

Synchronization and Time-Sensitive Networking (TSN)

Introduction to Session 3 at the
Ninth Joint IEEE 802 and ITU-T Study Group 15 Workshop

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&

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Session 3: Synchronization & TSN – Abstract

Synchronization and the propagation of time is a fundamental networking technology in various industries, e.g., in telecommunication networks (e.g., to support the operation of cellular networks), in industrial automation, in in-vehicle networks like automotive and aerospace. Time synchronization is also one of the tools in the toolset of IEEE 802.1 Time-Sensitive Networking. This session provides updates and future plans of the following groups actively dealing with synchronization: ITU-T Q13/15, IEEE 1588, 802.1, and 802.3.

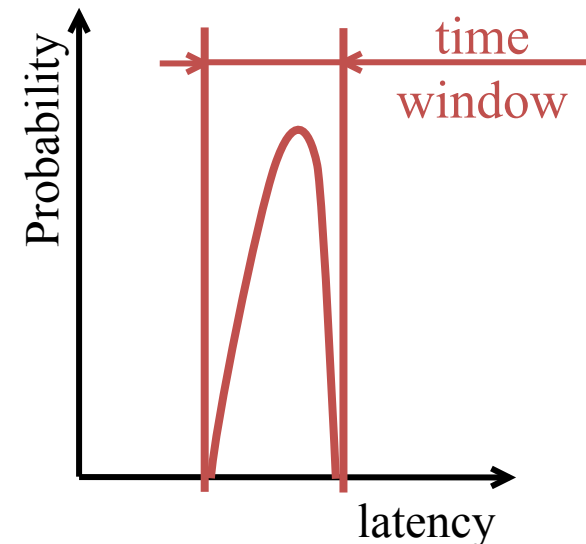
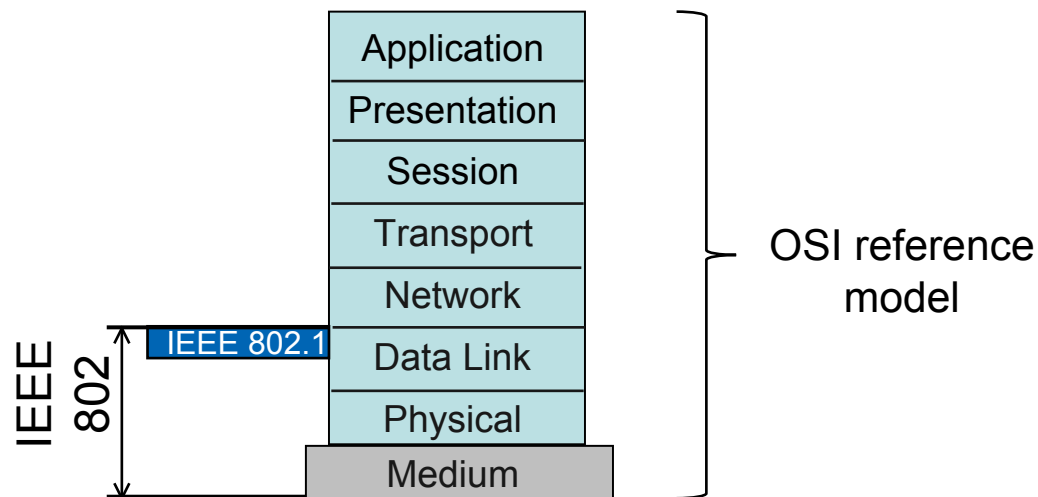


Agenda

- János Farkas and Stefano Ruffini: Introduction
- Stefano Ruffini: Synchronization solutions to address new needs in terms of resiliency, and interworking with new applications (e.g., TSN)
- Steve Gorshe: Synchronization over Optical Technologies – PTP over GMP, IEEE P802.3cx, PTP over optical interfaces
- Rodney Cummings: IEEE 1588 Evolution – Latest amendments, protocol evolution
- Silvana Rodrigues and Geoffrey Garner: IEEE 802.1AS Developments and Inclusive Terminology in ITU-T and in IEEE 802.1AS – Evolution of IEEE 802.1AS and its amendments, and updates in terminology in ITU-T Recommendations and IEEE 802.1AS
- David McCall and Geoffrey Garner: IEC/IEEE 60802 Time Synchronization Developments and Results – Achieving 1 μ s time synchronization accuracy across 100 network hops with regular XOs and existing silicon via clock drift tracking and error compensation
- Q&A

Time-Sensitive Networking (TSN)

- TSN is a set of standards specified by IEEE 802 to provide deterministic data transfer in packet networks, e.g., in Layer 2 bridged networks
 - All the benefits of open IEEE SA standards
 - Standard Ethernet = IEEE Std 802.3
- **The Right Packet at The Right Time**
- Deterministic data packet delivery
Data packet delivery within a time window without loss or delay due to congestion or errors



Time-Sensitive Networking (TSN) Profiles (Selection and Use of TSN tools)

Audio Video Bridging
[802.1BA]

Fronthaul
[802.1CM/de]

Industrial Automation
[IEC/IEEE 60802]

Automotive In-Vehicle
[P802.1DG]

Aerospace Onboard
[IEEE P802.1DP / SAE AS6675]

Time synchronization:

Timing and Synchronization [802.1AS-2020]
(a profile of IEEE 1588)
Hot Standby [P802.1ASdm]
YANG [P802.1ASdn]
Inclusive Terminology [P802.1ASdr]
Support for half-duplex [P802.1ASds]
Optional Announce [P802.1ASeb]

TSN Components

(Tools of the TSN toolset)

Synchronization

Reliability

Latency

Resource Management

Zero congestion loss =
Bounded latency

High availability / Ultra reliability:

Frame Replication and Elimination [802.1CB]
Path Control and Reservation [802.1Qca]
Per-Stream Filtering and Policing [802.1Qci]
Hot Standby [P802.1ASdm]

Dedicated resources & API:

Stream Reservation Protocol [802.1Qat]
Link-local Registration Protocol [802.1CS]
TSN Configuration [802.1Qcc]
Foundational Bridge YANG [802.1Qcp]
YANG for CFM [802.1Qcx]
YANG for 802.1Qbv/Qbu/Qci [802.1Qcw]
YANG for CBS [P802.1Qdx]
YANG for MSTP [P802.1Qdy]
YANG for LLDP [802.1ABcu]
YANG for LAG [P802.1AXdz]
YANG & MIB for FRER [802.1CBcv]
Extended Stream Identification [802.1CBdb]
LLDPv2 for Multiframe Data Units [802.1ABdh]
Resource Allocation Protocol [P802.1Qdd]
TSN Configuration Enhancements [P802.1Qdj]
Multicast and Local Address Assignment [P802.1CQ]

Bounded low latency:

Credit Based Shaper [802.1Qav]
Frame Preemption [802.1Qbu & 802.3br]
Scheduled Traffic [802.1Qbv]
Cyclic Queuing and Forwarding [802.1Qch]
Asynchronous Traffic Shaping [802.1Qcr]
Shaper Parameter Settings [P802.1Qdq]
QoS Provision [P802.1DC]
Cut-Through Forwarding [P802.1DU]
Enhancements to CQF [P802.1Qdv]

require time sync

Note: A 'P' in front of '802.1' indicates an ongoing Project.

Q13: Scope of the Question

- Network synchronization and time distribution performance

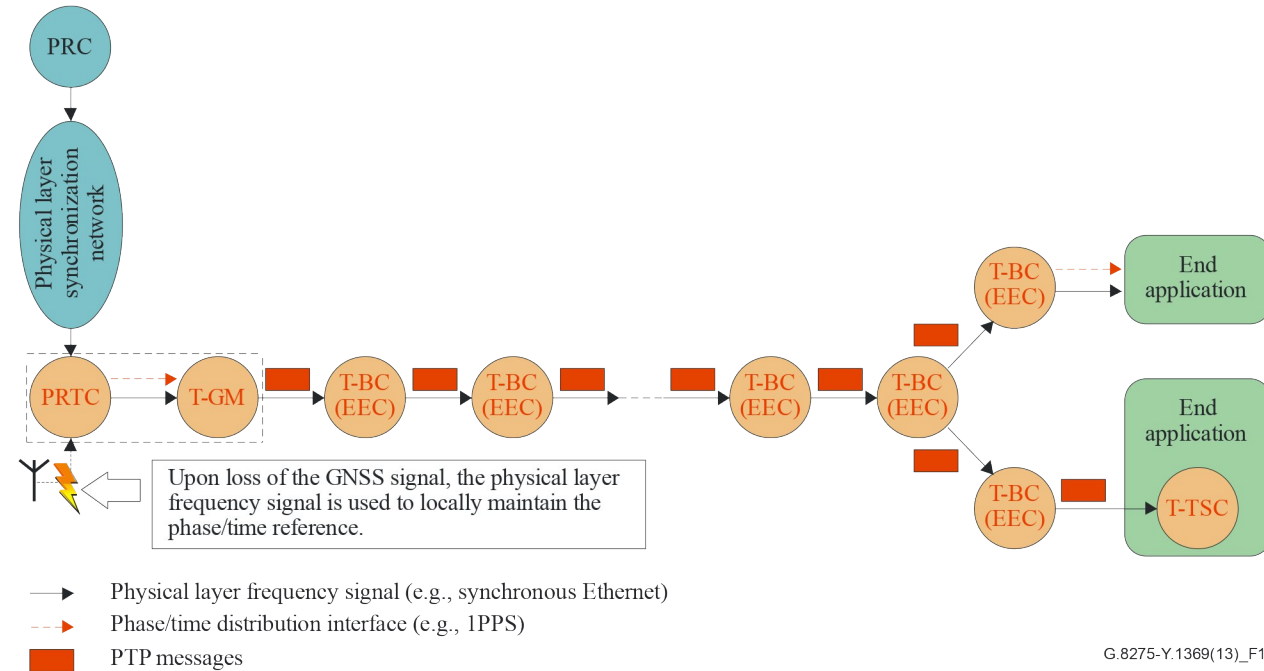
- Active since the 90s (sync for SDH in SG18)
- Networks Timing Needs (e.g., OTN, MTN)
- End Applications Timing Needs (e.g., 5G Base Stations)

- Distribution of Time-Phase and Frequency

- Methods (e.g., over physical layer, via packets, GNSS)
- Architectures
- Clocks
- PTP (IEEE 1588) profiles
- Performance, Redundancy, Reliability, etc.

- Networks

- Ethernet, IP-MPLS, OTN, xPON, MTN ...



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Cooperating with other Questions in SG15

Q11: sync for/over OTN , MTN

Q14: Sync Management

Q2, Q4: Sync in the access

Q6: sync over fibers

.. and SDOs (IEEE1588, 3GPP, O-RAN, etc.)

Outputs from Q13

- SDH and before packet timing:
 - G.803, G.810, G.811, G.812, G.813, G.823, G.824, G.825
- OTN: G.8251
- Enhanced Primary Reference Clocks: G.811.1
- Synchronization Layer Functions:
 - G.781, G.781.1
- Network requirements, Clocks, PTP Profiles
 - G.827x series (distribution of time synchronization)
 - G.826x series (distribution of frequency synchronization)
- Supplements :
 - G Suppl65 (simulations on timing transport),
 - G Suppl68 (synchronization OAM requirements)
 - G Suppl.DCSync (synchronization in datacentres) (recently approved)
- Technical Report:
 - GSTR-GNSS (Use of GNSS in Telecom)
 - GSTR-OCN (Optical clocks and their networking) (recently approved)

ITU Publications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation
ITU-T G.8273/Y.1368 (06/2023)


SERIES G: Transmission systems and media, digital systems and networks

Packet over Transport aspects – Synchronization, quality and availability targets

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet protocol aspects – Transport

Framework of phase and time clocks



IEEE
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