White Rabbit standardization in IEEE1588-20XX

Greg Daniluk (CERN)

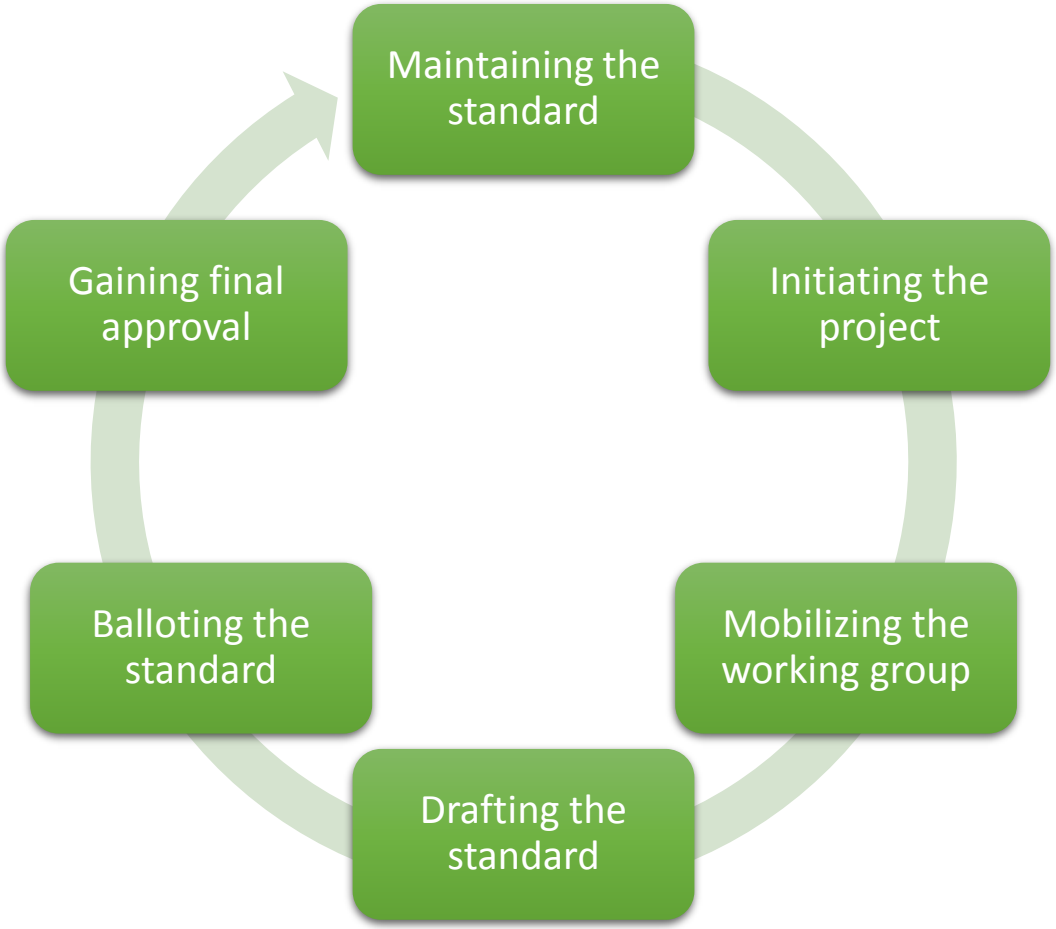
2nd White Rabbit Tutorial Workshop

28 June 2018

THU China

CERN

IEEE standard lifecycle

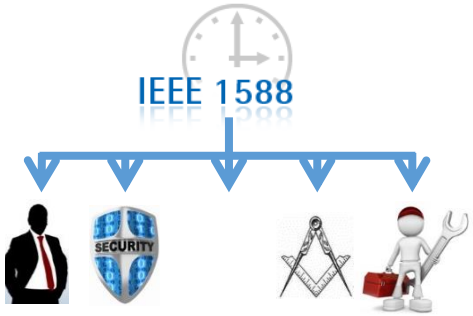


IEEE1588 standard revision

- Currently: IEEE1588-2008
- Revision started in June 2013
- Enforced by standard life-cycle

IEEE1588 standard revision

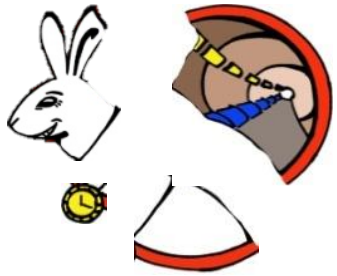
- Currently: IEEE1588-2008
- Revision started in June 2013
- Enforced by standard life-cycle
- Performed by **P1588 Working Group** with over 200 members
- Divided into 5 sub-committees



IEEE1588 standard revision

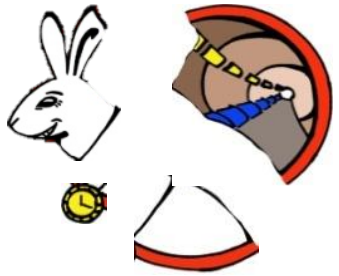
- Currently: IEEE1588-2008
- Revision started in June 2013
- Enforced by standard life-cycle
- Performed by **P1588 Working Group** with over 200 members
- Divided into 5 sub-committees
- High Accuracy (**HA**) sub-committee dedicated to White Rabbit

White Rabbit split into 5 parts

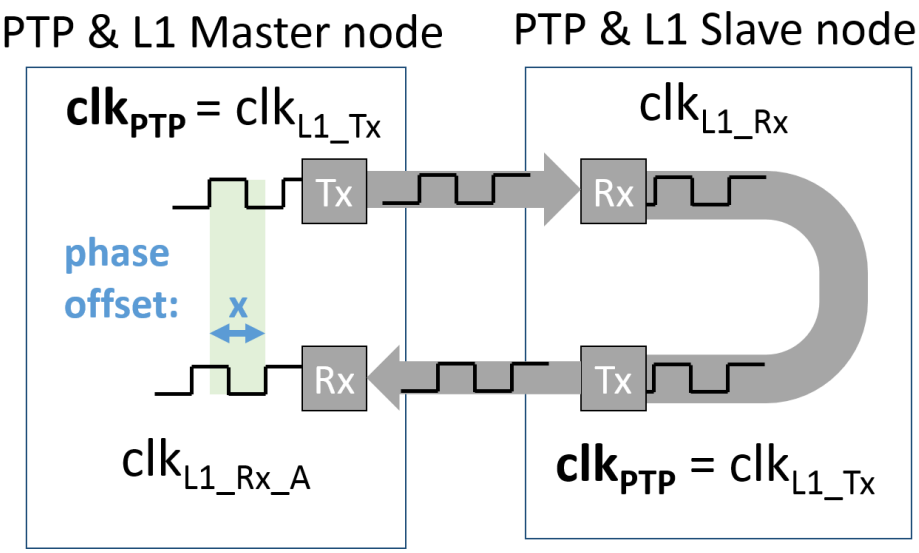


1. L1 syntonization
2. Delay asymmetry estimation and correction of PTP calculations for delay asymmetry and hardware delays
3. Calibration procedure
4. Assignment of fixed roles (master/slave) to WR ports
5. WR PTP profile compatible with Delay Request-Response default PTP profile

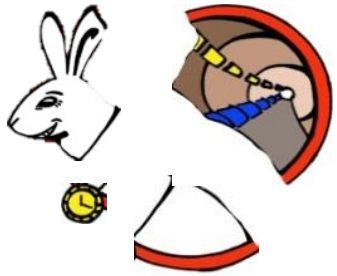
1. L1 syntonization in WR



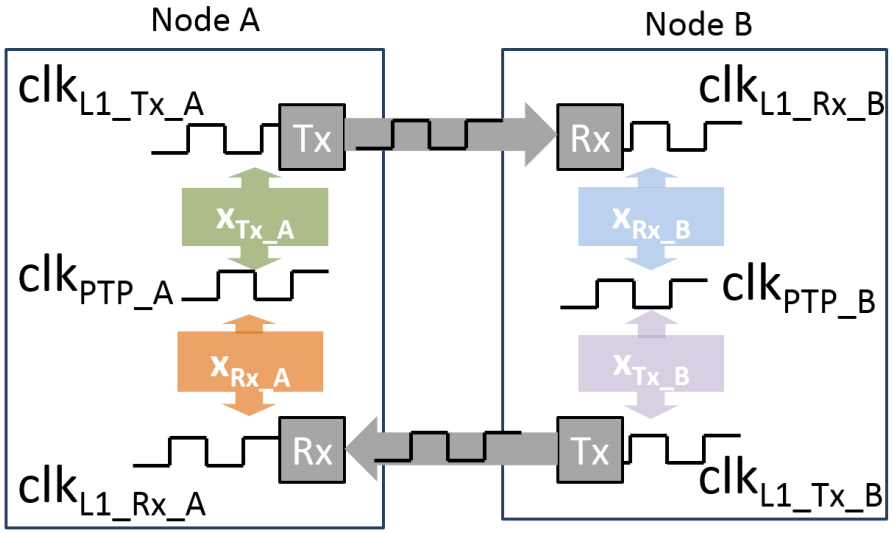
- Local PTP clock is the same as L1 clock



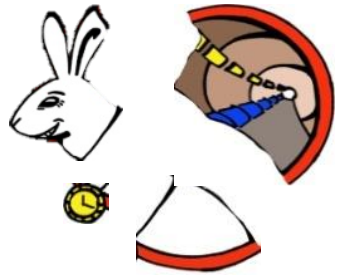
1. L1 syntonization in HA



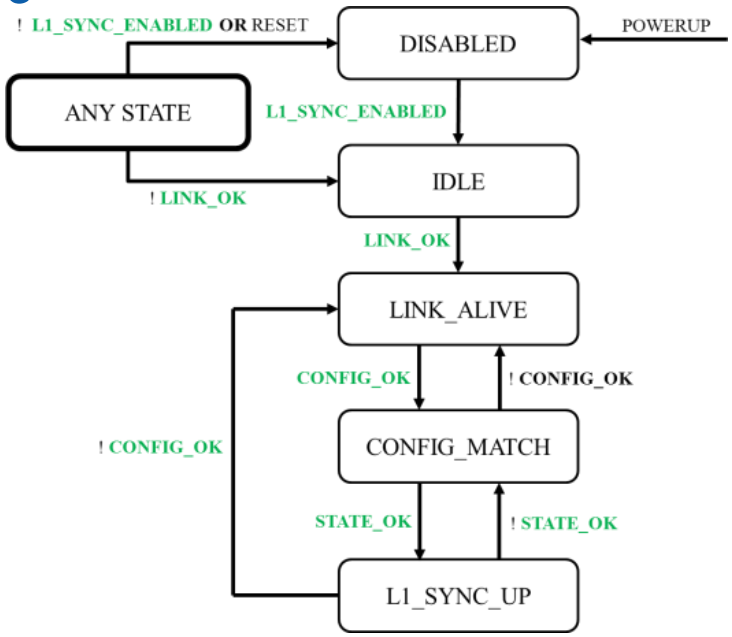
- Flexible and configurable relation between PTP and L1 clocks
- All phase offsets known and pseudo-constant



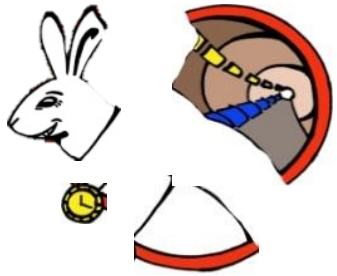
1. L1 syntonization in HA



- Introduces a new L1 state machine
- Semi-independent from PTP state machine
- Detects if a peer port supports L1Sync
- Handles L1 configuration matching



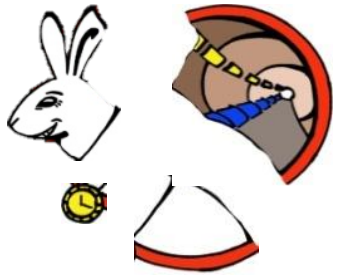
2. Correction of PTP calculations



- Delay asymmetry estimation:
  - In WR: $delay_{ms} = \frac{1+\alpha}{2+\alpha}\,\delta_{mm}$
  - In HA: $< delayAsymmetry > = constantAsymmetry + \frac{\alpha}{2+\alpha} < meanDelay >$

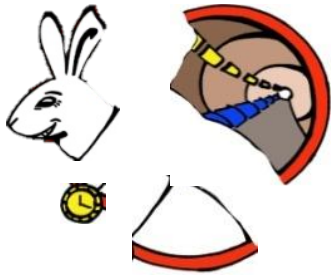
    $delay_{ms} = < delayAsymmetry > + < meanDelay >$

2. Correction of PTP calculations



- Delay asymmetry estimation:
  - In WR: $delay_{ms} = \frac{1+\alpha}{2+\alpha}\,\delta_{mm}$
  - In HA: $< delayAsymmetry > = constantAsymmetry + \frac{\alpha}{2+\alpha} < meanDelay >$
    $delay_{ms} = < delayAsymmetry > + < meanDelay >$
- Hardware delays:
  - In WR: only Slave corrects $offset_{ms}$ for $\Delta_{TXM}, \Delta_{RXM}, \Delta_{TXS}, \Delta_{RXS}$
  - In HA: both Master and Slave correct timestamps for ingress/egress latencies

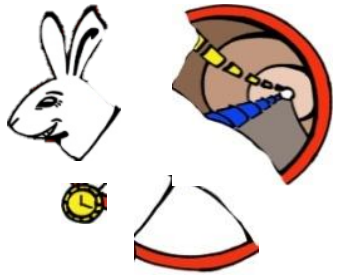
3. WR Calibration procedure v1.1



- In HA: *"Calibration Procedures"*
- *Rewritten into informative annex*
- *Rewritten to use IEEE-1588 terminology and data sets*
- *Exactly the same step-by-step procedure*

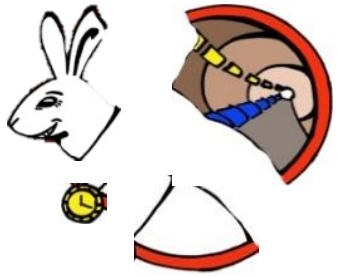
- *Does not include*
  - *Mathematical proofs*
  - *Measurement errors estimation*

4. Assignment of fixed roles



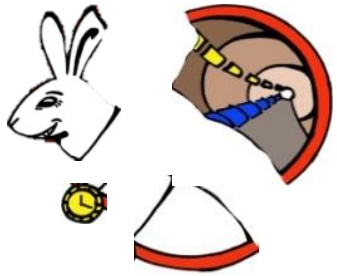
- MasterOnly PTP Ports
  - Best Master Clock Algorithm running
  - Some ports disallowed from becoming PTP Slaves

4. Assignment of fixed roles



- MasterOnly PTP Ports
  - Best Master Clock Algorithm running
  - Some ports disallowed from becoming PTP Slaves
- Mechanism for external role configuration
  - Best Master Clock Algorithm disabled
  - External mechanism to configure PTP port state

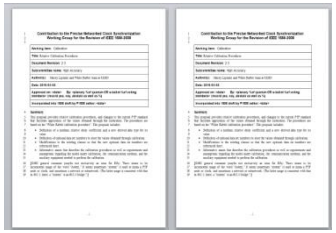
5. WR PTP Profile



- *“High Accuracy Delay Request-Response Default PTP Profile”*
- Extends Delay Req-Resp Default PTP Profile
- Mandates support of optional features required by High Accuracy
- Defines default and allowed values for the optional features
- Interoperates with Delay Req-Resp Default Profile
- Defines High Accuracy Clock Model
  - Syntonization through Layer-1
  - Synchronization through PTP

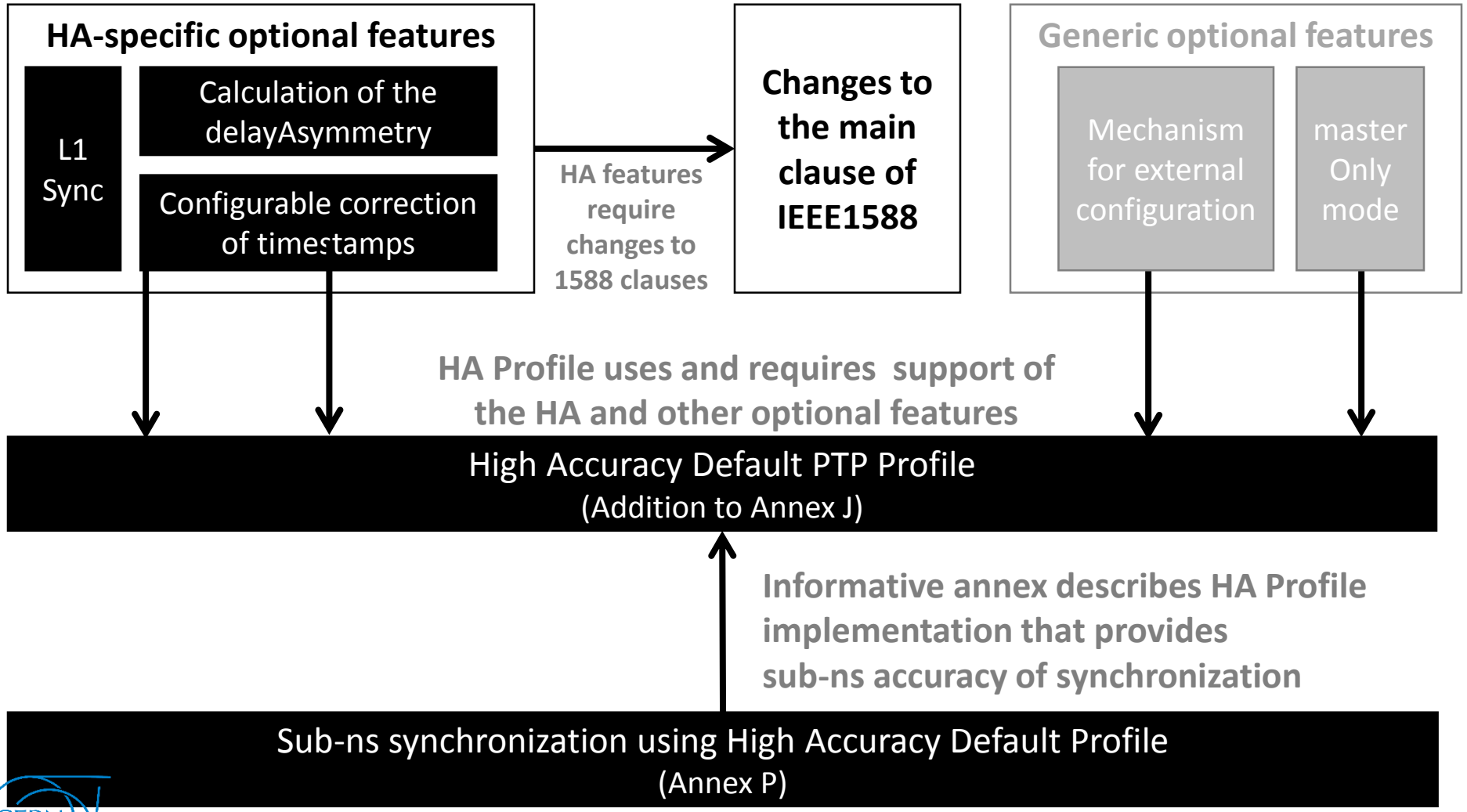
Where is WR in IEEE1588-20XX?

- L1 syntonization – *Annex O*
- Correction of PTP calculations – *Clause 16.7 / 16.8*
- Calibration procedure – *Annex Q*
- Assignment of fixed roles – *Clause 9.2.2.2 / 8.2.15.5.2 / 17.6*
- HA PTP Profile – *Annex J.5*
- Sub-ns implementation – *Annex P*



- Changes to core parts of the standard:
  https://www.ohwr.org/projects/wr-std/wiki/wrin1588

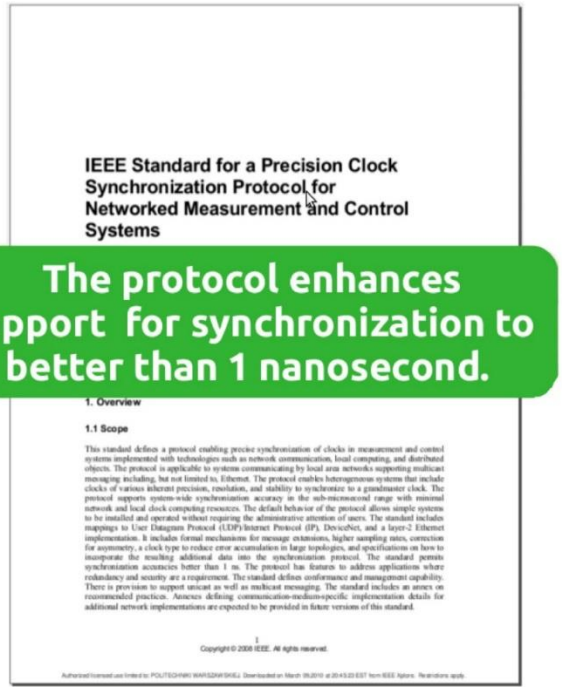
Where is WR in IEEE1588-20XX?



IEEE1588-20XX standardization process

2013 Jun: start

Project Authorization Request (PAR)


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

The protocol enhances support for synchronization to better than 1 nanosecond.

1. Overview

1.1 Scope

This standard defines a protocol enabling precise synchronization of clocks in measurement and control systems implemented with technologies such as network communication, local computing, and distributed objects. The protocol is applicable to systems communicating by local area networks supporting multicast messaging including, but not limited to, 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 system-wide synchronization accuracy in the sub-microsecond range with minimal network and local clock computing resources. The default behavior of the protocol allows simple systems to be installed and operated without requiring the administrative attention of users. The standard includes mappings to User Datagram Protocol (UDP)/Internet Protocol (IP), DeviceNet, and a layer-2 Ethernet implementation. It includes formal mechanisms for message extensions, higher sampling rates, correction for asymmetry, a clock type to reduce error accumulation in large topologies, and specifications on how to incorporate the resulting additional data into the synchronization protocol. The standard permits synchronization accuracies better than 1 ns. The protocol has features to address applications where redundancy and security are a requirement. The standard defines conformance and management capability. There is provision to support unicast as well as multicast messaging. The standard includes an annex on recommended practices. Annexes defining communication-medium-specific implementation details for additional network implementations are expected to be provided in future versions of this standard.

1

Copyright © 2008 IEEE. All rights reserved.

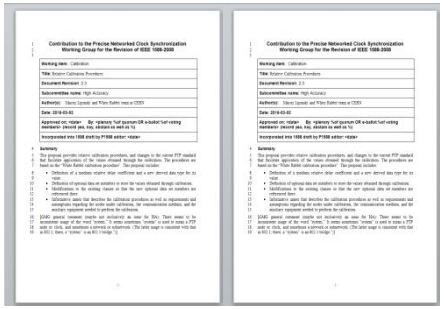
Authorized licensed use limited to: POLITECHNIKA WARSZAWSKA. Downloaded on March 09,2010 at 20:43:33 EST from IEEE Xplore. Restrictions apply.

IEEE1588-20XX standardization process

2013 Jun: start

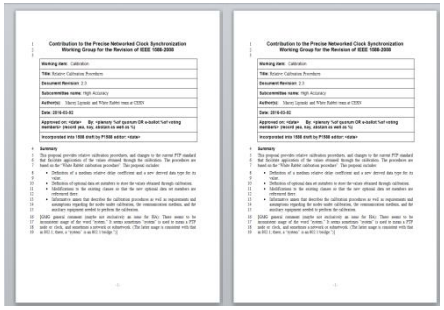
2016 Jan: stop new ideas

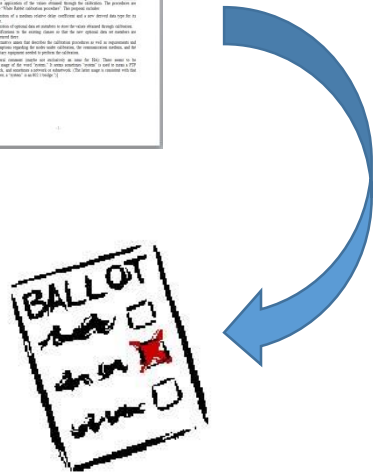
2016 Dec: PTP draft ready / 1st Ballot starts



IEEE1588-20XX standardization process

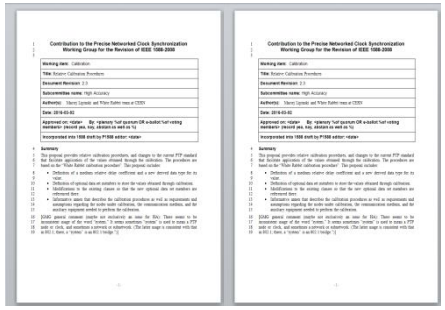
- **2013 Jun: start**
- **2016 Jan: stop new ideas**
- **2016 Dec: PTP draft ready / 1st Ballot starts**
- **2017 Nov: 2nd Ballot starts**
- **2018 Feb: 3rd Ballot starts**

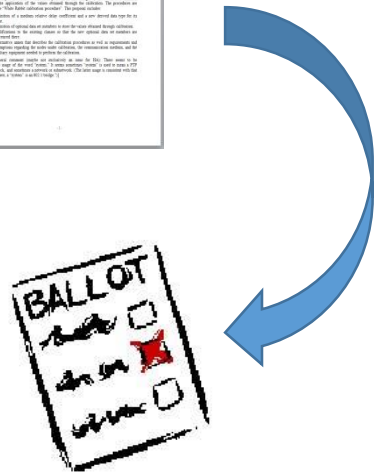




IEEE1588-20XX standardization process

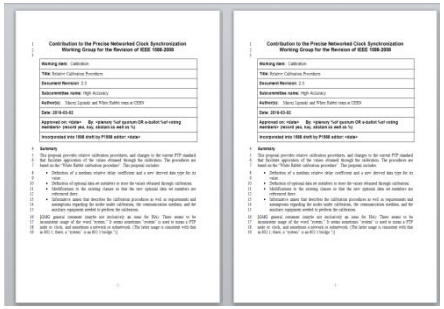
- **2013 Jun: start**
- **2016 Jan: stop new ideas**
- **2016 Dec: PTP draft ready / 1st Ballot starts**
- **2017 Nov: 2nd Ballot starts**
- **2018 Feb: 3rd Ballot starts**
- **2018 Aug: Sponsor Ballot**





IEEE1588-20XX standardization process

- **2013 Jun: start**
- **2016 Jan: stop new ideas**
- **2016 Dec: PTP draft ready / 1st Ballot starts**
- **2017 Nov: 2nd Ballot starts**
- **2018 Feb: 3rd Ballot starts**
- **2018 Aug: Sponsor Ballot**
- **2019 Jan: Final draft ready**



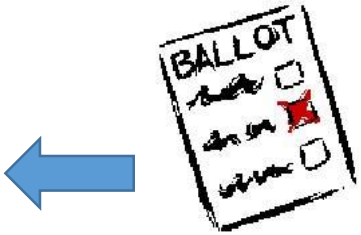
P1588™/D1.3
Draft Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

Sponsor

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

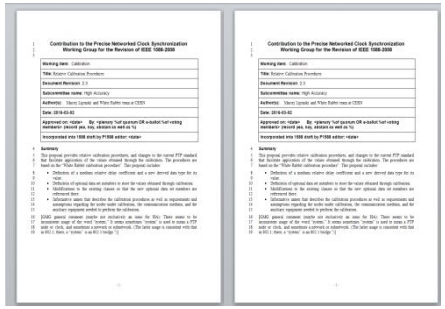
Approved <Date Approved>

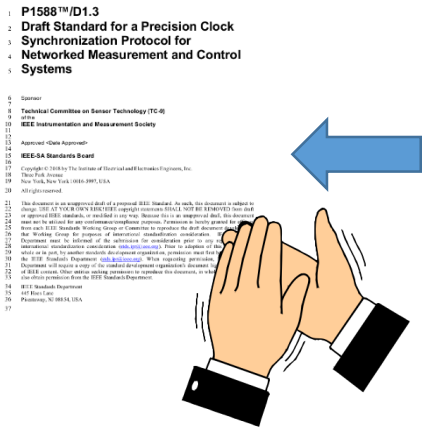
IEEE-SA Standards Board

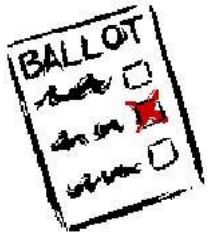


IEEE1588-20XX standardization process

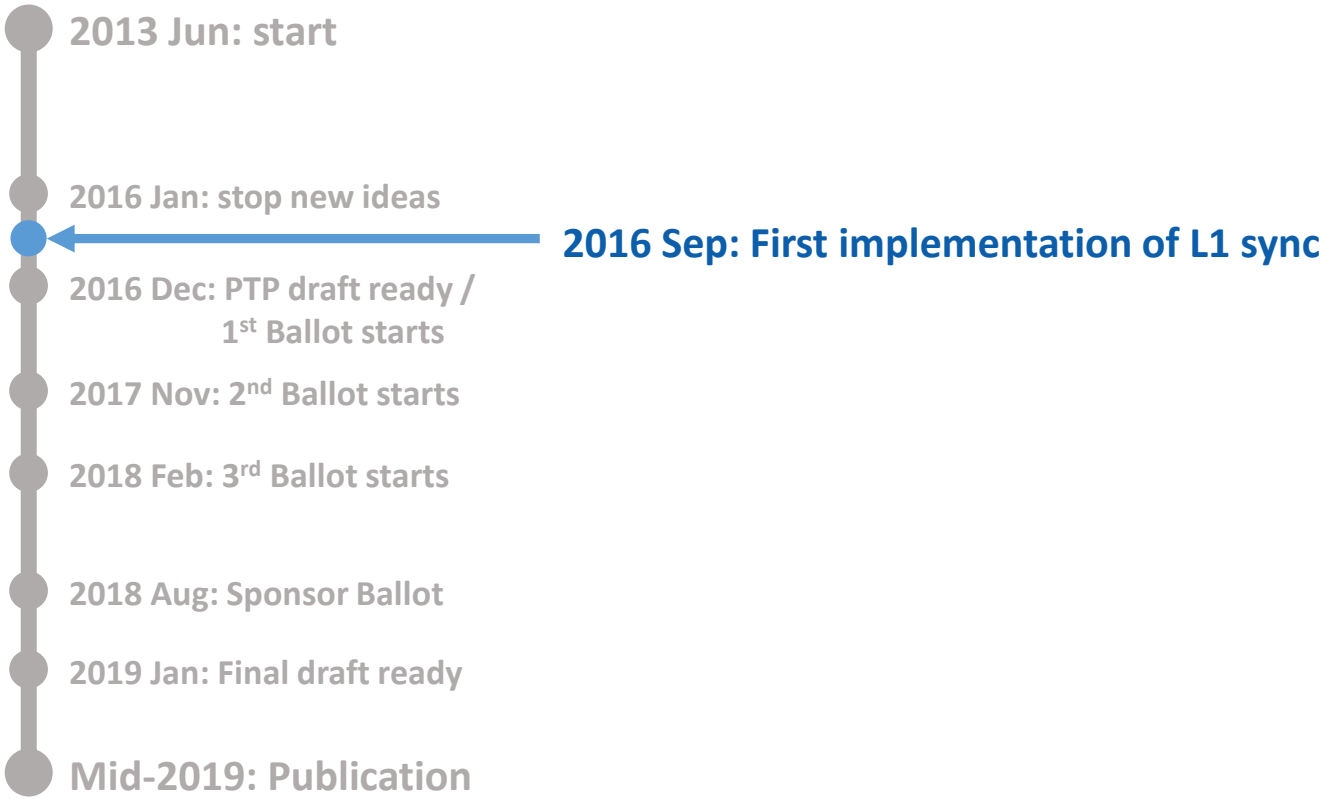
- **2013 Jun: start**
- **2016 Jan: stop new ideas**
- **2016 Dec: PTP draft ready / 1st Ballot starts**
- **2017 Nov: 2nd Ballot starts**
- **2018 Feb: 3rd Ballot starts**
- **2018 Aug: Sponsor Ballot**
- **2019 Jan: Final draft ready**
- **Mid-2019: Publication**



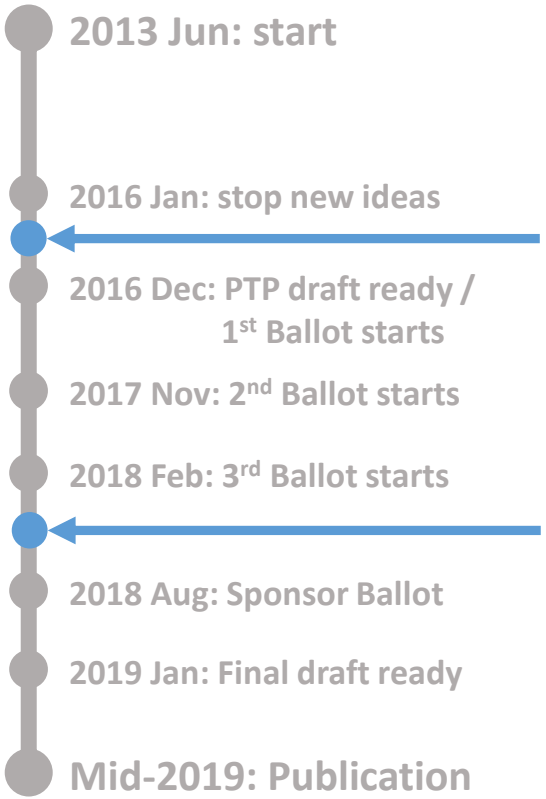




IEEE1588-HA implementation



IEEE1588-HA implementation



2016 Sep: First implementation of L1 sync

now:

- **Automated compliance tests delivered by Veryx**
- **Ongoing work on HA implementation**

Summary

- White Rabbit becomes High Accuracy profile of IEEE1588-20XX
- Standard drafted
- Now going through a Balloting phase
- We’re working on first HA implementation
- Compliance tests developed independently

- New IEEE-1588 standard to be published mid-2019