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

Stefano Ruffini (Q13 Rapporteur)
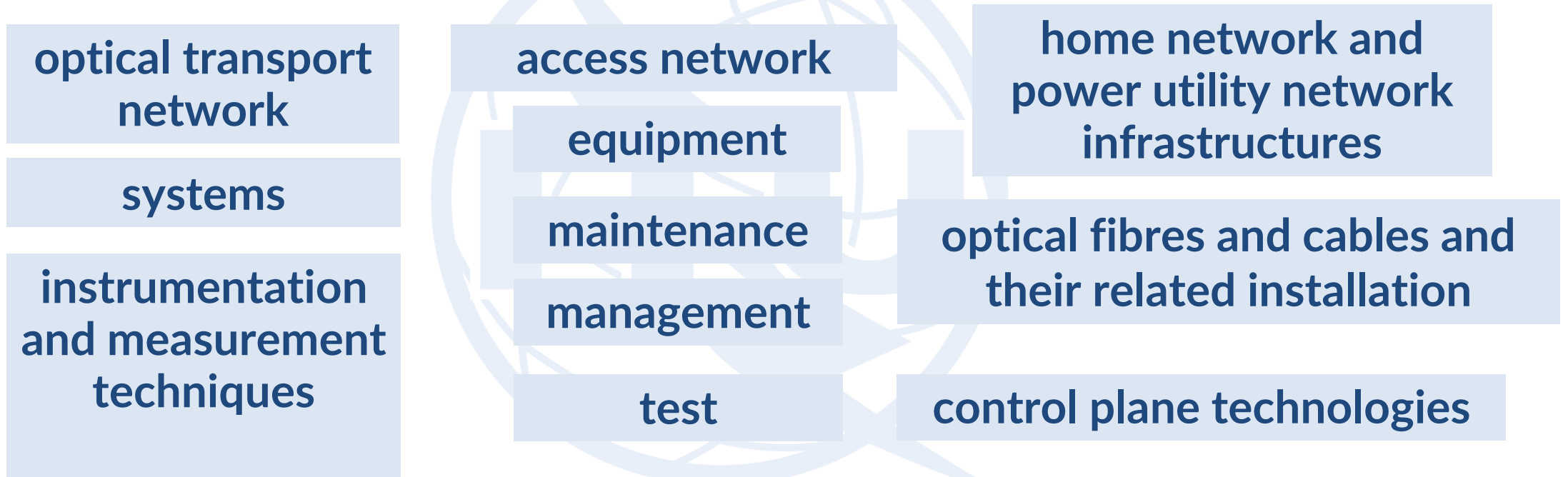*Silvana Rodrigues (Q13 Associate Rapporteur)*
Lee Cosart (Q13 Editor)

ITSF 2021 (1-4 November 2021), Brighton (UK)

Study Group 15 (SG15) mandate

SG15 is responsible for the development of standards on:

optical transport network

access network

home network and power utility network infrastructures

systems

equipment

maintenance

optical fibres and cables and their related installation

instrumentation and measurement techniques

management

test

control plane technologies

to enable the evolution toward intelligent transport networks, including the support of smart-grid applications.

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.FAST — Broadband access up to 2 Gbps

G.mgfast — Next generation G.fast targeting 5-10 Gbps

DTA — G.fast dynamic time assignment (DTA) – downstream/upstream bit-rates responsive to customer traffic

Continue collaboration with **broadband forum**

G.RoF — Radio over fiber for mobile fronthaul

Optical access — Higher Speed 50G-PON, Multi-Wavelength 25G/10G-PON NG-PON2 (40G), XG(S)-PON (10G)

Visible Light Communication for home networking

G.Hn — G.hn (-1 G) and G.hn2 (-10G) home networking over indoor phone, power, and coax wires

FTTR — Fibre to the room (FTTR)

Powerline communication (PLC)
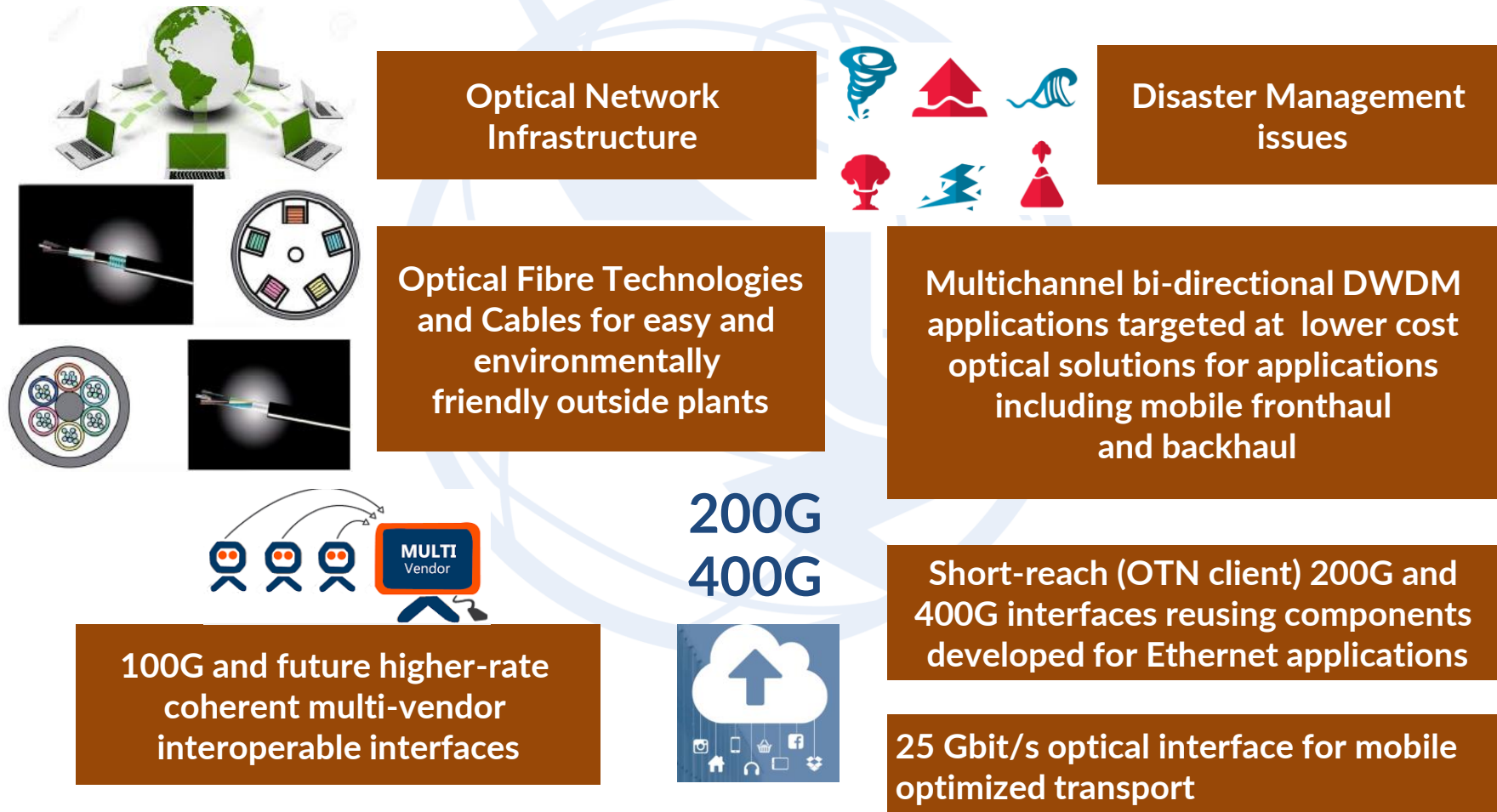
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WP2 – Optical Technologies

Optical Network Infrastructure

Disaster Management issues

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

Multichannel bi-directional DWDM applications targeted at lower cost optical solutions for applications including mobile fronthaul and backhaul

200G
400G

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

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

25 Gbit/s optical interface for mobile optimized transport

WP3 – Optical Transport Networks

Transport and synchronization supporting 5G mobile fronthaul and backhaul

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

Architecture and other Transport SDN Aspects

New "B100G" OTN interfaces, including the use of coherent G.698.2 interfaces

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

Synchronization of packet networks and future OTN networks, e.g., beyond 100G

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

New number	Question title	Status
1/15	Coordination of Access and Home Network Transport Standards	Continued
2/15	Optical systems for fibre access networks	Continued
4/15	Broadband access over metallic conductors	Continued
5/15	Characteristics and test methods of optical fibres and cables, and installation guidance	Continuation of Question 5/15 and part of Question 16/15
6/15	Characteristics of optical components, subsystems and systems for optical transport networks	Continued
8/15	Characteristics of optical fibre submarine cable systems	Continued
10/15	Interfaces, interworking, OAM, protection and equipment specifications for packet-based transport networks	Continued
11/15	Signal structures, interfaces, equipment functions, protection and interworking for optical transport networks	Continued
12/15	Transport network architectures	Continued
13/15	Network synchronization and time distribution performance	Continued
14/15	Management and control of transport systems and equipment	Continued
16/15	Connectivity, Operation and Maintenance of optical physical infrastructures	Continuation of part of Question 16/15 and Question 17/15
18/15	Technologies for in-premises networking and related access applications	Continued

WP 3 { 10/15, 11/15, 12/15, 13/15, 14/15 }

SG15 Meetings

- Past meetings since 2017
  - Geneva, 19 – 30 June 2017
  - Geneva, 29 January – 9 February 2018
  - Geneva, 8-19 October 2018
  - Geneva, 1 – 12 July 2019
  - Geneva, 27 January – 7 February 2020
  - "e-meeting", 7-18 September 2020
  - "e-meeting", 12-23 April 2021

- Future Meetings
  - "e-meeting", 6-17 December 2021

2017- ...
Study Period

- Interim Meetings, Correspondence activities, arranged by the Questions

Q13: Scope of the Question

- **Network synchronization and time distribution performance**
  - Active since the 90s (sync in SDH) (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 ...
- Cooperating with other Questions
  - Q11: sync for/over OTN , MTN
  - Q14: Sync Management
  - Q2, Q4: Sync in the access

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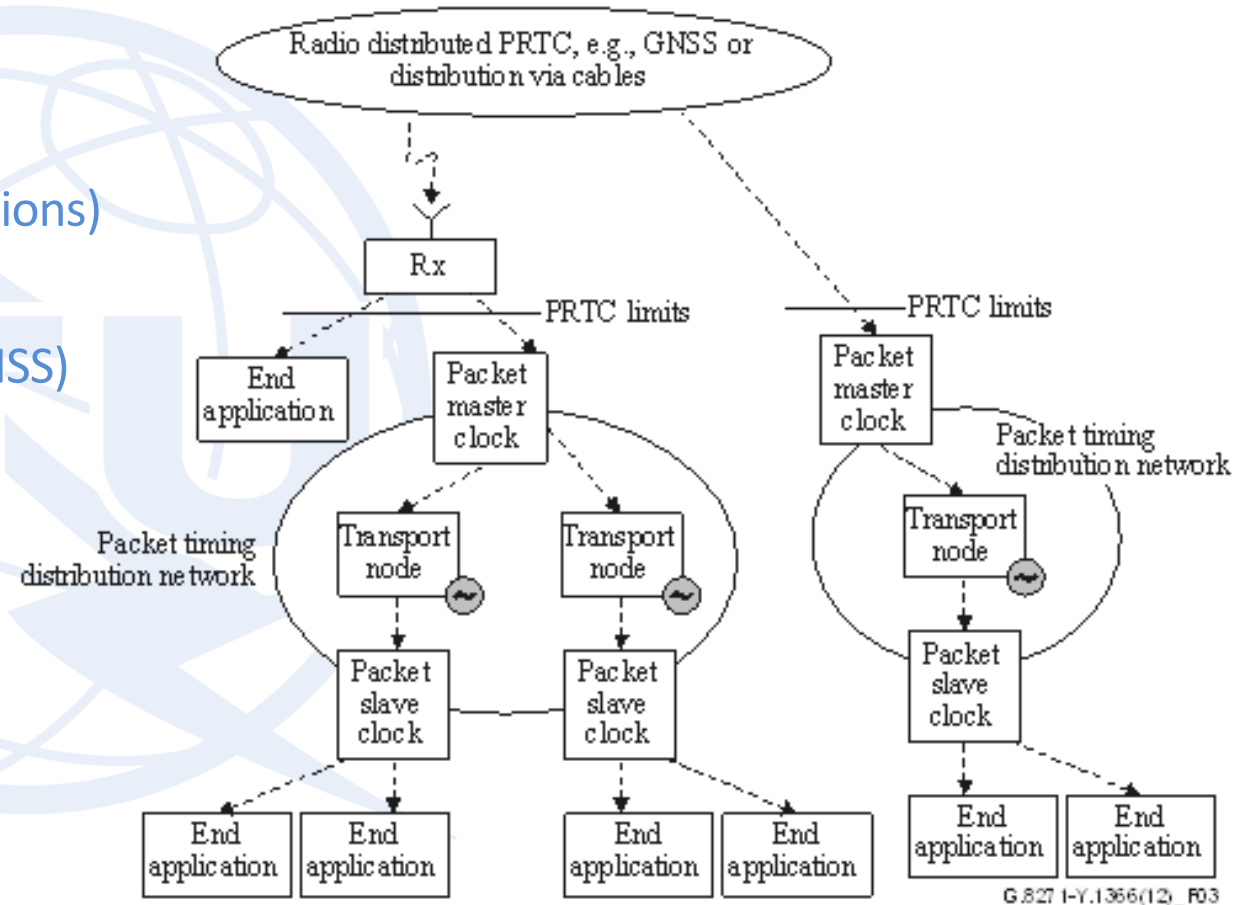
Outputs from Q13

- «Historical» (G.803, G.810, G.811, G.812, G.813, G.823, G.824, G.825…); G.811.1 , enhanced PRC, recently released

- G.781, G.781.1 (Sync Layer Functions)

  - G.826x series (distribution of **frequency synchronization**): *Network requirements, Clocks, PTP Profiles*
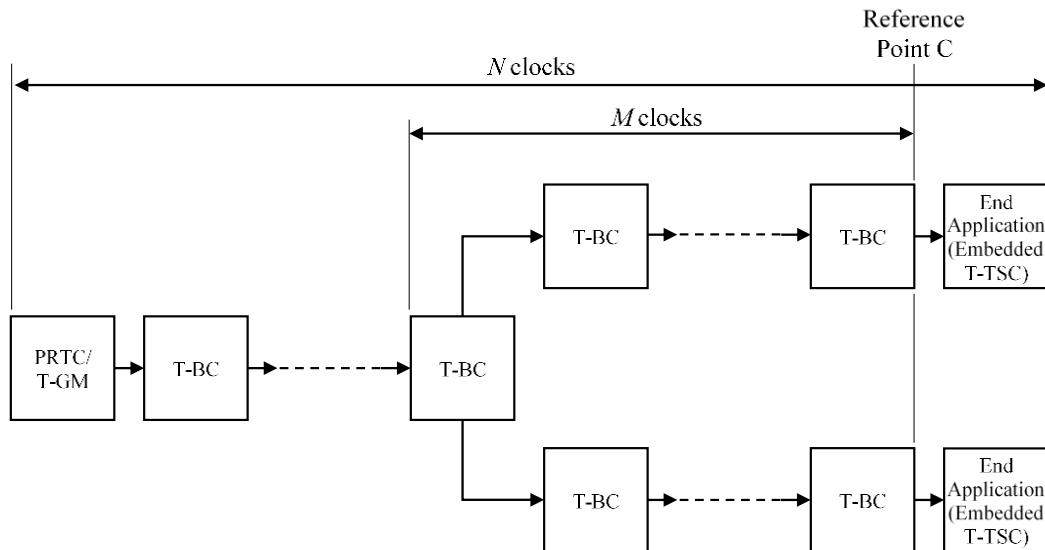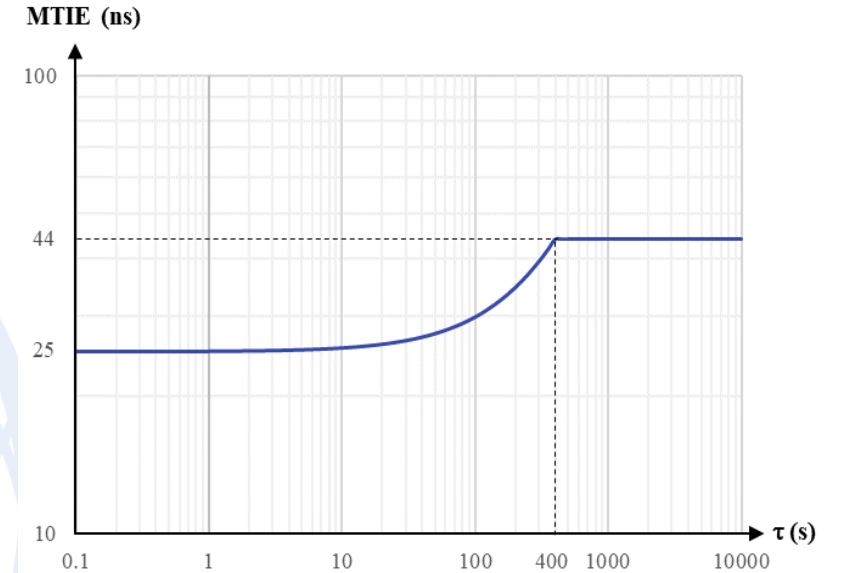
  - G.827x series (distribution of **time synchronization**): *Network Requirements, Clocks, PTP Profiles*

Supplements : G.Suppl65, G.Suppl68
Technical Report: GSTR-GNSS

# Example output from Q13: Fronthaul
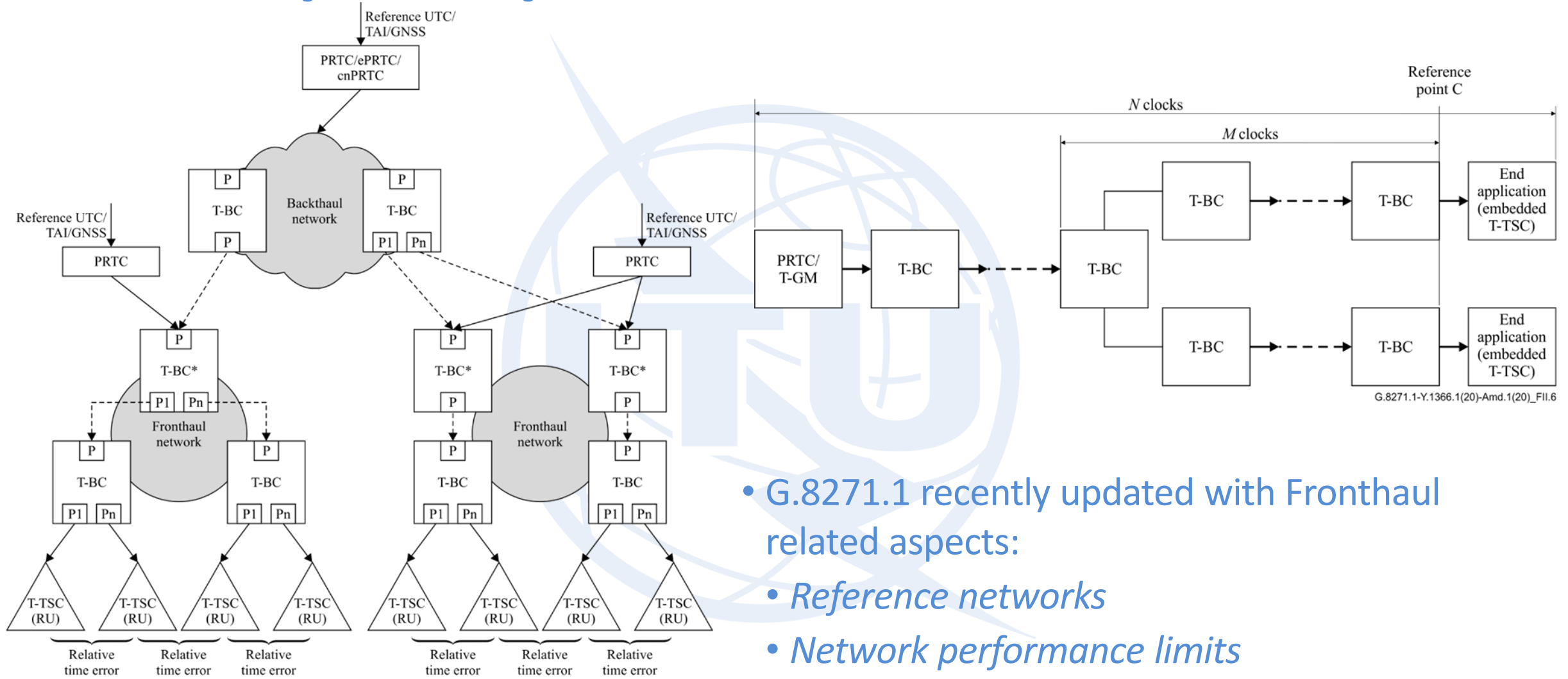
Case 2.1: Downstream T-BC located at the top of the fronthaul network connects to more than one T-BC through multiple ports.
NOTE – * In some cases, CU/DU could be co-located or integrated into the same equipment as the T-BC.

Case 2.2: Downstream T-BC located at the top of the fronthaul network connects to only one T-BC through a single ports.
NOTE – * In some cases, CU/DU could be co-located or integrated into the same equipment as the T-BC.

G.8271.1-Y.1366.1(17)-Amd.2(19)_FXII.4

G.8271.1-Y.1366.1(20)-Amd.1(20)_FII.6

- G.8271.1 recently updated with Fronthaul related aspects:
- *Reference networks*
- *Network performance limits*
- *Guidelines for Network design and for measurement of the network limits*

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Ongoing Studies: Packet Sync Aspects

- PTP Profile evolution (e.g., IEEE1588-2019 recently added)
- Ongoing work on Profile Interworking (G.8275)
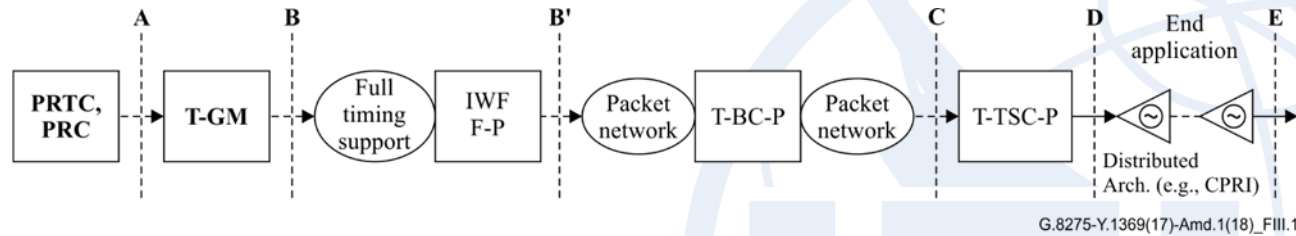
- Ongoing work on packet-based sync layer functions (G.781.1)

Example of series of packet-based synchronization distribution network connections transporting PRTC-quality timing reference information (G.781.1)
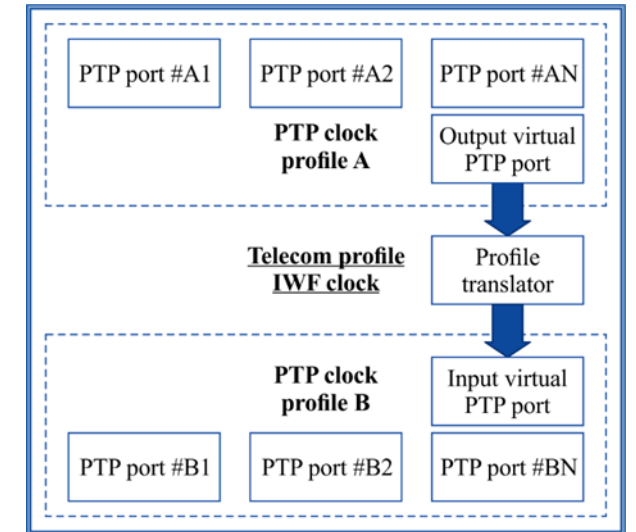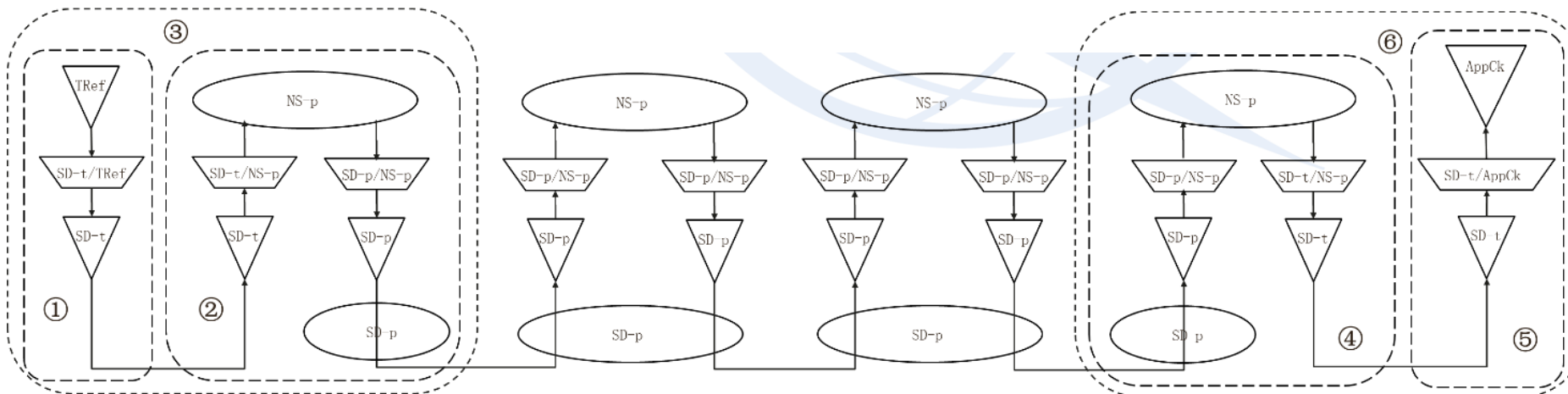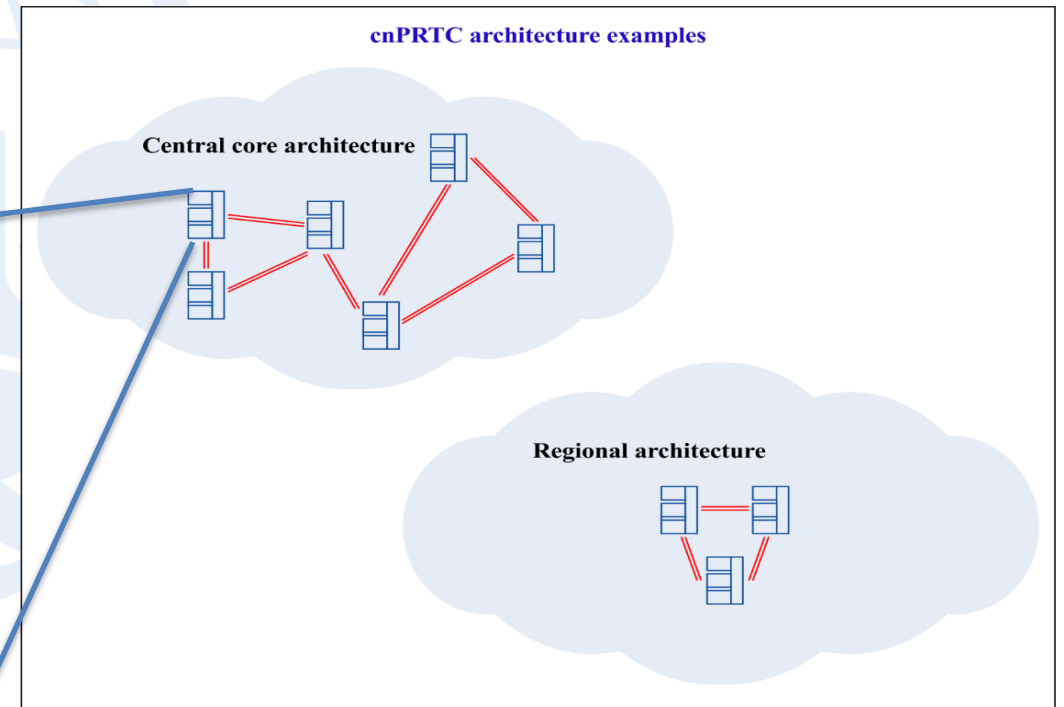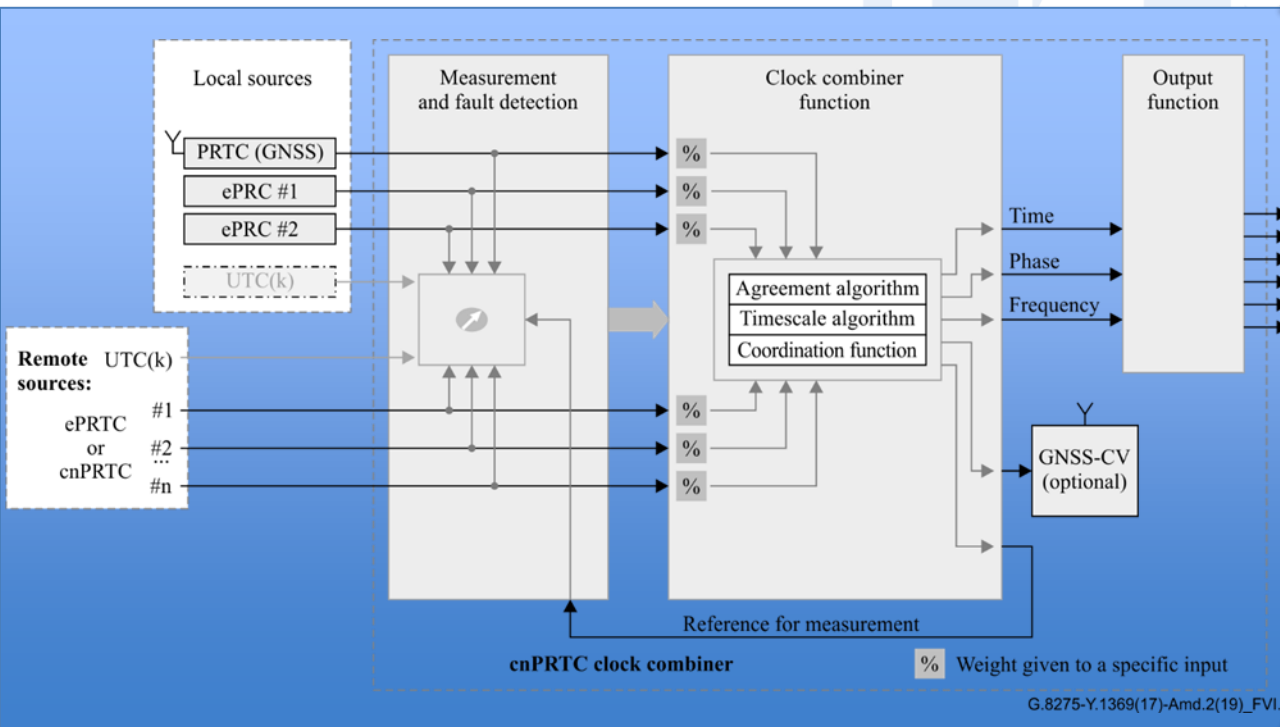
Ongoing Studies: work on cnPRTC

- cnPRTC (Coherent PRTC):
  - PRTCs network at the highest core or regional network level to maintain network-wide ePRTC time accuracy, even during periods of GNSS loss
- Network Requirements
- Methods (high accuracy profile?)
- Clock Recommendation ?

High-accuracy time transfer class	Maximum absolute time error – max$\|TE_L\|$ (ns)
A	5 ns
B	1 ns

cnPRTC architecture examples

Central core architecture

Regional architecture

G.8275-Y.1369(17)-Amd.1(18)_FVI.1

Local sources

Y PRTC (GNSS)
ePRC #1
ePRC #2
UTC(k)

Measurement and fault detection

Clock combiner function

Agreement algorithm
Timescale algorithm
Coordination function

Output function

Time
Phase
Frequency

Remote sources:
UTC(k)
ePRTC or cnPRTC #1
#2
...
#n

GNSS-CV (optional)

Reference for measurement

cnPRTC clock combiner
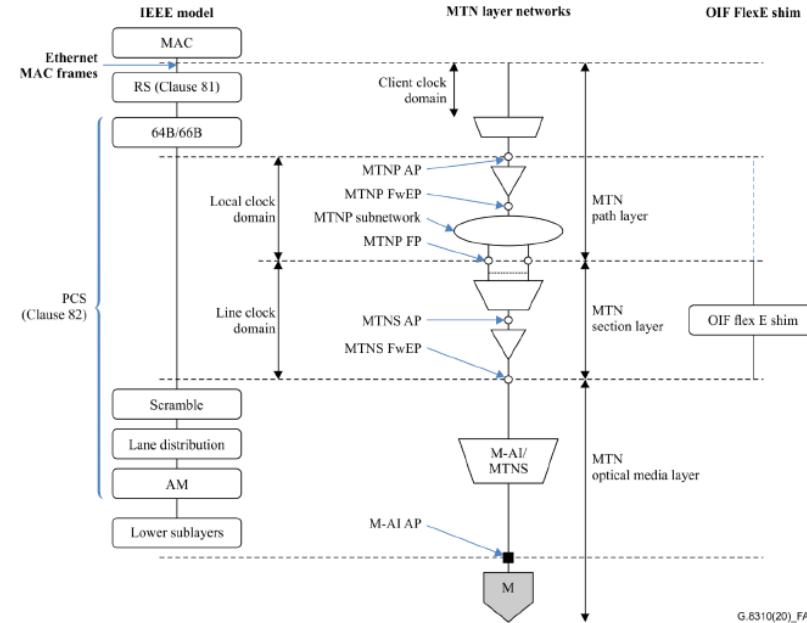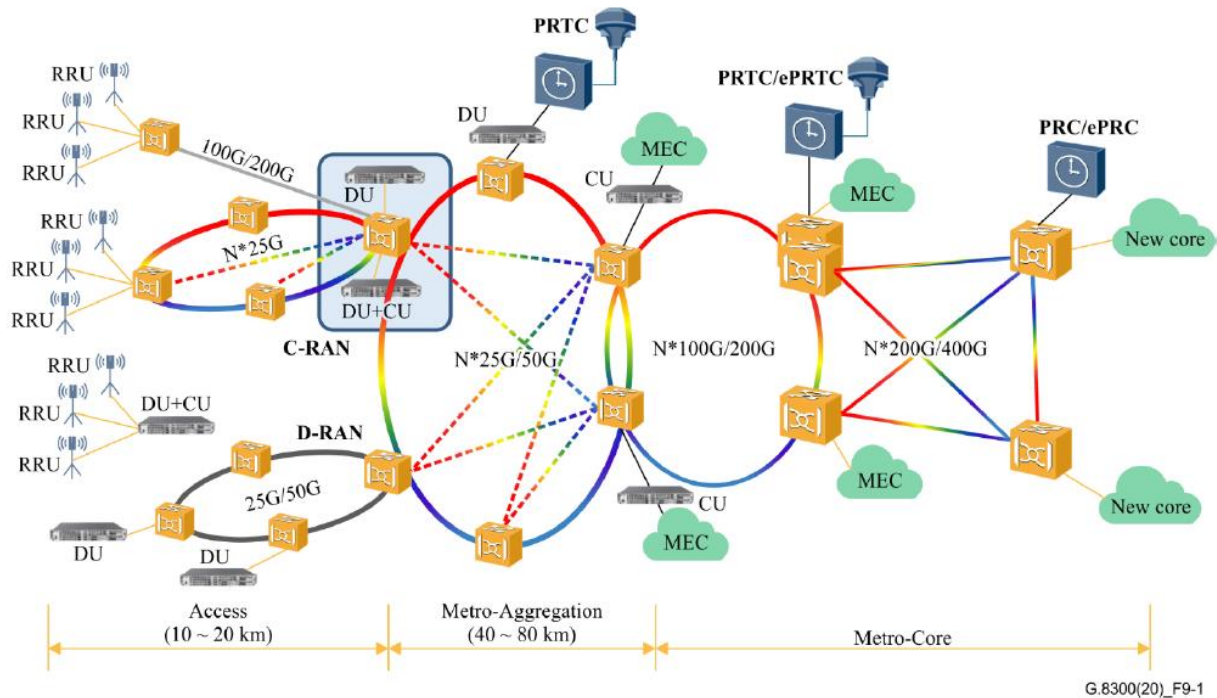
% Weight given to a specific input

G.8275-Y.1369(17)-Amd.2(19)_FVI.3

Ongoing Studies: MTN (Metro Transport Network)

- Metro Transport Network:
  Layer one transport network for 5G
  Transport Technology specified in G.8312

- *G.mtn-sync* under development, to address the related Sync aspects :
  Sync Requirements
  Sync Architecture
  PTP and syncE distribution
  Clocks

- Reference to existing
  Q13 Recommendations as applicable

Future Items ?

- Synchronization expected to continue as a fundamental function as networks and applications evolve
- Among new items that may be studied by Q13 in the future :
  - Address Emerging needs in mobile networks (e.g., 5G evolution) and connected applications (e.g., Industrial Automation)
  - Provide support for enhanced synchronization network management and monitoring
  - Provide support for enhanced security solutions
  - Continue to enhance Robustness and reliability in the network synchronization solutions (e.g., as related to GNSS backup synchronization references)
  - Address the needs of new applications with particularly stringent timing requirements (e.g., quantum key distribution (QKD) related applications has been mentioned).