Standardization in ITU-T Study Group 15 and Q13/15

Networks, Technologies and Infrastructures for Transport, Access and Home:
Network synchronization and time distribution performance

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WSTS Tutorials

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Study Group 15 (SG15) mandate

2025-2028 Study Period

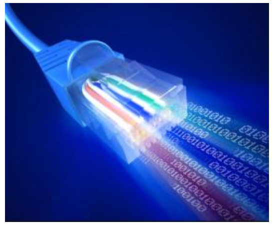
SG15 is the Lead Study Group on :

- **access network transport**
- **home networking**
- **optical technology**

Home Networking

Smart Grid

High Speed Access



Transport Technologies

The Optical Transport Network

✓ The LARGEST and MOST PRODUCTIVE group in ITU-T with broad, global industry participation

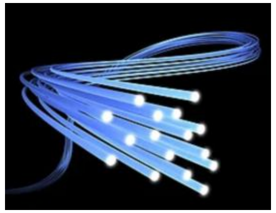
SG15 Working Parties (WPs)

- **WP1/15**: Transport aspects of access, home and smart grid networks
- **WP2/15**: Optical technologies and physical infrastructures
- **WP3/15**: Transport network characteristics

WP1 – Broadband Access

G.fastback — Multi-Gigabit copper backhaul

MGfast — Next generation copper access 5-10 Gbps



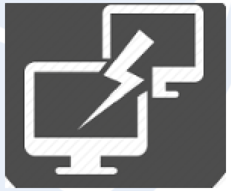
Optical systems for access networks
Bidirectional P2P
XGS-PON, HS-PON (50G)
TWDM-PON, TWLG-PON

Continue collaboration with broadband forum

G.RoF — PON support for mobile front/backhaul, Radio over fiber

High speed fibre-based in-premises transceivers (G.fin) for Fiber to the Room (FTTR)

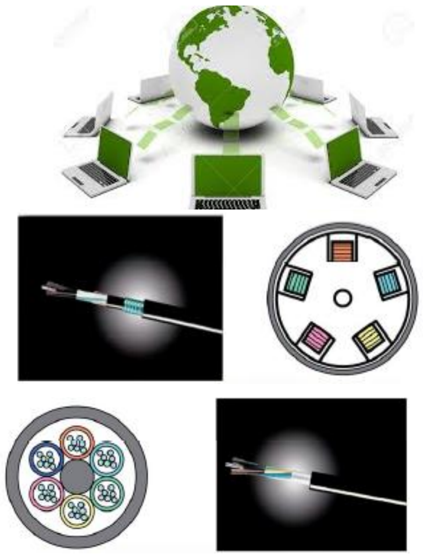
Free space optical home networking



Powerline communication (PLC)

G.Hn — G.hn and G.hn2 home networking over indoor phone, power, and coax wires >2 Gbps

WP2 – Optical Technologies



Optical Network Infrastructure

Optical Fibre Technologies and Cables for easy and environmentally friendly outside plants

L.pcc (Pre-connectorised cabling components)

Disaster Management issues

SMART submarine cables (G.SMART)

Space Division Multiplexing (SDM) for further high capacity

800G
B1T

G.fso (Free Space Optics)

G.dfos (Distributed Fibre Optic Sensing)

100G and future higher-rate coherent multi-vendor interoperable interfaces

Short-reach (OTN client) 200G and 400G interfaces reusing components developed for Ethernet applications

Note: G.SMART is now approved as G.9730.2

WP3 – Optical Transport Networks

Transport and synchronization supporting 5G mobile fronthaul and backhaul

MTN

G.83xx (metro transport network) for 5G optimized transport

Architecture and other Transport SDN Aspects

BEYOND
1 Tbit/s (B1T)

New “B1T” (Beyond 1 Tbit/s) OTN interfaces

Equipment & management specifications for OTN, Ethernet and MPLS-TP

Synchronization of packet Networks, MTN and future OTN networks, e.g., beyond 1 Tbit/s (B1T)

Network survivability (protection and restoration)

Management aspects of control and transport planes

Core Information model enhancement for management of synchronization and optical media

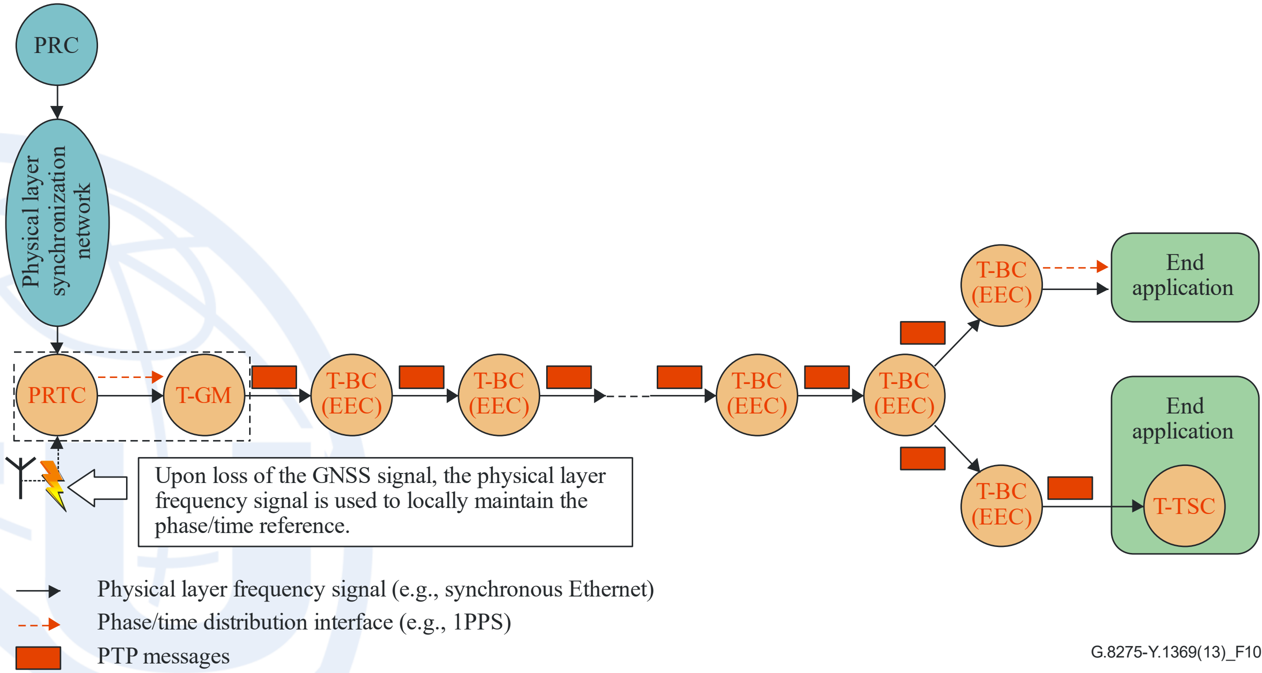
List of Questions (2025-28 Study Period)

Question Number	Question title
1/15	Coordination of Access and Home Network Transport Standards
2/15	Optical systems for fibre access networks (merging part of Q1/15)
3/15	Technologies for in-premises networking and related access applications (merging part of Q1/15)
4/15	Broadband access over metallic conductors
5/15	Characteristics and test methods of optical fibres and cables, and installation guidance
6/15	Characteristics of optical components, subsystems and systems for optical transport networks
7/15	Connectivity, Operation and Maintenance of optical physical infrastructures
8/15	Characteristics of optical fibre submarine cable systems
10/15	Interfaces, interworking, OAM, protection and equipment specifications for packet-based transport networks
11/15	Signal structures, interfaces, equipment functions, protection and interworking for optical transport networks
12/15	Transport network architectures
13/15	**Network synchronization and time distribution performance**
14/15	Management and control of transport systems and equipment

WP 3 (Questions 10/15 – 14/15)

Q13: Scope of the Question

- **Network synchronization and time distribution performance**
  - Active since the 90s (sync for SDH in SG18)
  - Network timing needs (e.g., OTN, MTN)
  - End application timing needs (e.g., 5G Base Stations)
- Distribution of Time-Phase and Frequency
  - Methods (e.g., over physical layer, via packets, GNSS)
  - Architecture
  - Clocks
  - PTP (IEEE 1588) profiles
  - Performance, redundancy, reliability, etc.
- Networks
  - Ethernet, IP-MPLS, OTN, xPON, MTN ...



Cooperating with other Questions in SG15

Q11: sync for/over OTN , MTN

Q14: sync management

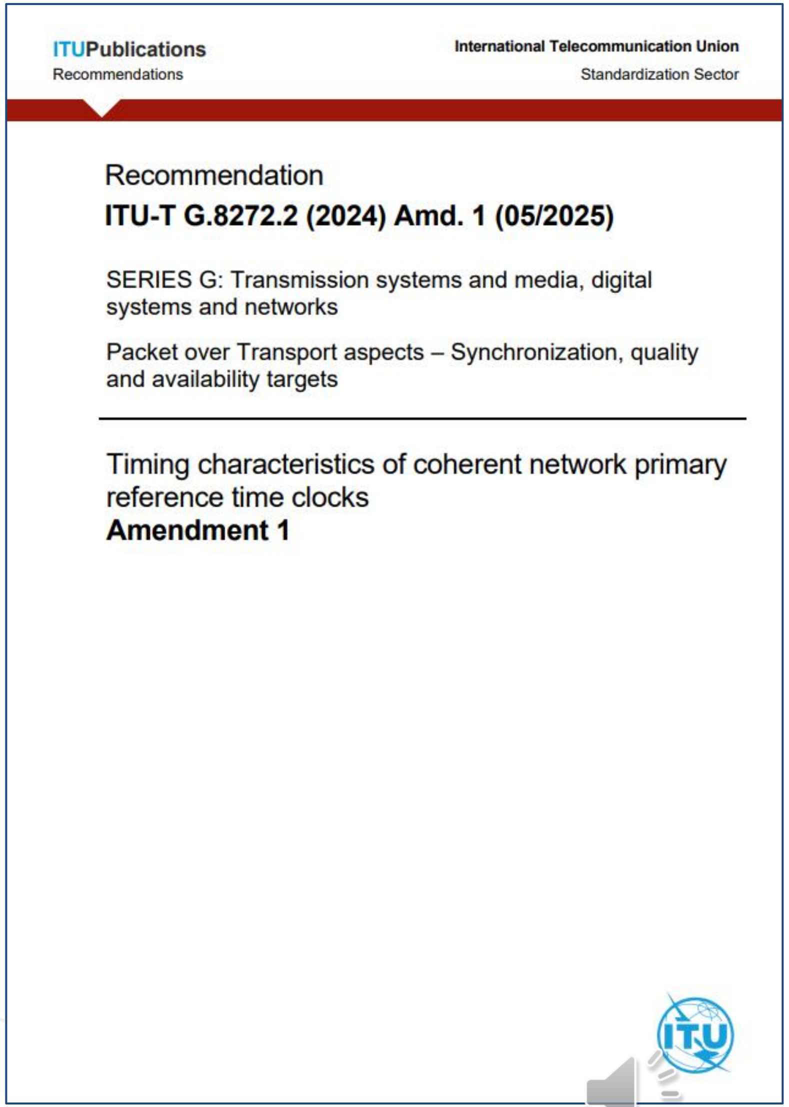
Q2, Q4: sync in the access

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.Suppl83 (full timing support options)
  - G Suppl.92 (synchronization for data centres)
- Technical Report:
  - GSTR-GNSS (use of GNSS in telecom)
  - GSTR-OCN (optical clocks and their networking) (work in progress)


ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation
ITU-T G.8272.2 (2024) Amd. 1 (05/2025)

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

Packet over Transport aspects – Synchronization, quality and availability targets

Timing characteristics of coherent network primary reference time clocks
Amendment 1

Recent releases: Sync Architecture and Profiles

- Split between G.8275 and G.8274
  - G.8274 addresses the time sync architecture
  - G.8275 addresses the PTP functions common to multiple PTP profiles

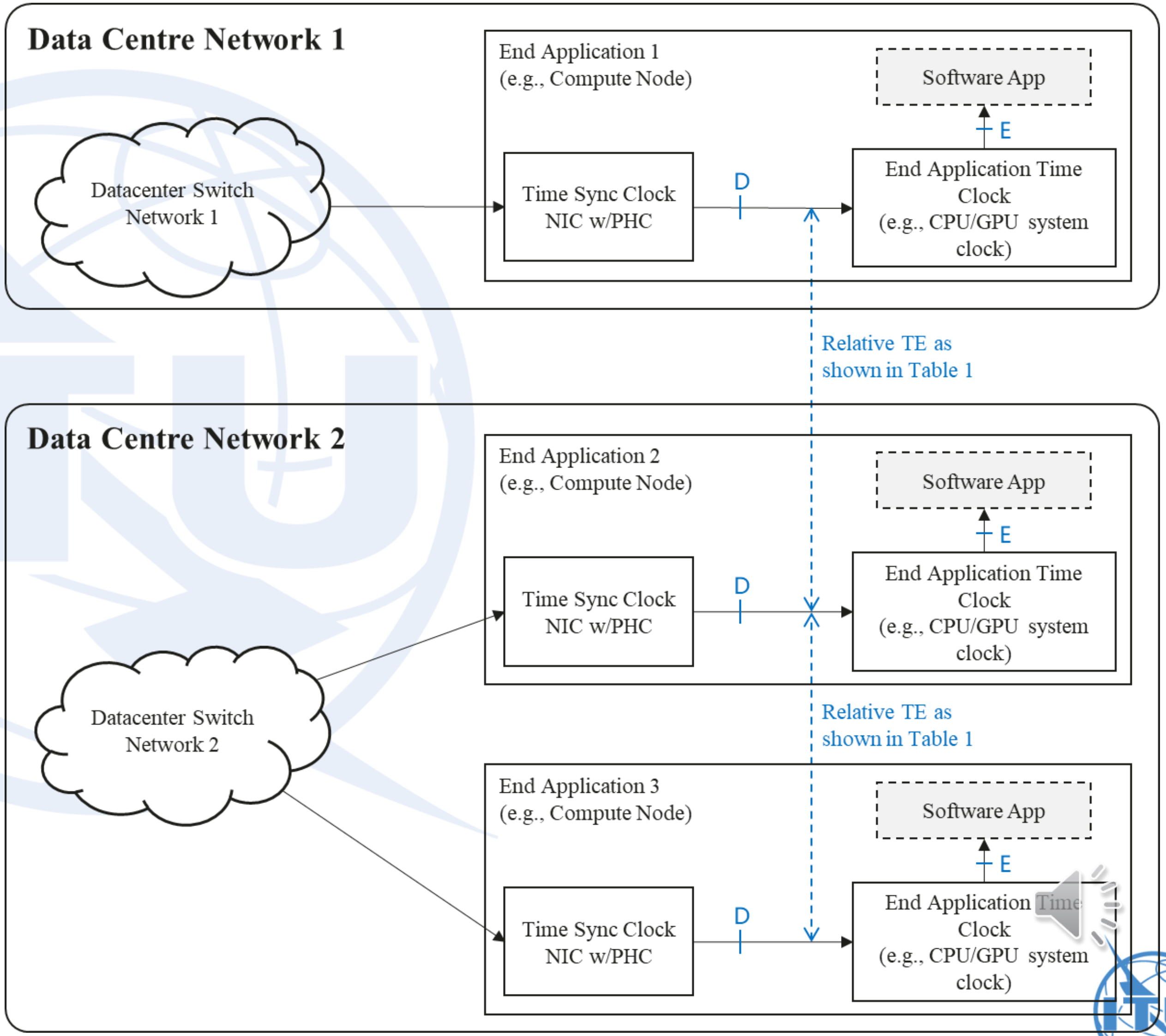
- Updates in PTP Profiles
  - New funtions such as WTR (wait-to-restore), holdover timers, sync as a service, etc.

Recent release: Synchronization in Data Centres

- Timing has become an important aspect for data centres (e.g., to control power consumption)
- G.Suppl.92 (Synchronization for Data Centres) released at last SG15 plenary:
  - Extension of ITU-T defined sync frameworks and profiles
  - Focus on sync technologies and methodologies that Q13 has developed in cooperation with IEEE 1588 and other relevant SDOs, to support data centre applications
- Work done in cooperation with the main groups addressing related items, mainly IEEE and OCP ("open compute project")

Synchronization in Data Centres

Accuracy Class level at Time Sync Clocks	Relative Time error requirements between Time Sync Clocks (Between Reference Points D, see Figure 2)	Typical applications (for information)
1	5 µs	Distributed databases, applications profiling
2	1 µs	High-Frequency Telemetry, Multi-node performance analysis tools
3	200 ns	Congestion control based on one way delay, Time synchronized collective communication



Ongoing Studies: Enhancements in timing solutions

- Enhanced Partial Timing Support ("ePTS")
  - Increased message rate (>128 packets per seconds)
  - Automatic asymmetry compensation via network management or local adjustments
- New Work Item on PRTC monitoring (G.Suppl-PRTC-Monitoring)
  - Including definition of datasets to monitor GNSS receivers
- Timing Resiliency

The Need for Increasing Resiliency

- Synchronization over the years has become a fundamental function for various critical infrastructure sectors (e.g., telecom, power grid, transportation, financial services). The consequences of disruption of timing can be very serious.
- GNSS has been the main technique used to deliver time sync, but its vulnerability raised increasing concerns. Common causes of GNSS disruptions:
  - GNSS segment errors, adjacent-band transmitters, GNSS spoofing, environmental interference, GNSS jamming
- Other threats exist in timing (e.g., at packet layer).
- These topics have been debated over several years at the major sync events and groups have started to address related solutions to increase resiliency to the timing solutions in the standards (e.g., IEEE P1952)
- The need for redundancy and robustness in sync in telecom has always been a major requirement. Now even more.
  - Q13/15 continues to add resiliency to the sync solutions being defined

Mapping with Resiliency Levels

Information based on P1952 draft					View on ITU-T specified Primary clock options								
IEEE P1952 Resilience Level related information				~~threat~~ Adversity duration time	PRTC			ePRTC-A			cnPRTC		Comments
					PRTC	PRTC with SyncE	ePRTC with UTC(k)	ePRTC	ePRTC with SyncE	ePRTC with UTC(k)	cnPRTC	cnPRTC with UTC(k)	
					1	2	3	4	5	6	7	8	
1	**Detect**	The ability to detect an adversity that might impact performance and generate an alert.	With the available on-board resources of the specific primary clock variants, resilience level 1 should be met without restrictions.		x	x	x	x	x	x	x	x	Internal supervison of sources (e. g. GNSS, PRC frequency, etc.)
	Alert												all ITU-T clock-internal measurement functions, raising events and alarms via TMN
2	**Recover**	The ability to automatically recover and operate normally after an adversity.	Resilience level 2 should be met without restrictions.		x	x	x	x	x	x	x	x	all ITU-T clocks do recover after the thread is over
3	**Resist**	The ability to operate during an adversity, perhaps with reduced performance, but still within specifications, for a specified length of time.	It is proposed to consider the maximal lenght of time for fulfillment of resilience level 3.	<= 1 day	x	x	x	x	x	x	x	x	Holdover based on own oscillator
				1 - 40 days (ePRC-A based)	-	**based on remote ePRC via SyncE**	**based on external UTC(k)**	x	**based on remote ePRC via SyncE**	**based on external UTC(k)**	x	**based on external UTC(k)**	As UTC(k) is out of the ITU-T clock domain, an agreement with UTC(k) provider is needed
				up to 1 year 1)	-			-			x		
4	**With-stand**	Withstand: The ability to operate during an adversity, perhaps with reduced performance, but still within specifications, ~~indefinitely~~ **w/o a finite time interval**	A ~~indefinitely~~ withstand w/o a finite time interval can be guarantied with usage of external UTC(k) only.		-	-	x	-	-	x	**x 2)**	x	
5	**Verify**	The ability to determine that information from a PNT source is accurate.			-	-	-	-	-	-	-	x	

1) This value is for information only, it depends on the number of involved ePRC clocks

2) Adversity is regional GNSS unavailability, minimum one cnPRTC clock combiner location with active GNSS

- Resilience Levels Appendix planned for G.8274
- The table maps clock variants to IEEE P1952 resilience levels.
  - It mainly addresses adversities related to GNSS interference (including jamming) and GNSS unavailability.

Summary

- Synchronization continues to be a fundamental function as networks and applications evolve
- Q13/15 expertise and technologies can play a key role to address network evolution and new challenges :
  - Increased resiliency (security, sync monitoring, holdover, etc.)
  - Emerging needs in mobile networks (e.g., 5G evolution towards 6G)
  - Support connected applications (industrial automation, data centres, etc.)
  - New applications with particularly stringent timing requirements (e.g., quantum key distribution (QKD))
  - Investigate new technologies (e.g., new work item on optical clocks)

[SG15 - Networks, technologies and infrastructures for transport, access and home (itu.int)]

[List of Questions and Rapporteurs (itu.int)]

SG15 Meetings

- Past meetings in the 2025-2028 Study Period
  - Geneva, March 2025
  - Geneva, October 2025
- Future Meetings in the 2025-2028 Study Period
  - Montreal, July 2026
  - Locations for 3 further meeting are to be confirmed (March 2027, October 2027, July 2028)
- Between Study Groups Meetings
  - Interim Meetings, Virtual Meetings, Correspondence activities, arranged by the Questions (Q13 usually meets face-to-face 4 times per year including the SG15 Plenary)

Getting Involved in Q13

- Q13 meets periodically , generally face-to-face (3-4 times per year), with eMeetings as needed
- Future Meetings :
  - Q13 Interim meeting (Paris, 23 - 27 March 2026)
  - SG15 Plenary (Montreal, 29 June – 10 July 2026)
- Where to find additional information (URL links):
  - SG15 Home Page: SG15 - Networks, technologies and infrastructures for transport, access and home (itu.int)
  - Q13/15 Terms of Reference: Text of the Question (itu.int)
  - How to become a member: Become a member- ITU/ UN Tech agency
  - Contacts:
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