above SFP module
- Part B: Measure delay asymmetry on medium
  - Disables protocol to run measurements; Accessed through management
- Part C: MIB and YANG for above

Future projects

Proposed 1588 Projects (awaiting NesCom)

- Roll-up revision
  - Editorial project to merge published amendments into revision
  - Likely published as IEEE 1588-2026
- P1588h: Option to disable Announce
  - Announce message is required by 1588-2019
  - In-vehicle and industrial applications want to disable Announce
    - This project adds an option for that
  - Project requested in liaison from IEEE 802.1

P1588.1: Background

- In 1588-2019, the grandmaster
  shall transmit PTP messages periodically
- In recent years, a few open-source projects
  implemented a simple client/server mode
  - Grandmaster (server) waits for a request,
    and then-and-only-then sends a response
  - Uses PTP messages, but does not conform to 1588-2019
    - Not formally a PTP Profile
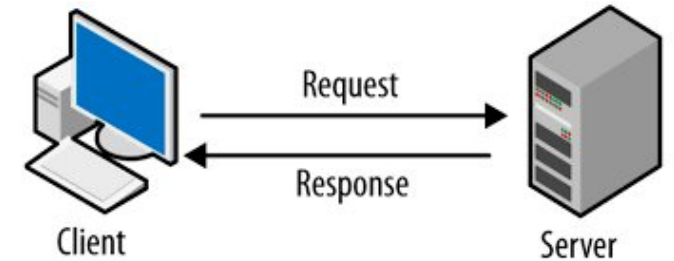
P1588.1: Approved Project

- In PNCS (1588) Working Group, consensus on need
  - E.g., Client/server is needed for some data centers
- Adding mode in 1588 itself would require fundamental changes
  - Could add confusion to an already full-featured document
- Decision was to specify as 2nd standard from PNCS
  - IEEE P1588.1: Client Server PTP (CSPTP)
  - New protocol specification that uses PTP messages from 1588
- Approved by NesCom, so project is underway as subgroup of PNCS
  - CSPTP Chair: Rodney Cummings of Keysight
  - CSPTP Vice Chair: Liuyan Han of China Mobile

IEEE Industry Connection (IC) on Timing in Data Centers

Background

- For years, Meta has advocated use of PTP inside data centers
  - Public presentations in <u>OCP-TAP</u> on this topic
- Recently, other data center operators have presented on timing
  - Forum varies: OCP-TAP, <u>ITSF</u>, <u>WSTS</u>, IEEE (1588), ITU-T, …
  - Presentation often covers use cases and requirements
  - Opinions on standards vary
    - Some use NTP (not PTP) for timing
    - Some use P1588.1-like protocol
    - Some use traditional PTP Profile (e.g. ITU-T G.8275.1)
    - Not yet clear that a new standard project is needed

IEEE Industry Connections

- In IEEE terms, discussion is not yet at Working Group stage
  - Discussion among experts to determine if/what standards are needed
- IEEE provides [Industry Connections](#) (IC) framework for this
  - Open and honest discussion among industry experts
    - Any relevant expert
    - Intentionally not limited to experts in IEEE
  - Output is typically a white paper
    - If standards are needed, forwarded to relevant standards organizations

IEEE IC on Timing in Data Centers

- Initiated by participants in IEEE PNCS (1588)
  - Not formally managed by PNCS, to avoid perception of "a 1588 thing"
  - Relevant standards can include ITU-T and IETF (for NTP)
- Connects timing experts and data center experts
- Hope is to have one set of calls for relevant discussion
  - Plans to merge with OCP-TAP calls
  - Plans to coordinate with ITU-T project
- Approved formally by IEEE SA on 28 June 2024
  - Chair: Rodney.Cummings@keysight.com