Calnex Solutions

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Sync Standards updates

October 2023

SDOs for synchronization, Telecom and related

Calnex

Industrial Automation

Smart Grid

Automotive

Data Centers

IEEE 1588
IEEE 802.1AS
IEEE 8021.CM
IEEE/IEC 60802
IEEE P3335
IEEE P1952
...

IEEE STANDARDS ASSOCIATION IEEE

PTP (IEEE 1588)

O-RAN

O-RAN.WG4.CUS
O-RAN.WG4.CONF
O-RAN.WG4.IOT
O-RAN.WG9.XTRP-SYN
O-RAN.WG9.XTRP-TST
...

PTP (IEEE 1588)

Network limits, Clocks
PTP Telecom Profiles

End application requirements

3GPP A GLOBAL INITIATIVE

ITU

Telecom

ITU-T G.826x
ITU-T G.827x

Applicable PTP Profiles
(TSC/TSN integration)

ITU-T: What’s new?

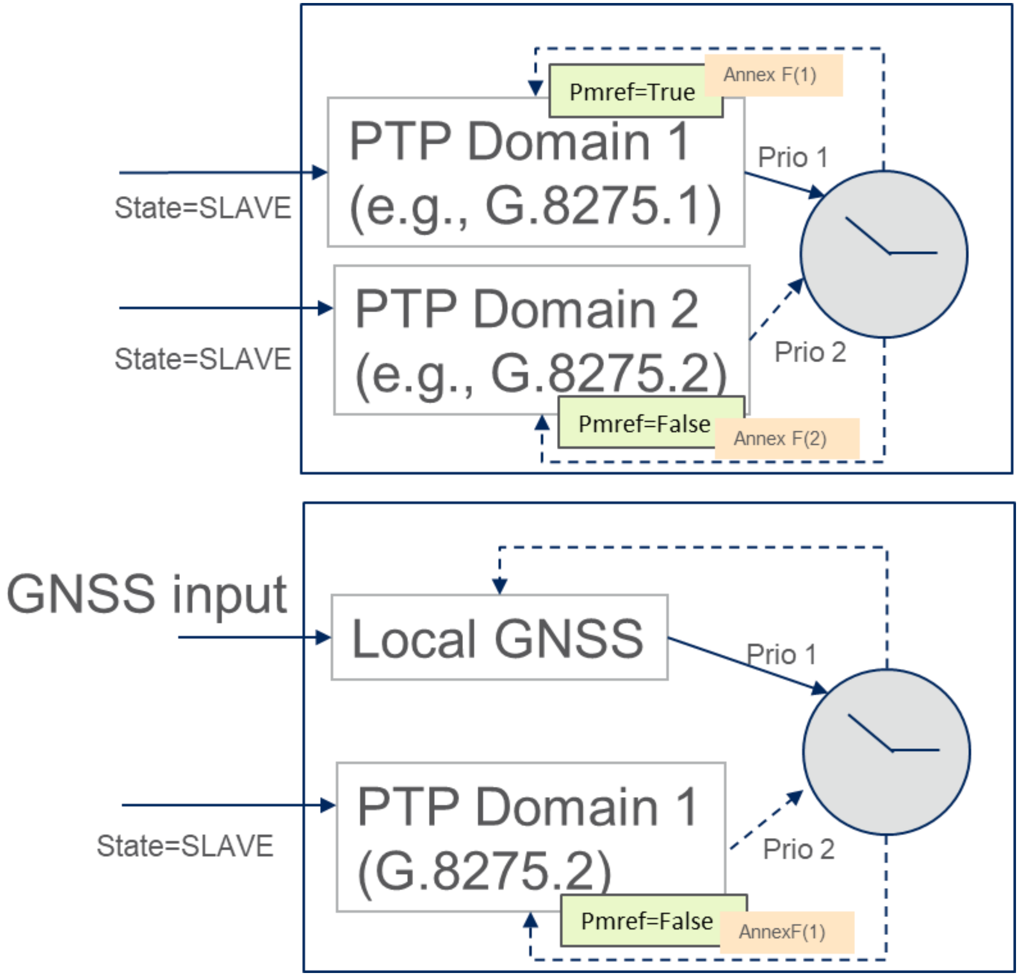
ITU-T Q13, Highlights and Next Steps

- **Q13 participants**
  - META, Keysight, Intel, NOS (Pedro as invited expert) at last Q13 meeting (san Jose September 2023)
  - Calnex candidate host for April 2024 Interim meeting in Edinburgh
- **Documents planned for consent at the next SG15 plenary :**
  - G.8275, G.8275.1 Amd1, G.8275.2 Amd1, G.8271.1 Amd2, G.8272.1, G.8272.2 (new), G.8260, G.8264, G.781, G.Suppl68
- **PTP profiles**:
  - PM data (Annex F) further adjusted; Enhance accuracy TLV may be delayed
  - New work item on Net Insight solution for Asymmetry control from management system?
  - Security TLV opposed by Huawei and Ericsson; enforcing MACsec –based solution.
- **Updated Clocks (G.8273, G.8273.2)**
  - Clock Class D to be completed; new enhanced syncE clock to be defined in G.8262.1
  - New interfaces (e.g., FlexE, MTN) to be added (planned contribution for next meeting)
  - Sync requirements for Optical modules ? (next year)
  - Requirements for Settling time ? (next year)
  - G.8272.1 (ePRTC), TDEV/MTIE requirements
  - Planned new testing guidelines in G.8273 addressing recent updates in G.8273.2 (next meeting)
- **Master clocks:**
  - G.8272.1 (with enhanced holdover); (for December 2023)
  - G.8272.2 (cnPRTC) (for December 2023)
- **New Network limits for full timing support** (G.8275.1) in G.8271.1
  - max|TE| < 600 ns ;
  - G.8271 Category 5 (1 us) use cases for timing over radio

Performance Monitoring: G.8275 Annex F G.8275 evolution

- Complementing data recommended for the NMS (e.g., PTP and SyncE datasets) in new Appendix XI (“*Information that can be used in the analysis of the Performance Monitoring data*”)

- New parameter *PMref* informs whether the reference for the PM measurement is the Local PTP Clock locked to the PTP input reference itself (port in Slave state) or not (e.g., local GNSS).

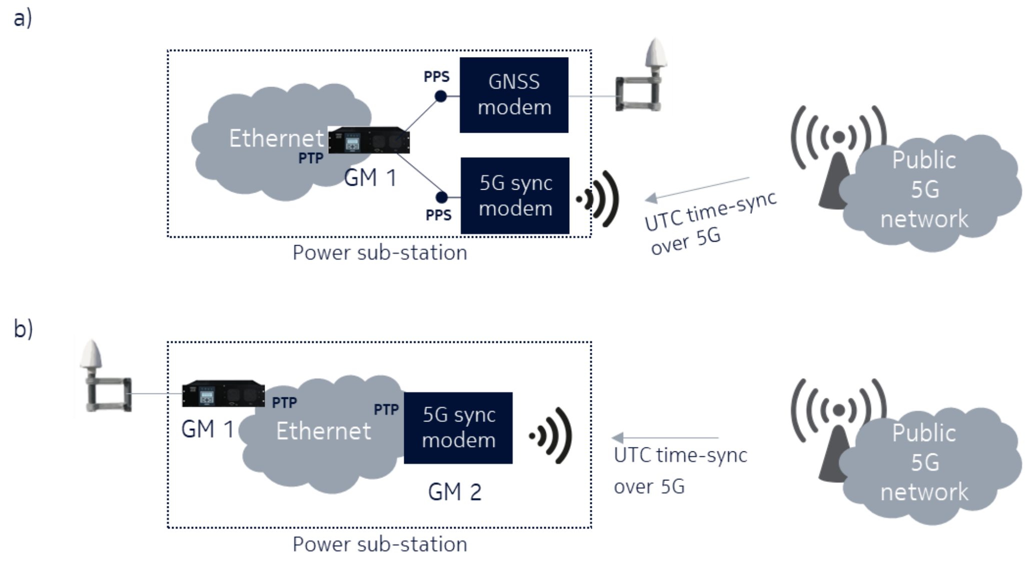


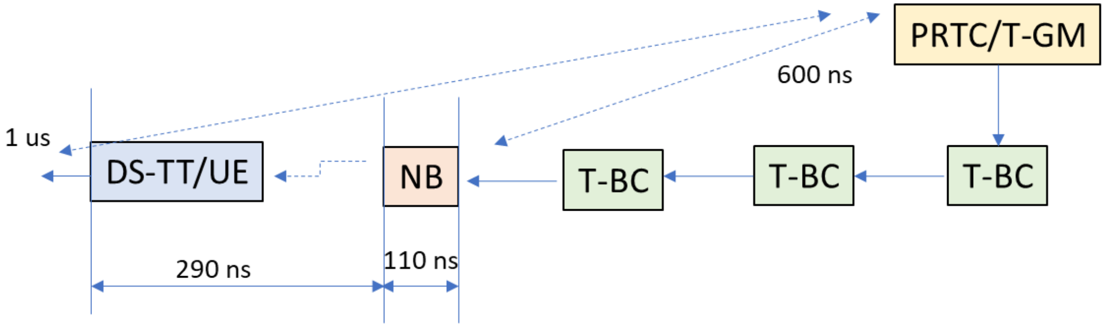
G.8271.1 Amd 2: completed new Network Limits

- Based on G.8271.1 from Nov 2022
- Restructuring of clause 7.3:
  - **7.3.1** Regular network limits at reference point C (former 7.3)
  - **7.3.2 Enhanced network limits at reference point C (New, eSyncE based)**
  - **7.3.3** Network limits for accurate time transfer with a PRTC deployed in the access network (former 7.5)
- Enhanced SyncE and Class C clocks based
  - MTIE up to 200 ns
  - dTE_H< 50 ns
  - Within the O-RAN dTE limits
  - **max|TE| < 600 ns**

Budget component	Failure scenario (a) *(T-GM rearrangement causing short holdover at the End application)* **(Note 2, i.e., 20 T-BCs)**	**Failure scenario (d)** *(Long holdover periods, e.g., three days, based on Physical layer sync)* (Note 1, i.e., 10 T-BCs)	**Failure scenario (d)** *(Long holdover periods, e.g., three days, based on Physical layer sync)* (Note 2, i.e., 20 T-BCs)
Time error generation of the PRTC/T-GM (ce_{ref}) (Note 3)	100ns	100 ns	40 ns
Re-arrangements and long-term holdover in the network (TE_{HO}) (Note 4)	NA	840 ns	670 ns
Dynamic time error of the network of T-BCs (dTE')	60 ns	60 ns	60 ns
Constant time error of T-BCs (ce_{ptp_clock})	200 ns	Class C 100 ns	Class C 200 ns
Constant time error of links (ce_{link_asym}) (Note 5)	240 ns (Note 8)	250 ns	380ns
Total time error at reference point C (TE_C)	**600 ns**	**1 350 ns**	**1 350 ns**
Rearrangements and holdover in the end application (TE_{REA})	750 ns	NA	NA
Noise contribution of the end application (TE_{EA})	150 ns	150 ns	150 ns
Total time error at reference point E (TE_E)	**1500 ns**	**1 500 ns**	**1 500 ns**

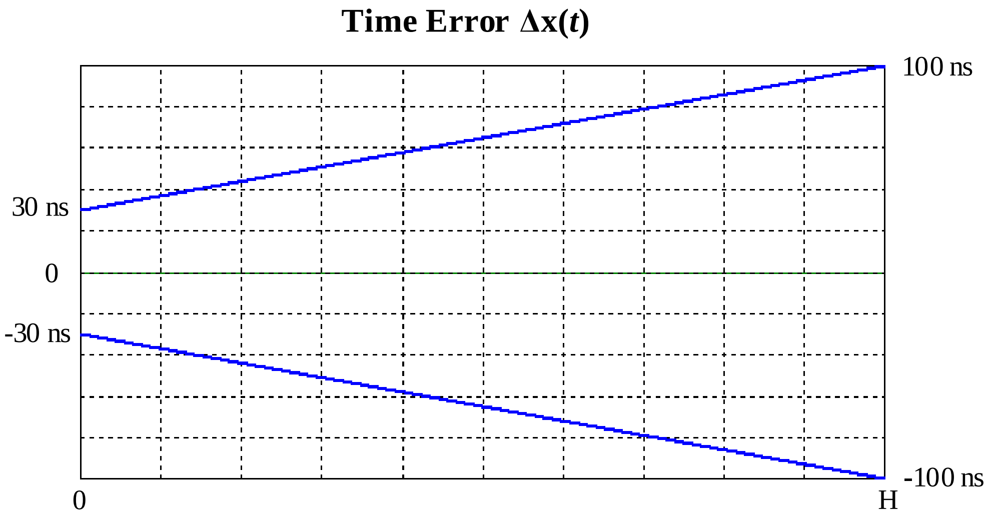
Timing over Radio (3GPP)

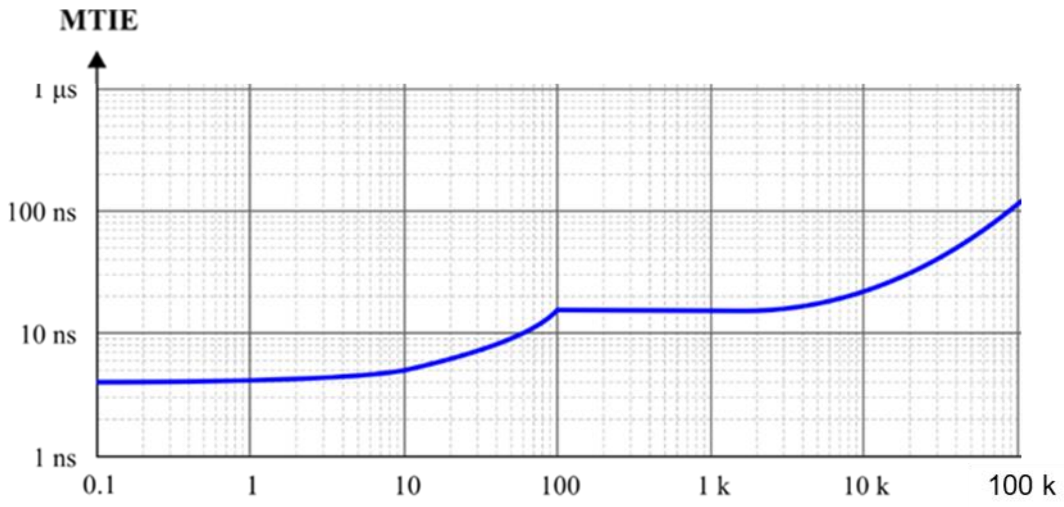




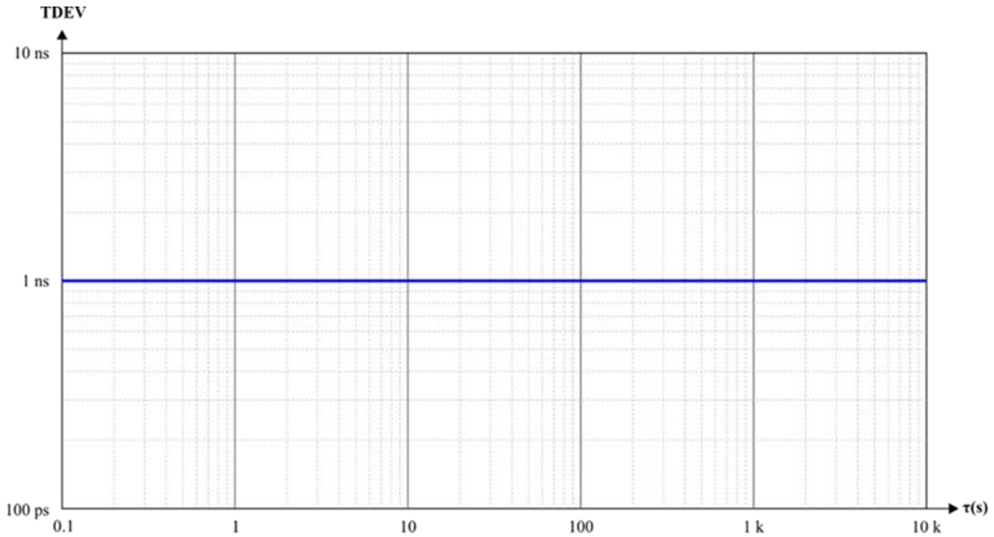
Budget component	**Failure scenario (a)** *(T-GM rearrangement causing short holdover at the End application)* (Note 2, i.e., 20 T-BCs)	**Failure scenario (d)** *(Long holdover periods, e.g., three days, based on Physical layer sync)* (Note 1, i.e., 10 T-BCs)	**Failure scenario (d)** *(Long holdover periods, e.g., three days, based on Physical layer sync)* (Note 2, i.e., 20 T-BCs)
Time error generation of the PRTC/T-GM (ce_{ref}) (Note 3)	40ns	30 ns	30 ns
Re-arrangements and long-term holdover in the network (TE_{HO}) (Note 4)	NA	70 ns	70 ns
Dynamic time error of the network of T-BCs (dTE')	60 ns	60 ns	60 ns
Constant time error of T-BCs (ce_{ptp_clock})	200 ns	100 ns	200 ns
Constant time error of links (ce_{link_asym}) (Note 5)	300 ns	340 ns	240 ns
Total time error at reference point C (TE_C)	**600 ns**	**600 ns**	**600 ns**
Rearrangements and holdover in the end application (TE_{REA})	0 ns (Note 8)	NA (Note 8)	NA (Note 8)
Noise/Time Error contribution of the end application (TE_{EA})	400 ns (Note 8)	400 ns	400 ns
Total time error at reference point E (TE_E)	**1000 ns**	**1000 ns**	**1000 ns**

G.8272.1, ePRTC requirements during holdover





For the ePRTC-A, holdover is based on the frequency reference during loss of phase/time input requirements, and the following requirements apply for TDEV and MTIE



syncPHY Management : G.781 Annex B

- This Annex specifies the data sets for the physical layer clocks of this recommendation, including:
    - **defaultDS**: defines members for the default device attributes of a physical layer clock.
    - **currentDS**: defines members for the current device attributes of a physical layer clock.
    - **parentDS**: defines members for the clock source attributes of a physical layer clock.
    - **portDS**: defines members for the port attributes of a physical layer port.
- Further progress made at last meeting. To be consented in December 2023 (G.781 revision)
- To be used as a reference in G.7721.1 (Q14 Recommendation on Data model of synchronization management), planned for consent in 2024

Miscellaneous

- G.8273.2: Note added on the clock class D requirements. Interfaces applicable to class D have to be identified

Table 7-2 – Maximum absolute time error low-pass filtered ($\max|TE_L|$)

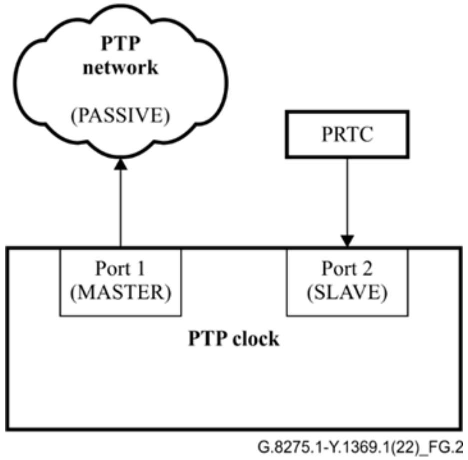
T-BC/T-TSC class	Maximum absolute time error – $\max|TE_L|$ (ns)
D	5 ns

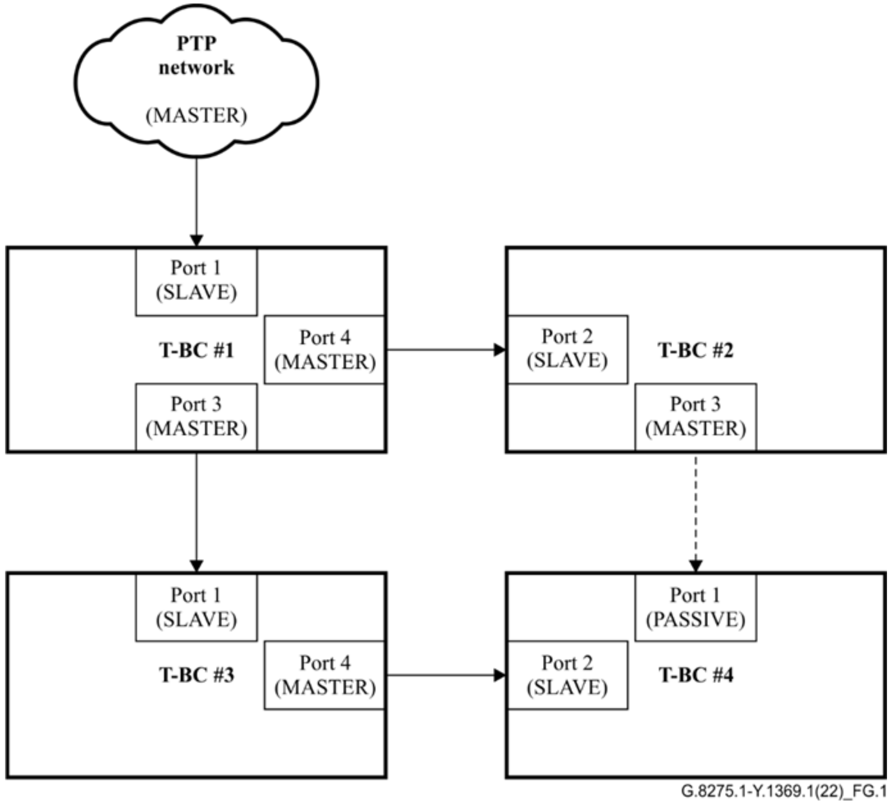
NOTE – The detailed list of interfaces relevant to Table 7-2 are for further study.

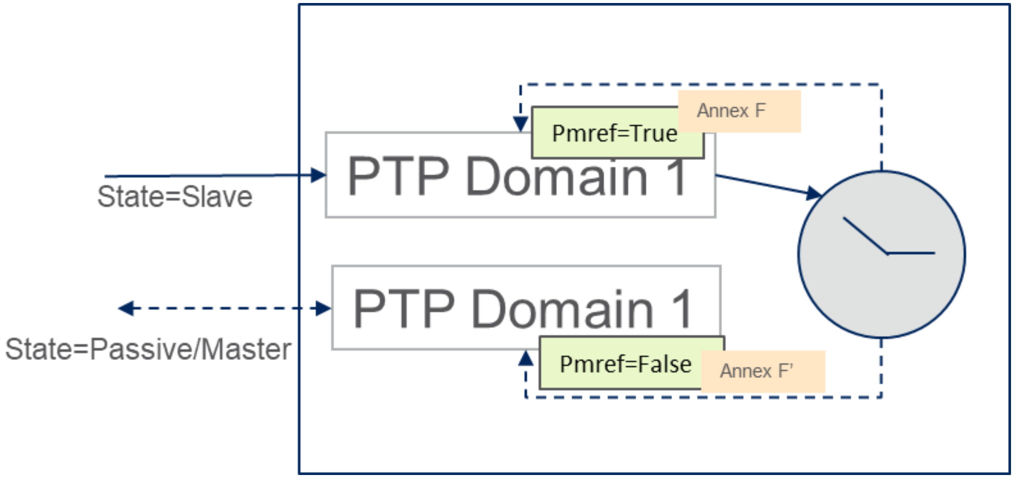
ITU-T: Work in Progress

PMRef other potential use cases: multiple PM data collections from the same PTP domain

- Other cases under study
  - Collection of PM data from ports not in Slave state (using G.8275.1 Annex G)
  - New per port data collection: *PortClockPerformanceMonitoringDataRecord*
  - Need to distinguish per parent Port number

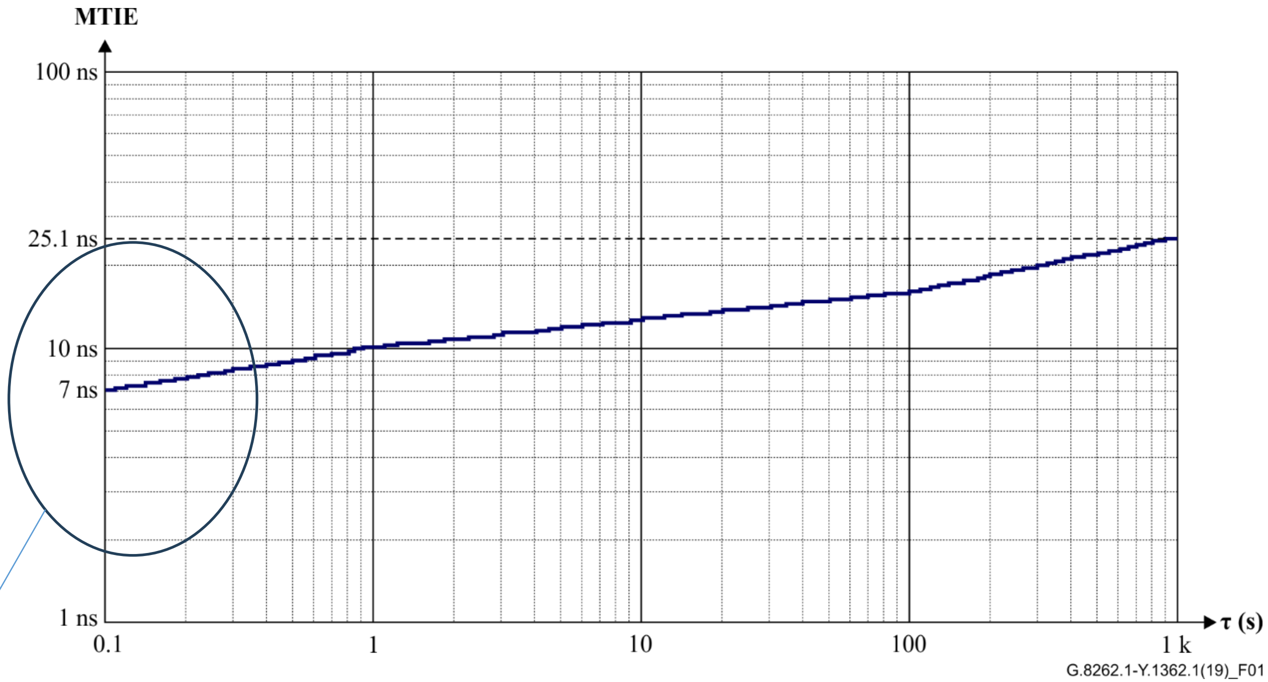






Clocks: future work

- New G.8262.1 clock
  - Better enhanced syncE clock to support class D clocks
- G.8273. 2 Clock Class «D» to be completed (including the list of applicable interfaces)
- Settling time for all clocks
- Class D interfaces

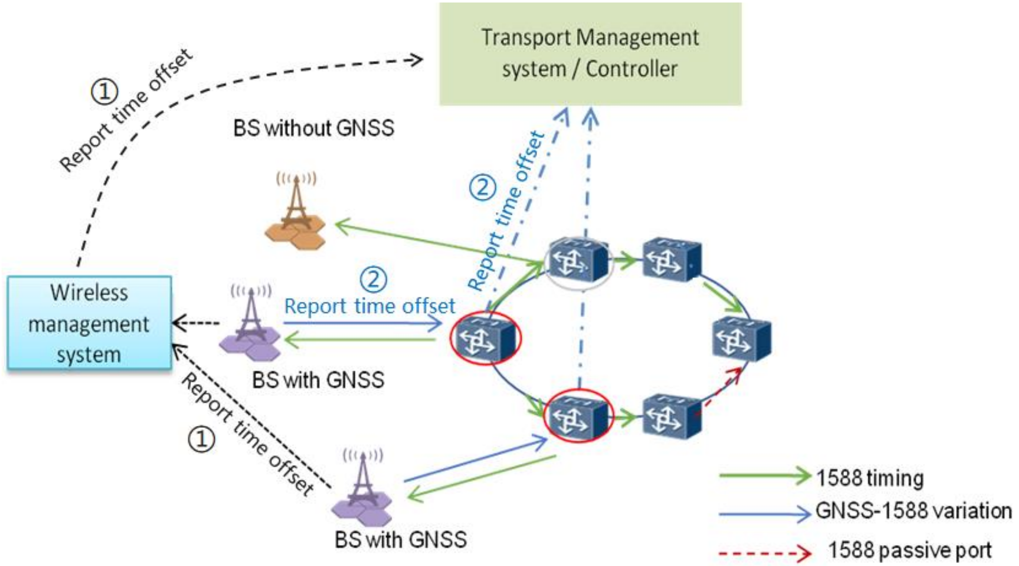


Critical region to meet 5 ns for class D clocks

Others

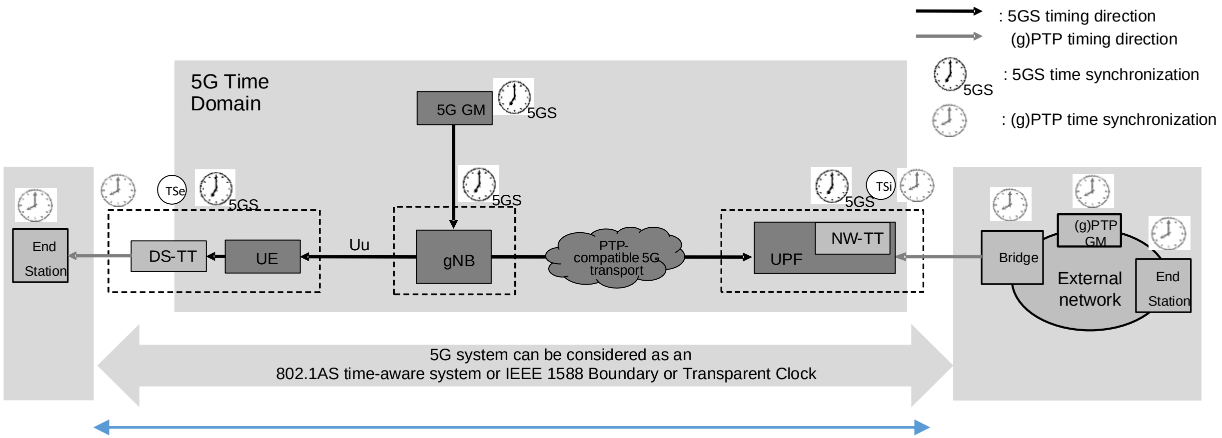
- PTP Security
  - Optional IEEE1588-2019 Security TLV (as requested by O-RAN) not agreed
  - MACsec preferred by some vendor
    - If security is required, MACsec is likely to be used anyway (to protect traffic)

- GNSS-PTP difference
  - TLV to carry difference between GNSS and PTP
  - Enhanced Accuracy TLV and related ABMCA
    - Contributions expected at the next meeting

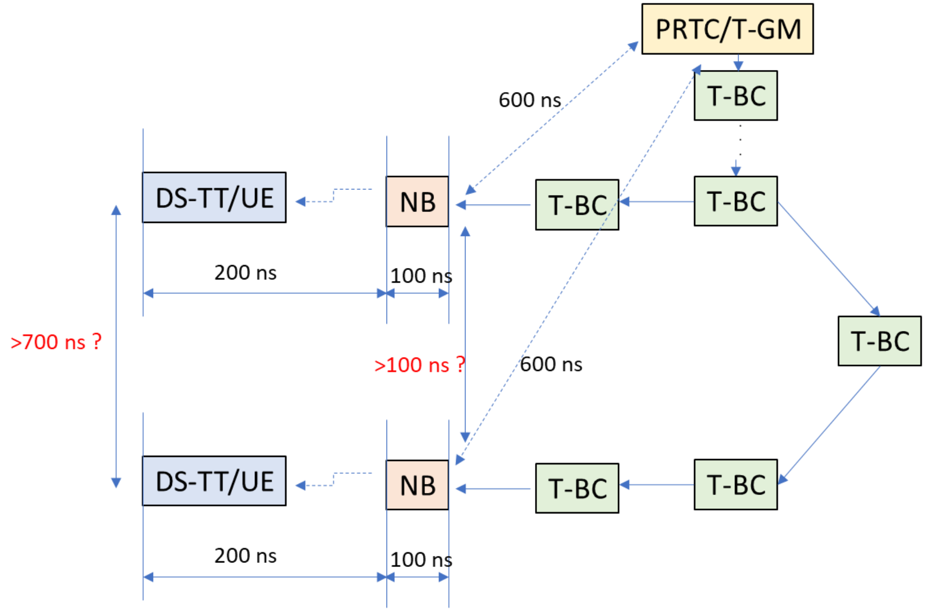


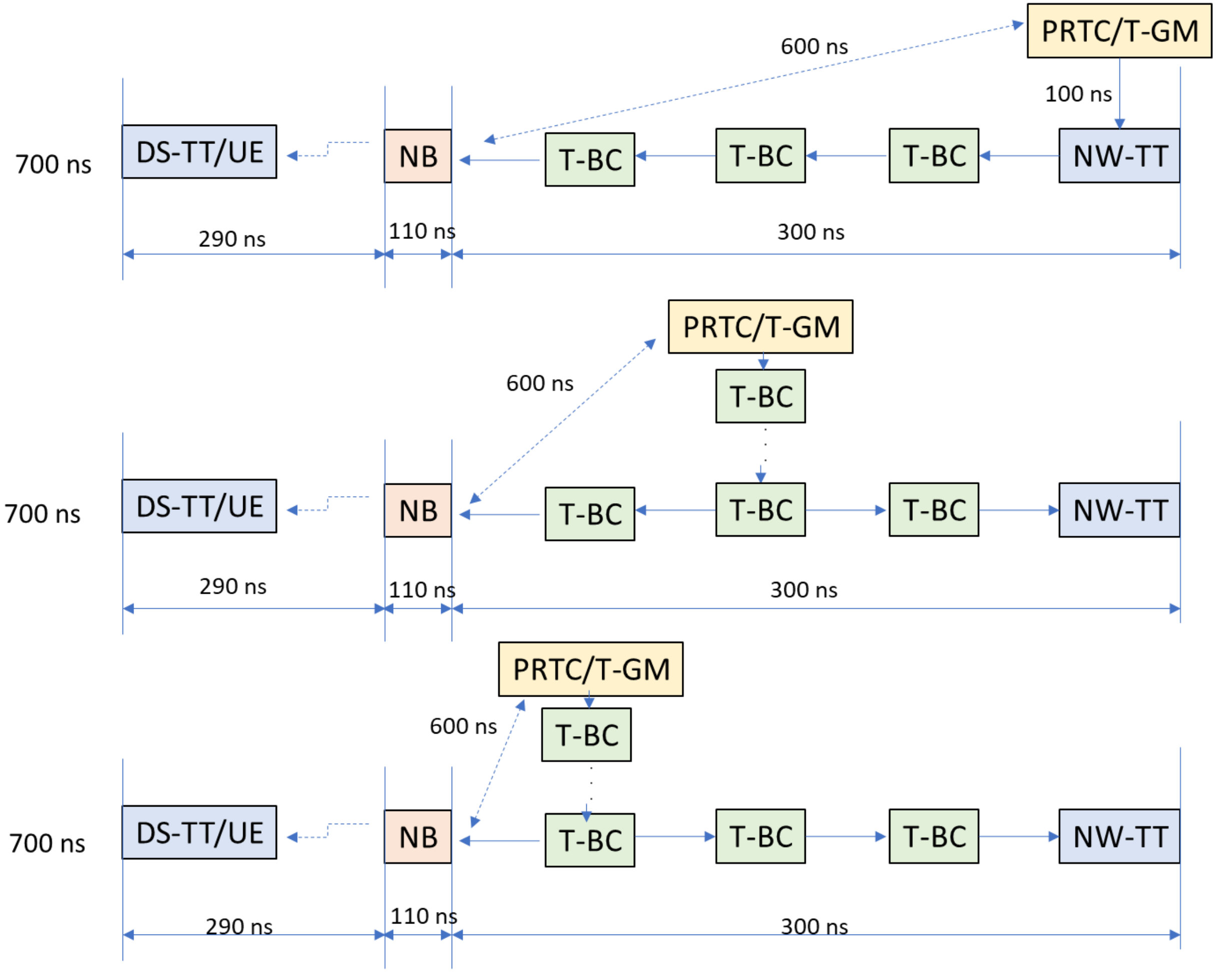
TSN Integration with 5G: Analysis in G.8271.1

- Relative Time Error analysis in G.8271.1



700 ns required by latest revision of 3GPP TS 22.104





What’s next

- MTN
- ABMCA based on Enhanced Accuracy TLV
- Sync requirements for optical modules?
- «Net Insight» solution for Asymmetry compensation in PTS?
- White Rabbit?
- Solutions for datacenters?
- ...

Future Q13 meetings

- Mid-November , SG15 meeting in Geneva
  - Docs planned for consent:
    - G.8275, G.8275.1, G.8275.2 (e.g., Performance monitoring)
    - G.8271.1 (e.g., network limits for enhanced SyncE)
    - G.8272.1 (e.g., enhanced holdover)
    - G.8272.2 (new recommendation)
    - G.8260
    - G.8264
    - G.781 (SyncPHY dataset)
    - G.Suppl68
- April 2024: Interim Meeting hosted by Calnex?

O-RAN: What’s new?

ORAN : Highlights and Next Steps

Calnex

- Control, User and Synchronization Plane Specification (**CUS**); Latest published version: **ORAN.WG4.CUS.0.v12.00** – June 2023
    - No major updates in v13 (July 2023, to be published);
    - **Plans for v14 :** alignment with latest version of G.8271.1 (new network limits); Clarifications on O-RU syncE tolerance; New terminology (November)
- Fronthaul Conformance Test Specification (**CONF**); Latest published version: **ORAN.WG4.CONF.0.v08.00** –June 2023
    - v08 with Further alignment with ITU-T (test methodology for LLS-C1,C2); Specification for diagnostic O-RU 1PPS output ;
    - v09 from July 2023, to be published : O-RU syncE+PTP input noise; tests for cascaded O-RUs (G.8273.2/G.8273,3)
    - **Plans for v10:** Further details on tests for cascaded O-RUs?; FHM performance; LLS-C3 tests; new terminology
- X-Haul Transport Testing (**XTRP-TST**); Latest published version**: ORAN.WG9.XTRP-TST-v02.00** –October 2022
    - Focus on G.8275.1 (G.8275.2 for further study); Applicable to field tests and lab tests; For lab cases, the type and number of inserted Transport Node Elements (TNE) will be determined by operators
    - Latest v03 (July 2023, to be published): Additional use cases in LLS-C3 and LLS-C4
    - **Plans for v4:** security related tests ?
- Synchronization Architecture and Solution Specification (**XTRP-SYN**); Latest published version: **ORAN.WG9.XTRP-SYN.0.v03.00** – October 2022:
    - v04 from July 2023, to be published: security considerations; LLS-C2/C3 mixed scenarios; Shared O-RUs
    - **Plans for v05:** performance monitoring ; Optical modules sync ?

Cascaded O-RU in CONF spec v09

Calnex

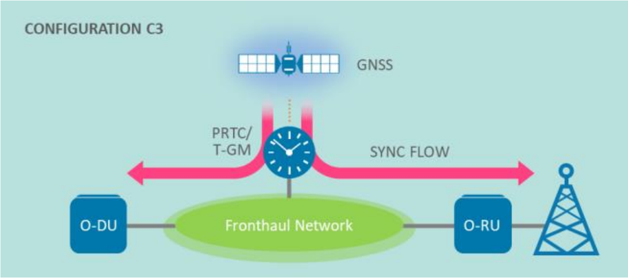
- Reference to G.8273.2 and G.8273.3 for cascaded O-RUs
- Section 3.3.3 (O-RU performance tests)
  - “when O-RUs implement cascaded O-RU mode see also 3.3.9”

3.3.9 Performance test of O-RU using ITU-T G.8275.1 Profile (LLS-C1/C2/C3), additional tests for cascaded O-RUs

- *In addition to tests described in clause 3.3.3, the full validation of an O-RU that is deployed in the synchronization path in cascaded O-RU mode requires the implementation of additional tests. In particular, as per 11.2.2.2 of O-RAN CUS Specification [2], if deployed in this mode, the O-RU shall also implement Recommendation ITU-T G.8273.2 [28], T-BC or Recommendation ITU-T G.8273.3 [29] T-TC. Therefore, further performance testing to ensure conformance to either or both of those recommendations shall be performed in addition to this performance test.*
- *Details of the additional tests are not yet specified. Until details of the test case to be used are specified in the present document, the tester shall verify proper T-BC and/or T-TC functionality according to ITU-T G.8273.2 and/or ITU-T G.8273.3 utilizing additional test cases that can verify compliance with these Recommendations. These measurement results along with details of the test executed shall be documented in the test report.*

Work in Progress, planned CRs

New Network Limits in G.8271.1 to address LLS-C3: Agreed CR for the CUS specification (v13)

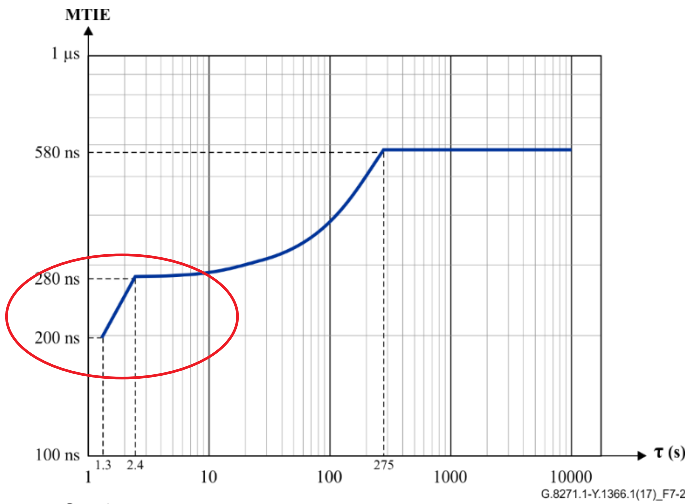


- LLS-C3 refers to latest G.8271.1 with 3 levels of network limits
- To meet 50 ppb on the air interface the O-RAN specification requires that the high frequency noise input to the O-RU is **less than 126 ns peak to peak**
- **Clause 7.3.1 is not suitable**

Two MTIE masks previously defined in G.8271.1

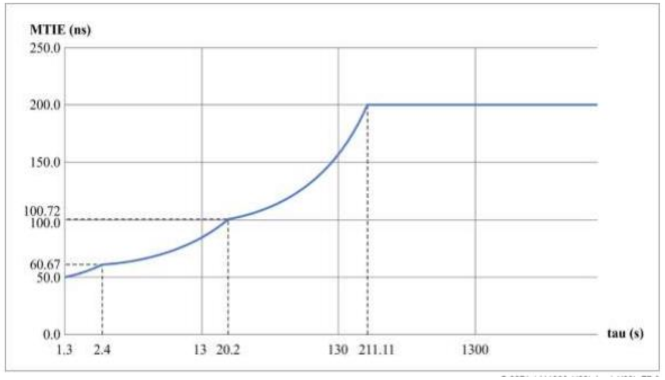
- Clause 7.3 (now 7.3.1): long clock chain using synchronous Ethernet, and with allowance for one syncE transient with target for 1.5 us at reference point E.

- Clause 7.5 (now 7.3.3) for a short clock chain using enhanced syncE, and no allowance for transients.



Clause 7.3.1

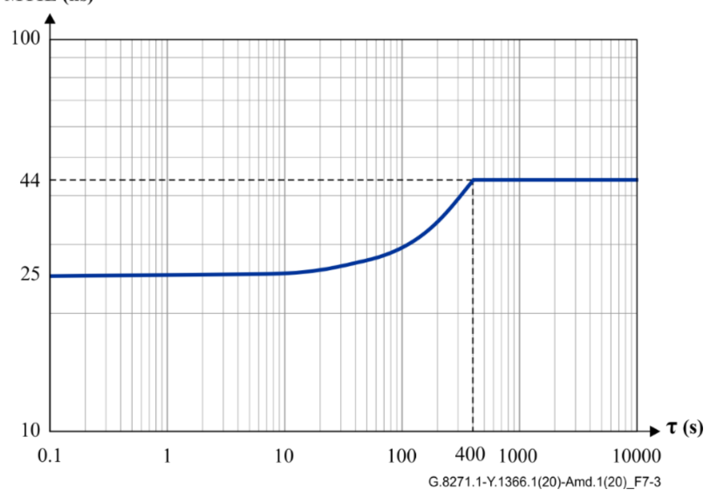
Max|TE|< 1100 ns
dTE_H < 200 ns



Clause 7.3.2 (New)

Max|TE|< 600 ns
dTE_H < 70 ns

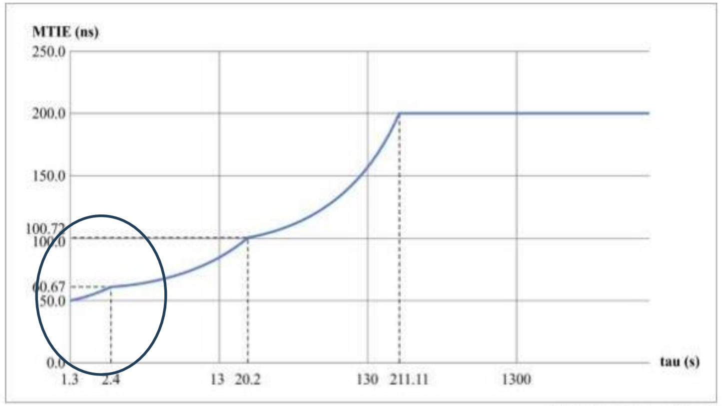
Clause 7.3.3

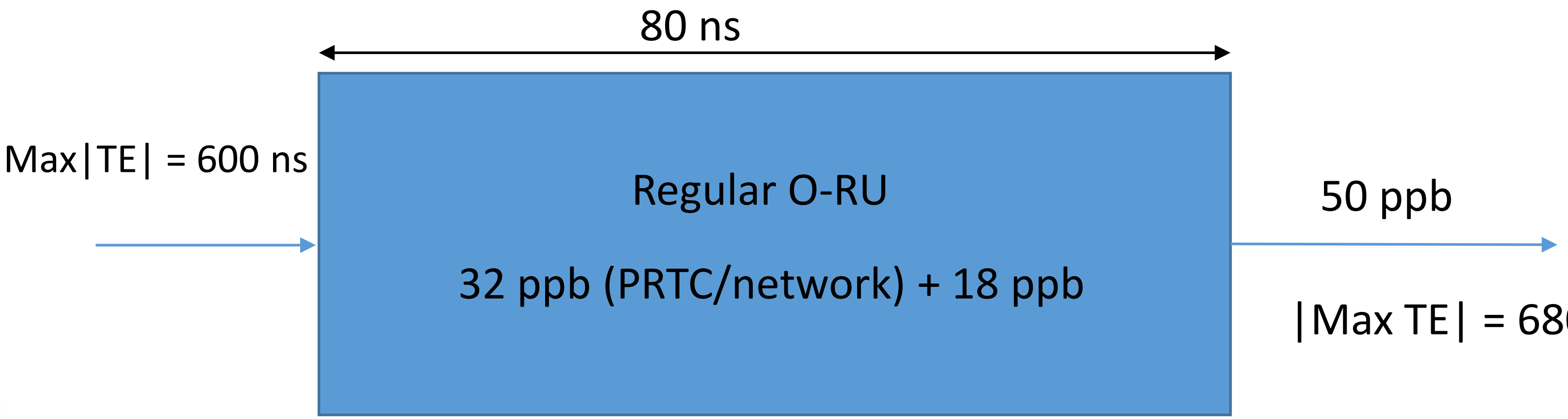


Max|TE|< 100 ns
dTE_H < 70 ns

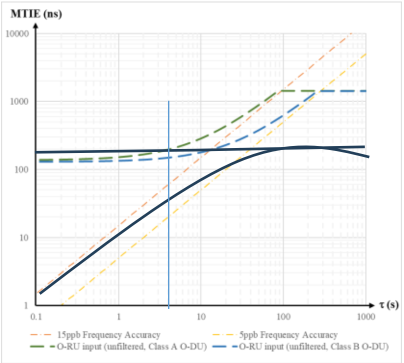
O-RU tests (clause **3.3.3**): **CR** on LLS-C3 (currently for further study)

- New G.8271.1 requirements (that can more easily meet the frequency error related requirements); expected in v14 as a reference to 7.3.2; including Max|TE|= 600 ns in v15 (after G.8271.1 is consented in December)
- CR for the CONF specification to address the LLS-C3 missing tests (may be discussed in November/December)
- Output (air interface): max|TE| = 680 ns; Max Frequency Error = 50 ppb
- LLS-C2 tests covering most of the worst case (max|TE| up to 1420 ns, and larger MTIE for τ > 4 seconds)
  - LLS-C3 test recommended mainly to cover frequency error requirements;
- Optional test using G.8271.1 7.3.1 limits (Max |TE|= 1.1 us, and large MTIE mask, with 200 ns on the shorter obs intervals)





Up to τ= 4, >15 ppb

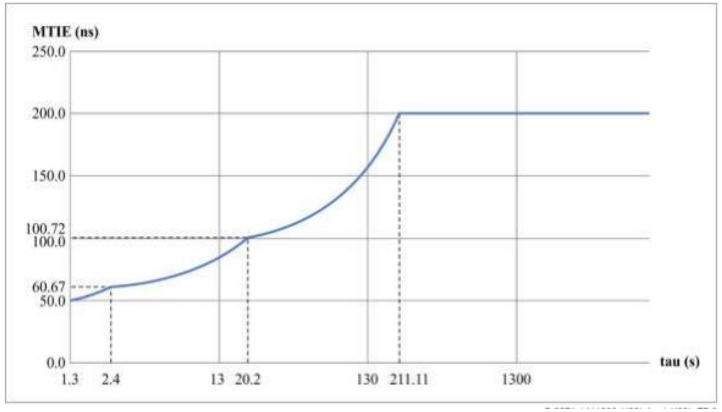


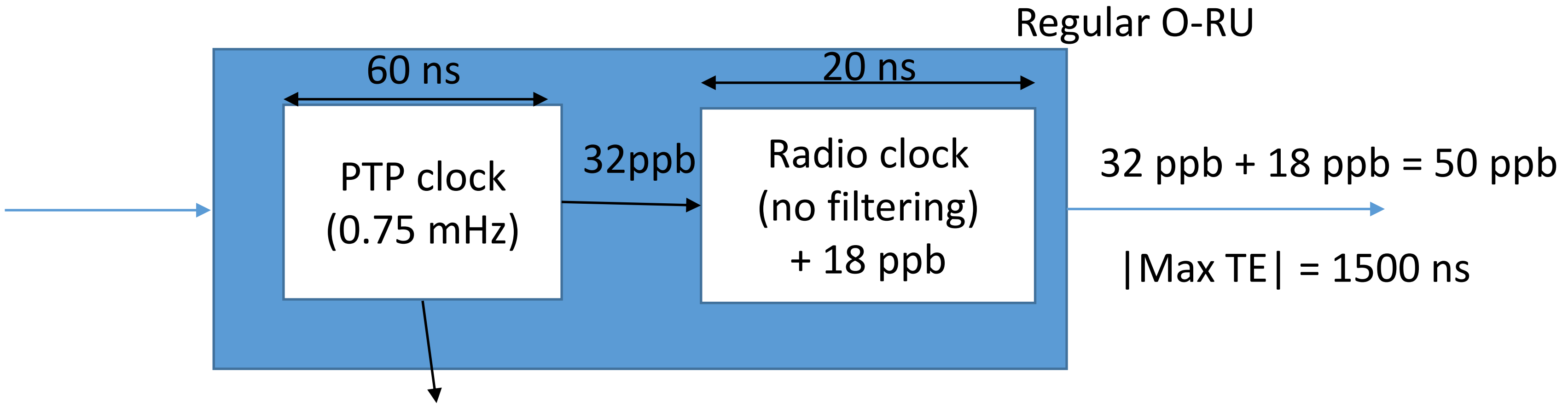
+ Sinusoidal profiles following the MTIE

Optionally with 7.3.1 (Max|TE| = 1100 ns ; MTIE as per 7.3.1)

O-RU tests (Section **3.3.3**): **CR** on LLS-C3, informative test on 1PPS

- Diagnostic test on 1PPS when available:
  - 600 ns max|TE|
  - MTIE as per G.8271.1 clause 7.3.2





Max|TE| = 600 ns

Frequency Error= 30ppb + 2 ppb
|Max TE| = 600 ns + 60 ns = 660 ns
MTIE = 200 ns plateau (rms addition from PTP clock is negligible)
and < 32 ppb slope on the short term

+ Sinusoidal profiles following the MTIE

Optionally with 7.3.1 (Max|TE| = 1100 ns ; MTIE as per 7.3.1)

O-RAN : Others

- Security
  - Security requirements for Open FH are available in clause 3.2.5.3 of O-RAN Security Requirements Specifications. This publication is available at the following location: https://orandownloadsweb.azurewebsites.net/specifications
  - Ongoing Joint discussions between WG9 and WG11
  - Use of IEEE1588 Security TLV for PTP announce messages is considered; but no much progress; Issue with the security key distribution method
  - WG9 describing some use cases as part of the X-Haul Transport Testing (XTRP-TST)
- Performance Monitoring
  - List of parameters for performance monitoring under discussions in WG9
  - These include: Annex J; syncE parameters (partly with reference to G.781) and PTP parameters (partly with reference to ITU-T G.7721.1)
  - Suggestions to align with ITU-T
- Optical
  - MOPA and sync presented at the O-RAN WDM working Group and sync group:
  - Attachments - WG9-2022-011 Contributions - Open X-haul Transport Work Group - Confluence (atlassian.net)
  - 2 main parts are still missing (and to be done outside MOPA):
    - Standardized registers
    - Testing methodology

IEEE 1588

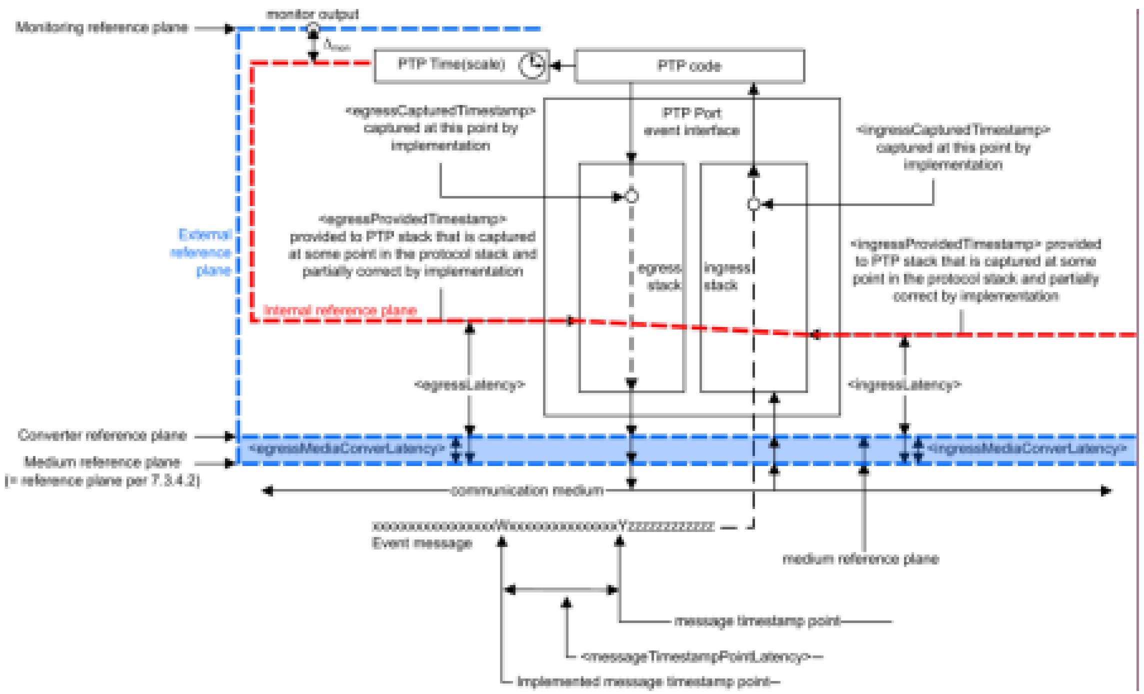
Status

- **P1588a** (Enhancements for Best Master Clock Algorithm (BMCA) mechanisms): being published. P1588a, includes both an update of the "Enhanced synchronization accuracy metrics (optional)" (Enhanced Accuracy TLV) and two new Annexes dealing with the Alternate BMCA with examples on the use of the enhanced accuracy TLV.
- **P1588b** IEEE SA ballot on the PTP over OTN Amendment has been completed and P1588b has been approved. The Amendment has been published .
- **P1588c** (Clarification of Terminology): under comment resolution.
- **P1588d** (Guidelines for selecting and operating a Key Management System): under final approval steps.
- **P1588e** (MIB and YANG Data Models), SA Ballot completed, main comment is to update the terminology in MIB/YANG. Two modules will be submitted. SA recirculation to start soon. YANG: https://github.com/YangModels/yang/blob/master/standard/ieee/draft/1588/ieee1588-ptp.yang ; MIB: ieee1588 / mib · GitLab
- **P1588f** (Latency and/or asymmetry calibration): Part A: Delay Asymmetry Measurement Mode - WG Ballot 2 - recirculation . Part B: Absolute Calibration - WG Ballot 1 . Part C on MIB/YANG additions to be developed
- **P1588g** (Master-slave optional alternative terminology): The amendment has been approved published. Terms recommended for the Master-Slave replacement are *timeTransmitter* and *timeReceiver* respectively.
  - Note: the old terms are still valid (not being changed in the standard). A new PAR would be required to make this change. IEEE SA has a separate project specifically on this type of language. A new PAR may be issued when this is complete.

IEEE1588 – Highlights and Next Steps

Calnex

- Last Amendments being completed:
  - P1588e: MIB and YANG data models
    - Duplicated models with new terminology
    - Might be approved by RevCom by December 2023 (earliest date); January 2024 more probable
  - P1588f: Calibration procedures
    - 2 sections under WG ballot
      (Fiber asymmetry measurement;
      Absolute calibration)
    - Last part with MIB/YANG additions to P1588e
    - Can be approved after IEEE1588e
      (or at the same time)



- Next step: roll-up of all amendments; possibly with new terminology (by 2025 ?)

Others

Time-Sensitive Networking (TSN) Industrial Automation Profile (IEC/IEEE 60802)

Calnex

- IEC/IEEE 60802 profile is a joint project between IEC SC65C/WG18 and IEEE 802
- It addresses bridges and end stations for industrial automation
- Time synchronization is based on IEEE 802.1AS;
  - additional TLV to improve rate ratio function
  - Additional performance requirements
- Typically, Industrial automation contains multiple tasks that are based on time or cycles
- The data flow needs to operate continuously and relies on regular updates based on a local or network time base
- Latency and time delays are critical and needs to be minimized and bounded
- Two types of clocks are being defined: Global Time (synchronized to TAI (International Atomic Time)), and Working Clock (synchronized to an arbitrary time (ARB)
- The Working Clock, a network of at least 64 nodes must be supported, and it is desirable to support up to 100 nodes between the grandmaster and the end application
  - Need to meet a maximum absolute Time Error of 1us
  - Simulations are being run to define key parameters that will be specified in the profile (e.g. residence time, Sync and Pdelay message rates)
- Under Working Group Ballot (Draft 2.1)

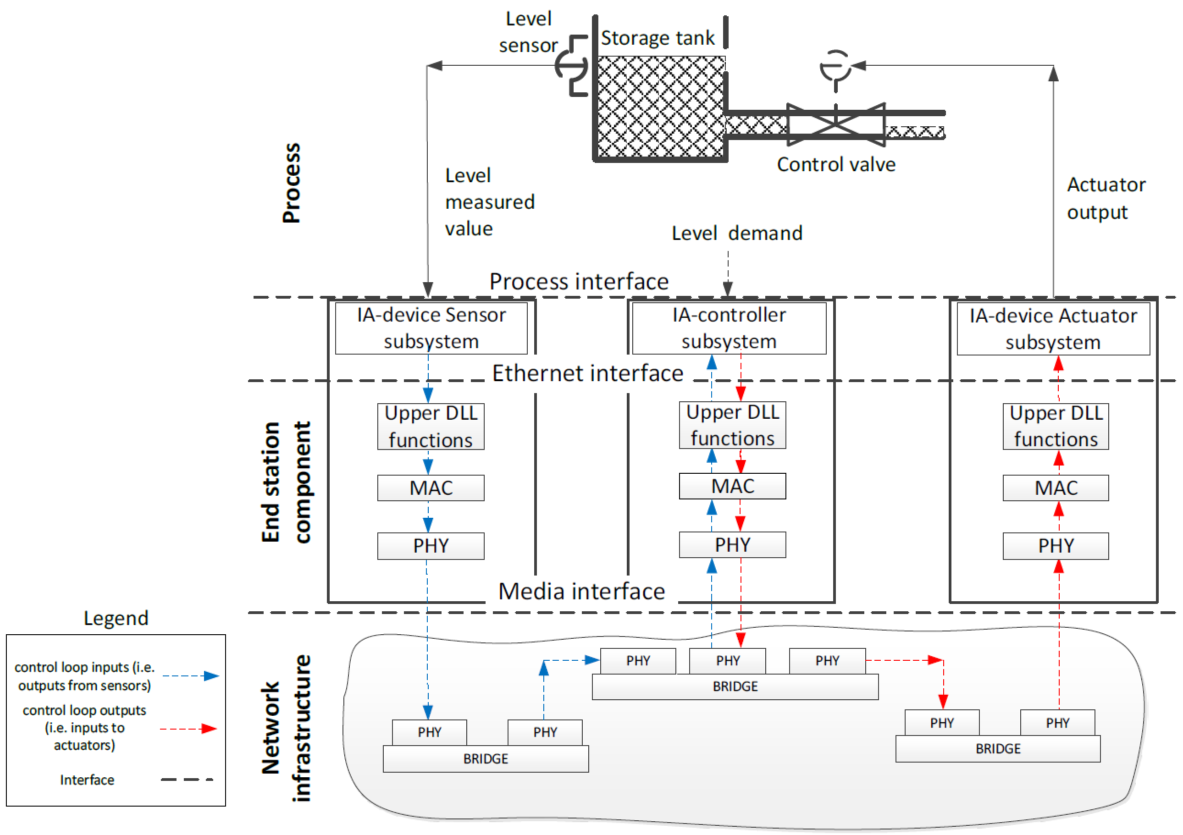


Figure 1 – Data flow in a control loop

- Source: IEC/IEEE 60802 D2.1 draft

IEEE P3335 - Standard for Architecture and Interfaces for Time Card

- **Scope of (P3335) standard:**
  - *This standard defines the generic architecture and interfaces of a time card system, which constitutes a traceable source of time-of-day to heterogeneous systems that distribute and/or use that time. Additionally, this standard defines figures of merit that univocally characterize the relevant performance of the Time Card.*
  - *The Time Card provides a traceable time-of-day for systems directly attached to it, as well as networked distributed systems. Such systems include, but are not limited to, servers hosting the Time Card, and servers synchronized with the Time Card using such protocols as Precision Time Protocol (PTP) or Network Time Protocol (RFC Request for Comments) 5905).*
  - *This standard also defines the basic building blocks of the Time Card and their interfaces in order to allow modularization. The main building blocks include time source, local oscillator, and time processor.*
  - *Additionally, this standard defines interfaces between the Time Card and other systems. ….*
- WG Chair: Ahmad Byagowi
- WG Secretary: Denis Reilly
- Start of a first sub-group: “System Architecture Subgroup” led by Kevin Stanton
  - Time card sub-functions and interfaces.
  - Time card should be treated as a peripheral
  - Internal interfaces are not specified in detail

Conferences

- 2023 OCP Global Summit (San Jose 17-19 October):
  - 2023 OCP Global Summit » Open Compute Project
  - Q13/15 talk (“A Set of standards to deploy sync in OCP”), delivered by Kishan Shenoi (Intel)
- ITSF (Antwerp – Belgium, 30 Oct-2 Nov 2023)
  - ITSF 2023 (executiveindustryevents.com)
  - Agenda: ITSF 2023 Programme (executiveindustryevents.com)
  - Sessions (in addition to Tutorials):
    - Sync in the Infrastructure
    - Practical Implementations of Timing & Synchronisation and Network Performance Monitoring
    - Strengthening Resilience and Integrity in Timing
    - Sources of Time/Time References
    - Building Blocks of Timing Architecture
- WSTS 2024 (San Diego CA, May 7-9 2024)
  - Virtual Tutorial
  - CfP will be open on Friday 20 October
    - Telecom
    - Finance, data centers, multi-cloud networking
    - PNT
    - Sources and Synchronization
    - Emerging Applications

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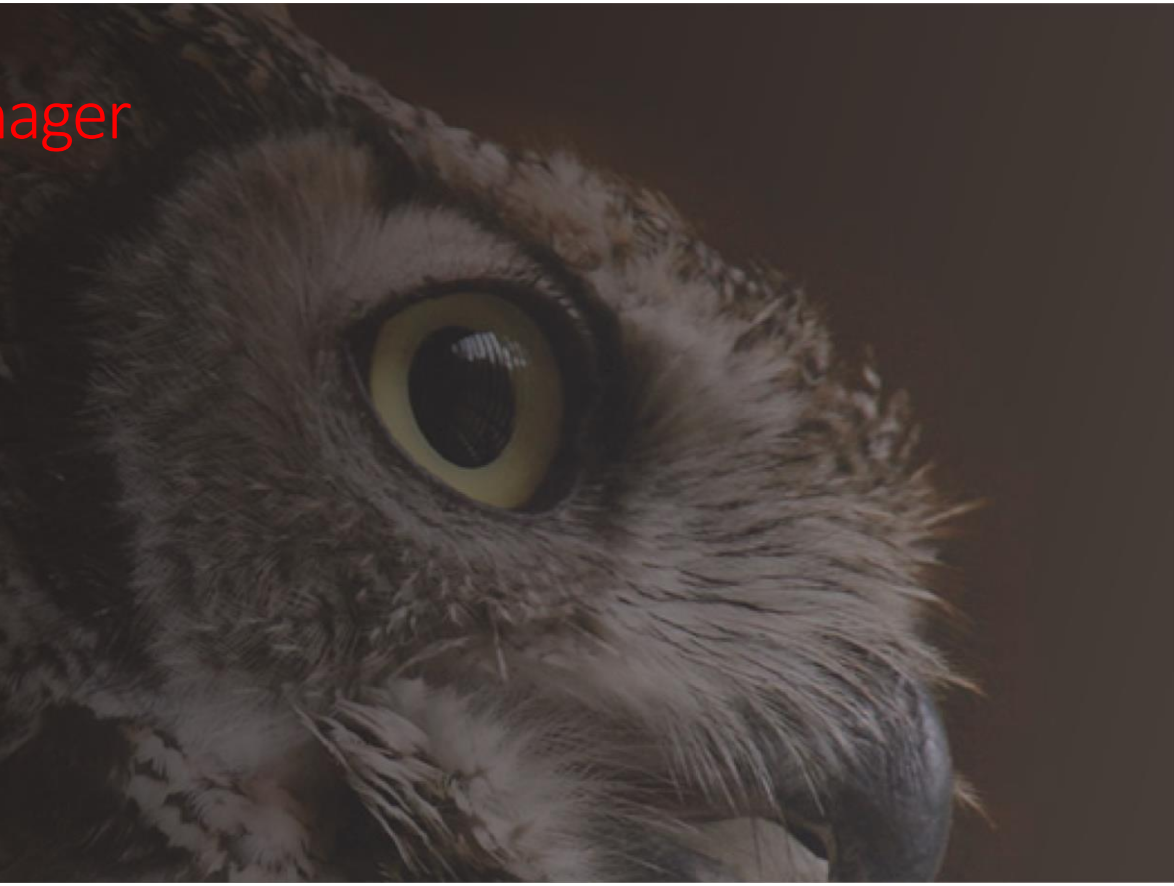

Insight and Innovation

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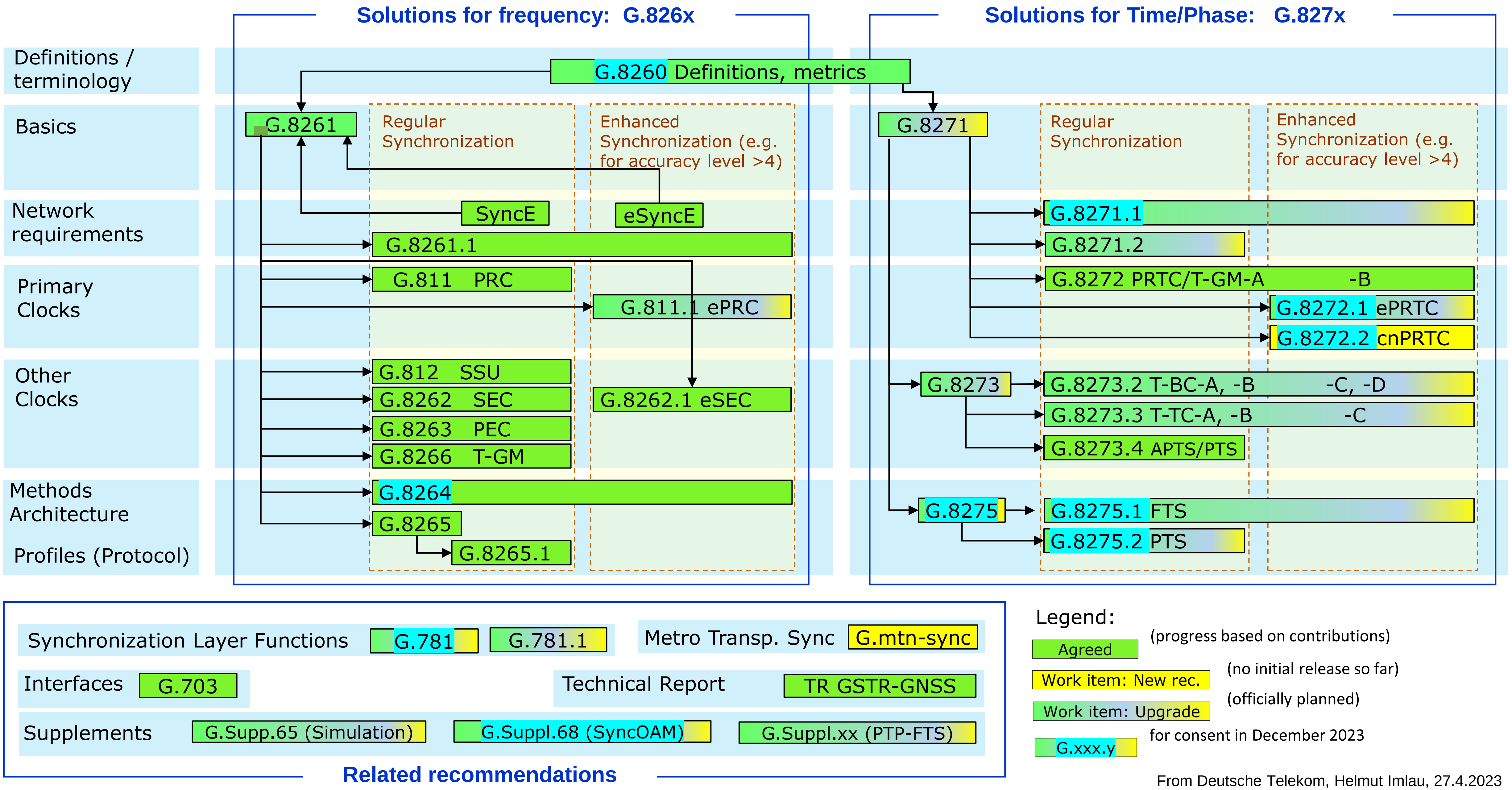
ITU-T SG15 Q13-Recommendations



From Deutsche Telekom, Helmut Imlau, 27.4.2023

IEEE1588 Amendments

- **P1588 WG is working at several Amendments addressing various aspects (Active Projects - IEEE P1588 Working Group) for updating IEEE1588-2019 :**
  1. **P1588a: Enhancements for Best Master Clock Algorithm (BMCA) mechanisms**
  2. **P1588b: Addition of PTP mapping for transport over Optical Transport Network (OTN)**
  3. **P1588c: Clarification of Terminology**
  4. **P1588d: Guidelines for selecting and operating a Key Management System**
  5. **P1588e: MIB and YANG Data Models**
  6. **P1588f: Enhancements for latency and/or asymmetry calibration**
  7. **P1588g: Master-slave optional alternative terminology**
- **Work is structured into several sub-committees addressing various topics as follows:**
  - **Security** – e.g., to finalize security features such as key management and to define a default security profile
  - **Management** – e.g., to work on YANG models for new edition of IEEE1588
  - **New features** – e.g., to work on PTP over OTN mapping, on distribution of information on the PTP chain performance towards the PTP slaves (using an updated version of the Enhanced synchronization accuracy metrics TLV), on clarifications on BMCA expected behaviour, on tools to Assist Link Asymmetry Measurement, etc.
  - **Maintenance** – to address potential need for corrections and/or clarifications
  - **Outreach** – to promote awareness and community engagement with IEEE 1588