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

Network synchronization and time distribution

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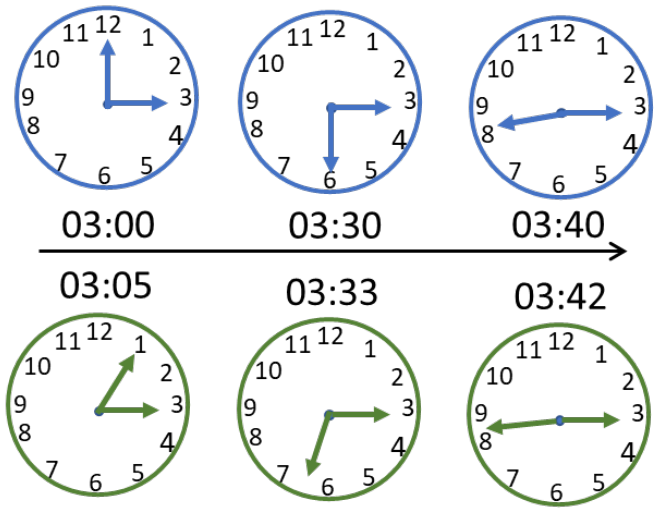
Agenda

- Synchronization Fundamentals
- The need for synchronization
- ITU-T Q13 Synchronization
  - ITU-T G.8275.1
  - ITU-T G.8275.2
  - Q13 ongoing Studies
  - Q13 new studies
- Conclusion

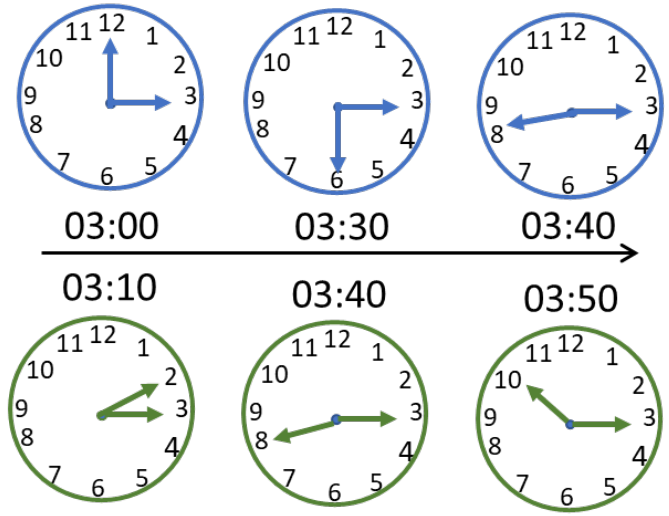
Synchronization Fundamentals

Time vs Frequency

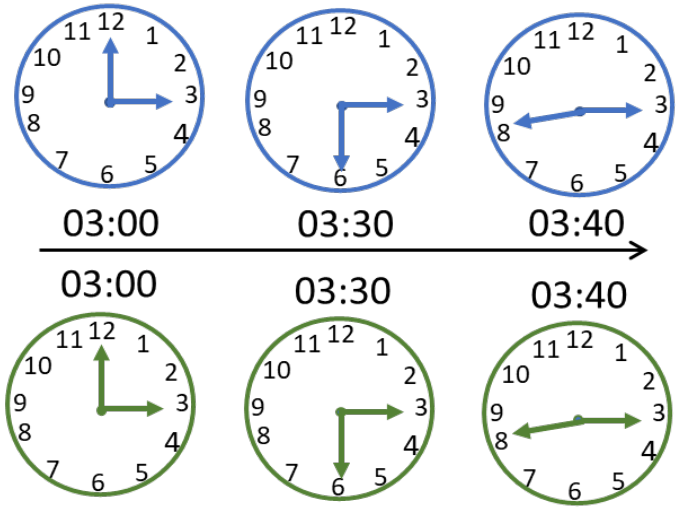
Not Synchronized



Frequency Synchronized (Syntonized)

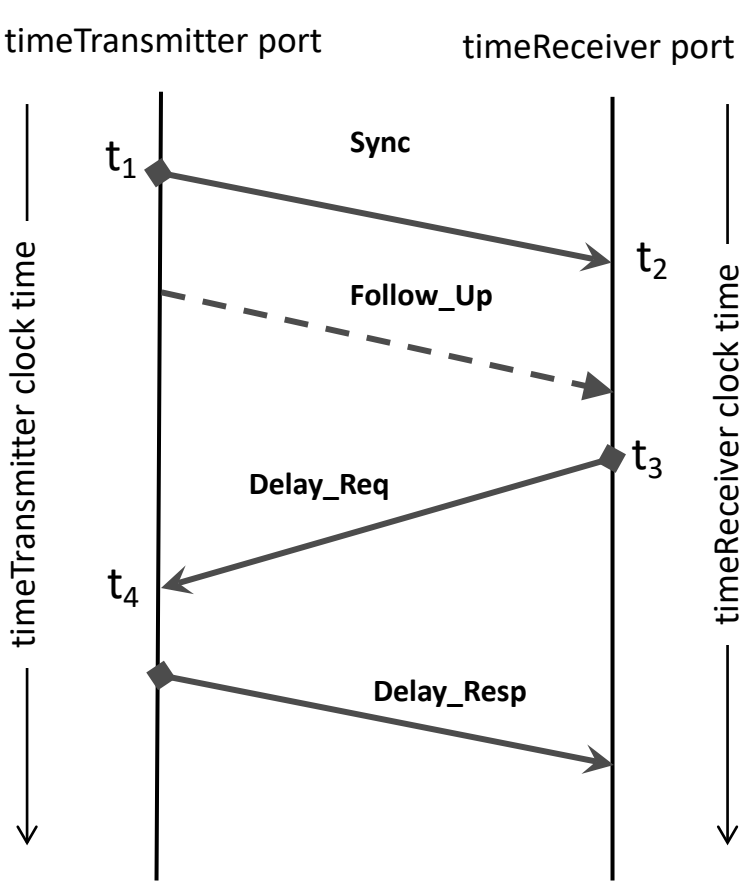


Time/Phase/Frequency Synchronized



Credits: **F**igures based on book «Synchronous Ethernet and IEEE 1588 in Telecoms: Next Generation Synchronization Networks» (Wiley, 2013, ISBN: 978-1-848-21443-9)

Packet layer transport of Synchronization (IEEE 1588 Precision Time Protocol (PTP))



Timestamps known by

one-step clock	two-step clock
t_1, t_2	t_2
	t_1, t_2
t_1, t_2, t_3	t_1, t_2, t_3
t_1, t_2, t_3, t_4	t_1, t_2, t_3, t_4

Offset:
(timeReceiver clock error and one-way path delay)
$Offset_{SYNC}$ = t2 – t1
$Offset_{DELAY\_REQ}$ = t4 – t3

We assume path symmetry, therefore
Mean Path Delay = [(t2 - t1) + (t4 - t3)] ÷ 2

timeReceiver Clock offset = [(t2 - t1) - (t4 - t3)] ÷ 2

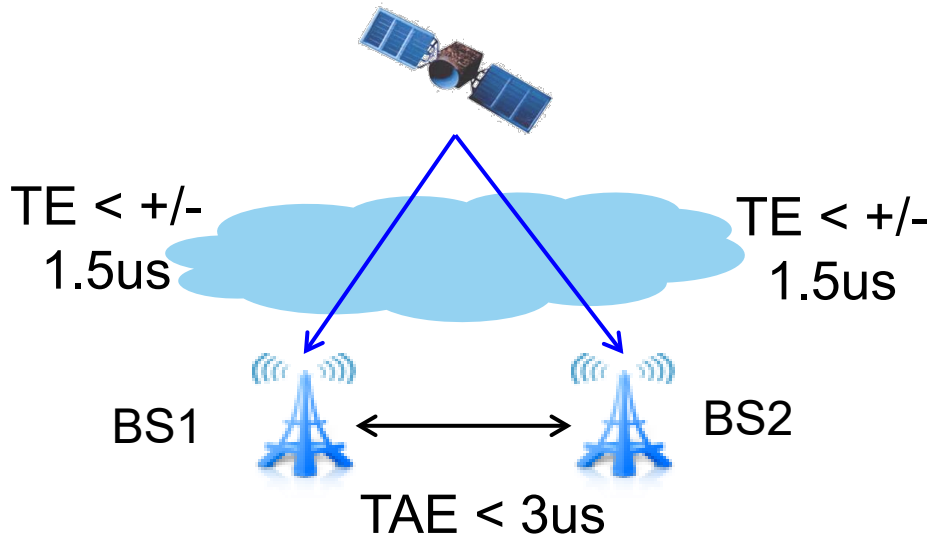
Notes:

1. One-way delay cannot be calculated exactly, but there is a bounded error.
2. The protocol transfers TAI (Atomic Time).
   UTC time is TAI + leap second offset from the *announce* message.

The need for Synchronization

Synchronization in 5G

- Synchronization is vital for the operation of telecom networks
  - 3GPP defines time requirements for the base stations

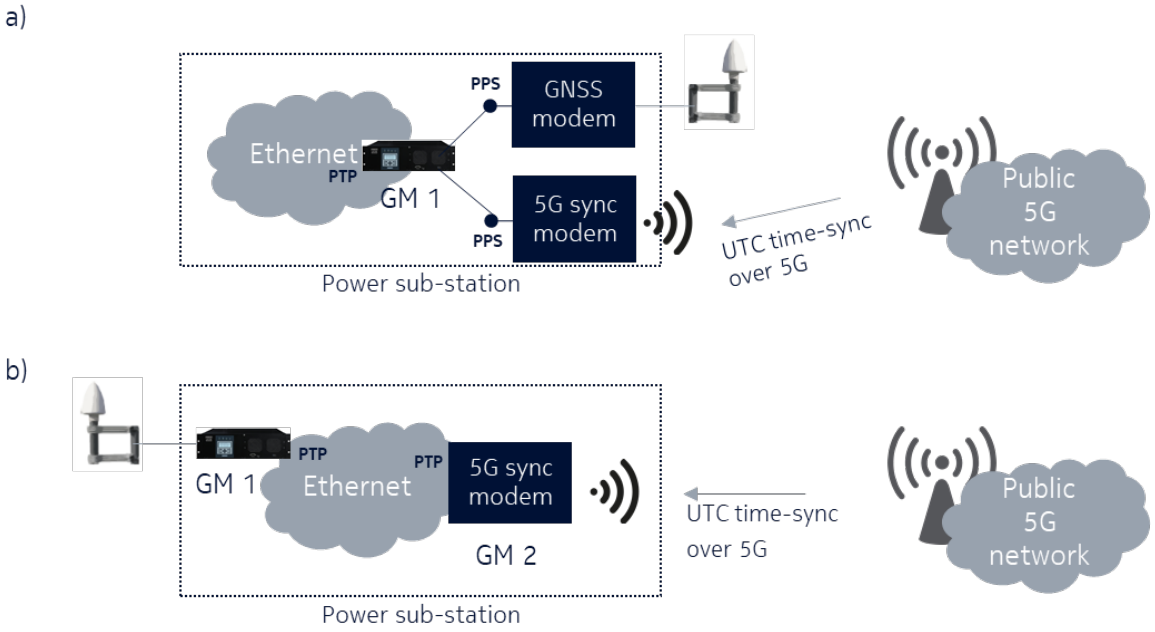


Need for Resiliency

- GNSS is widely used today as a source of timing (either local reference or distributed via PTP)
  - Widely used to synchronize critical infrastructure (Telecom, Power, Media broadcast, etc.)
- Vulnerable signal: jamming, spoofing
- Request from the users to enhanced resilience:
  - Better Holdover
  - Alternative sources

3GPP: Timing Resiliency in 5G Networks

- New requirements from 3GPP related the 5G Timing Resiliency applications (TS 22.261, TR 22878)
  - Timing over 5G used as back – up (or primary reference) for connected devices
- Example Applications: Power Grid, Trading, etc.
- Ongoing study item on monitoring and reporting for timing synchronization status in the 5G system (TR 23.700-25)

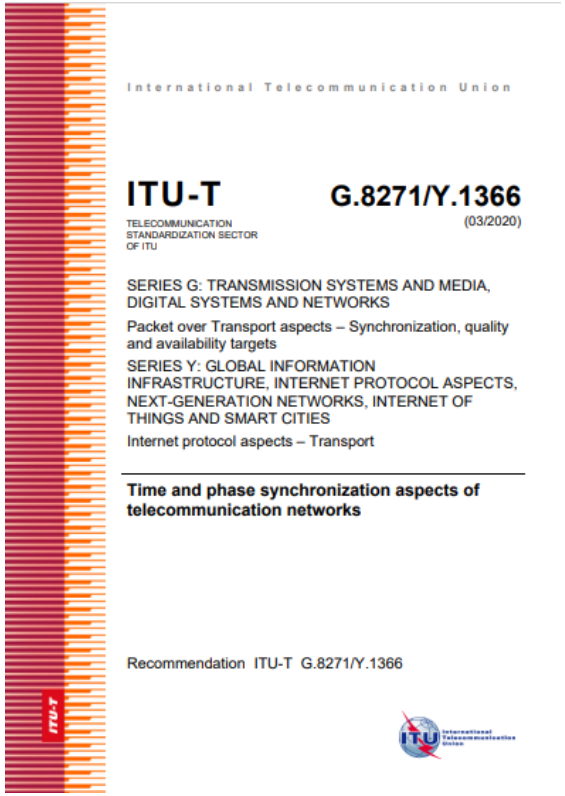


From TR 22.878 Figure 4.1.3-2:
5G integration into system – resilience and alternative mode

ITU-T Q13 Synchronization

Outputs from Q13

- Several Recommendations with clear requirements for Synchronization
- 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
- Sync Layer Functions: G.781, G.781.1
- 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


International Telecommunication Union

ITU-T G.8271/Y.1366
(03/2020)

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

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

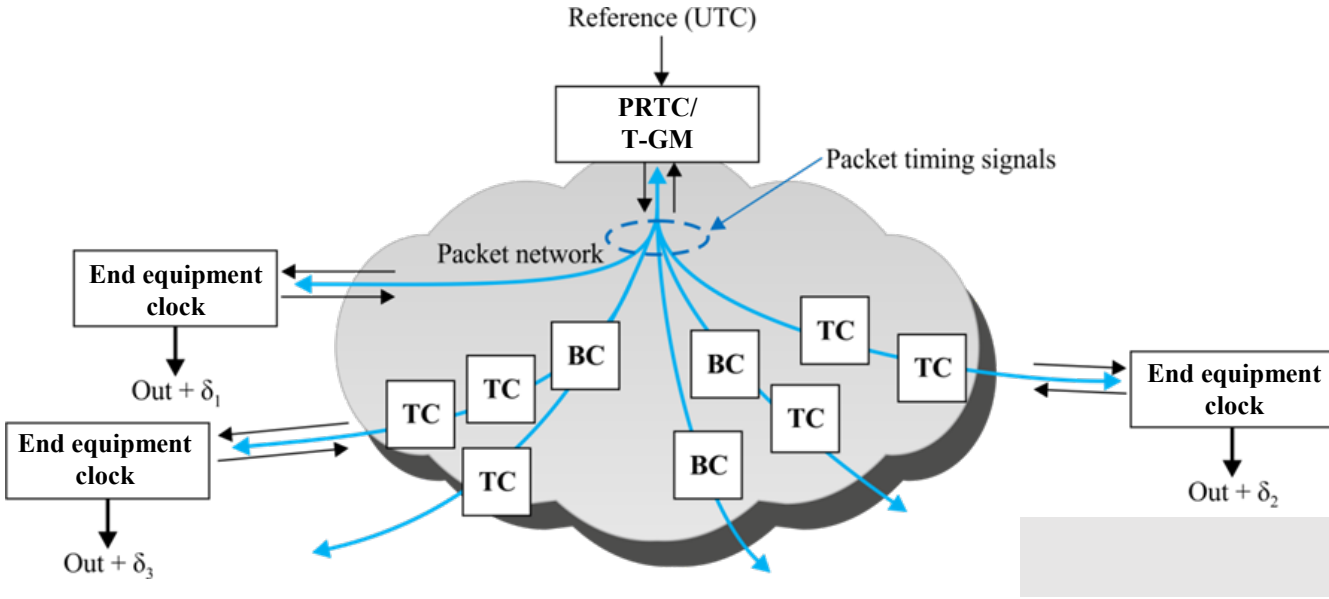
Internet protocol aspects – Transport

Time and phase synchronization aspects of telecommunication networks

Recommendation ITU-T G.8271/Y.1366

ITU-T G.8275.1
IEEE-1588 with full timing support (FTS) from Network

- Profile for applications that need accurate phase/time synchronization
- Based on the full timing support from the network (i.e., Telecom Boundary Clocks (T-BCs) and Telecom Transparent Clocks (T-TCs) are used in every node)
- Several ITU-T Recommendations, G.827x series, G.781.1, have been developed to support FTS phase/time synchronization



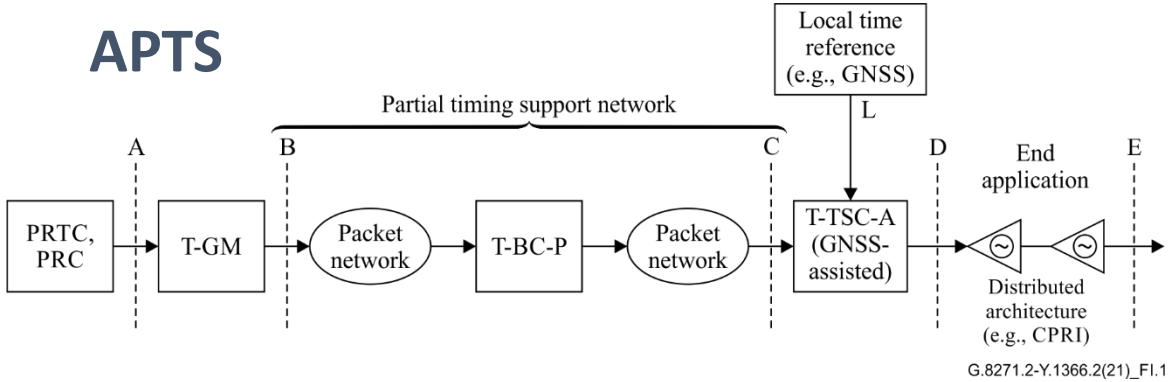
PRTC	Primary Reference Time Clock
BC	Boundary Clock
TC	Transparent Clock

ITU-T G.8275.2 IEEE-1588 without timing support from Network

- Assisted Partial Timing Support (APTS) – GNSS is co-located with the T-TSC-A
  - PTP is used as a backup for GNSS failures
- Partial Timing Support (PTS) – without the GNSS co-located with T-TSC-P
  - Only PTP is used for timing
- Several ITU-T Recommendations, G.827x series, G.781.1, have been developed to support phase/time synchronization for PTS/APTS

PRC	Primary Reference Clock
T-GM	Telecom Grandmaster
T-BC-A	Telecom Boundary Clock – Partial Support
T-BC-P	Telecom Boundary Clock – Partial support
T-TSC-A	Telecom Time Synchronous Clock – Assisted

APTS



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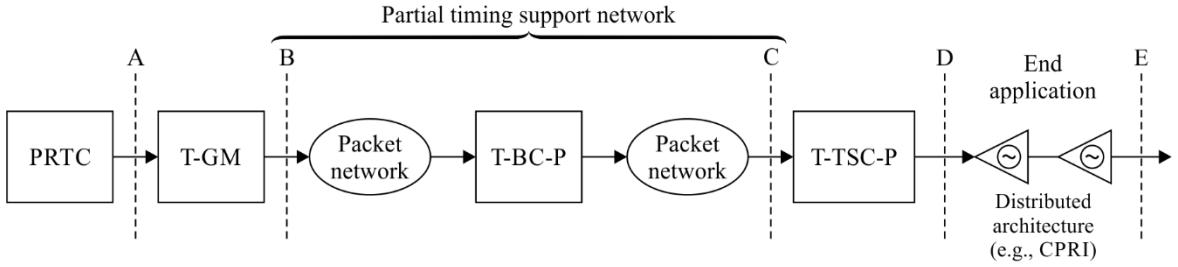
PTS



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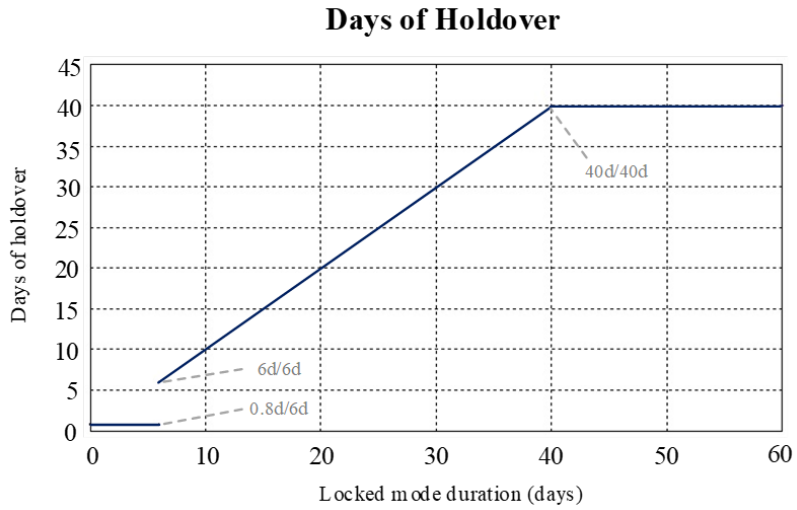
Q13 Ongoing Studies

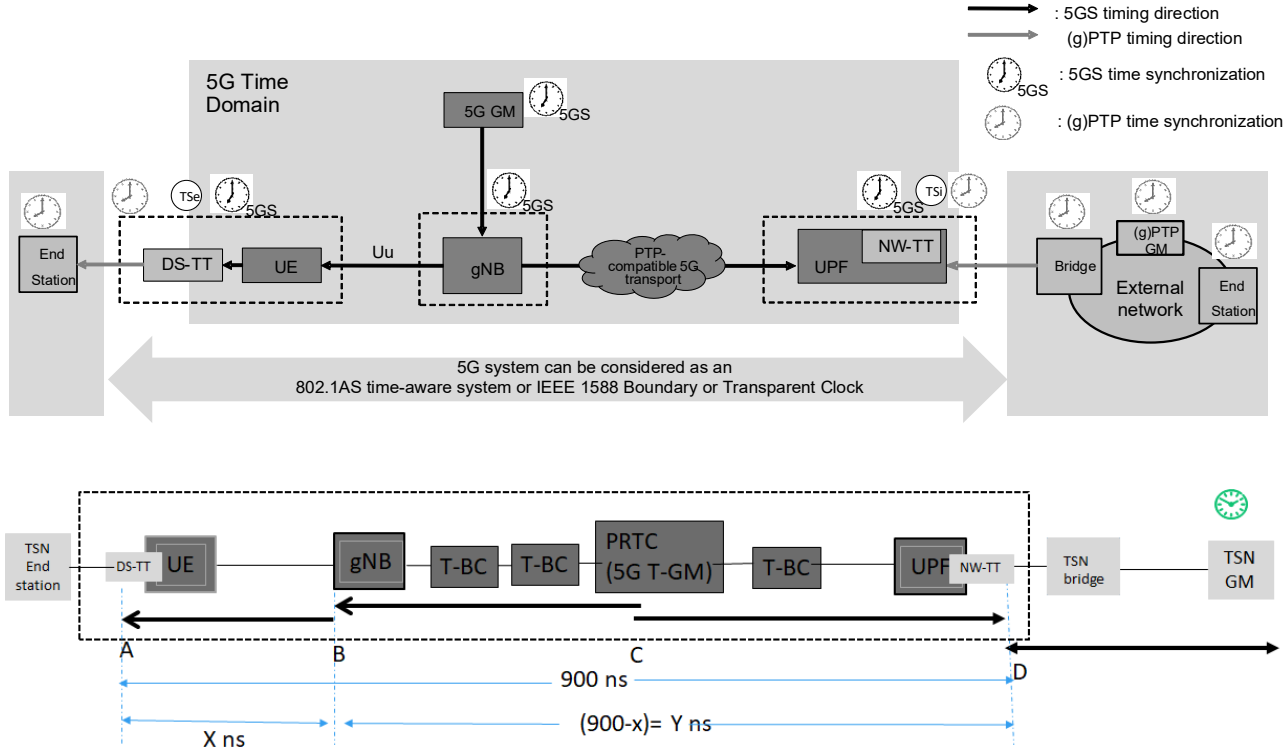
- PTP Profiles evolution
- MTN (Metro Transport Network)
  - Layer one transport network for 5G Transport technology specified in the G.83xx series
- Enhanced Primary Reference Time Clock (ePRTC)
- cnPRTC (Coherent PRTC)



From ePRTC G.8272.1 draft

Q13 New Studies: 5G integration with Industrial Automation ?

- Q13 is starting to consider the impact from integration of 5G with Industrial Automation application
- Liaison exchanged with 3GPP last year to understand the impact on current time sync architecture



Conclusion

- Synchronization continues to be a fundamental function as networks and applications evolve
- Among new items being studied or that may be considered in Q13 for the future :
  - Emerging needs in mobile networks (e.g., 5G evolution) and connected applications
  - Support for enhanced synchronization network management and monitoring
  - High accuracy timing over pluggable optical modules
  - Support for enhanced security solutions
  - Continue to enhance robustness and reliability in the network synchronization solutions
  - Timing resiliency over 5G
  - “Time Transfer Overlay Network” – new timing technique for a partial timing support via very high timing message rate
  - Needs of new applications with particularly stringent timing requirements (e.g., quantum key distribution (QKD) related applications)