

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

Network synchronization and time distribution

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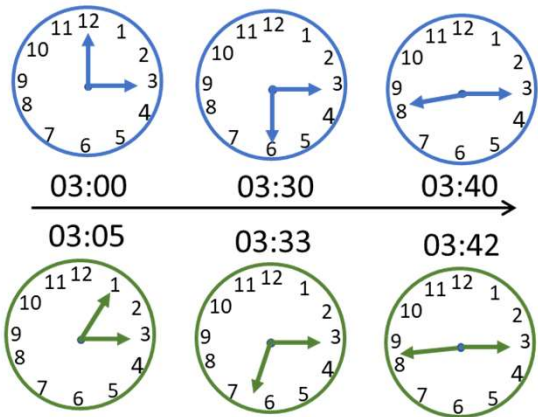
Agenda

- 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

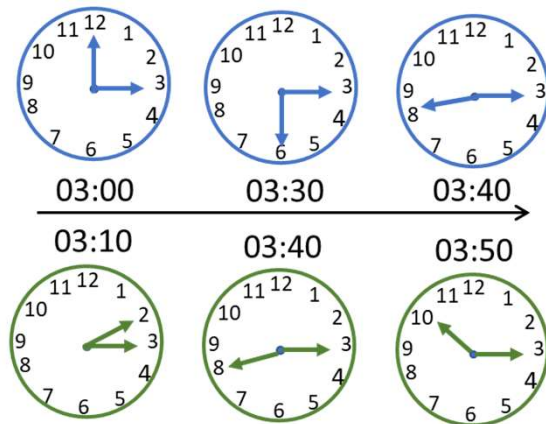
Synchronization Fundamentals

Time vs Frequency

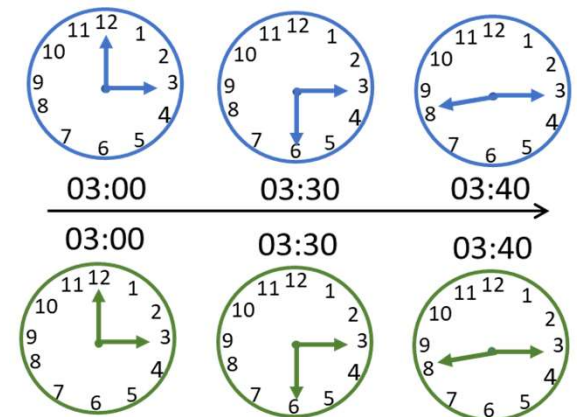
Not Synchronized



Frequency Synchronized (Syntonized)

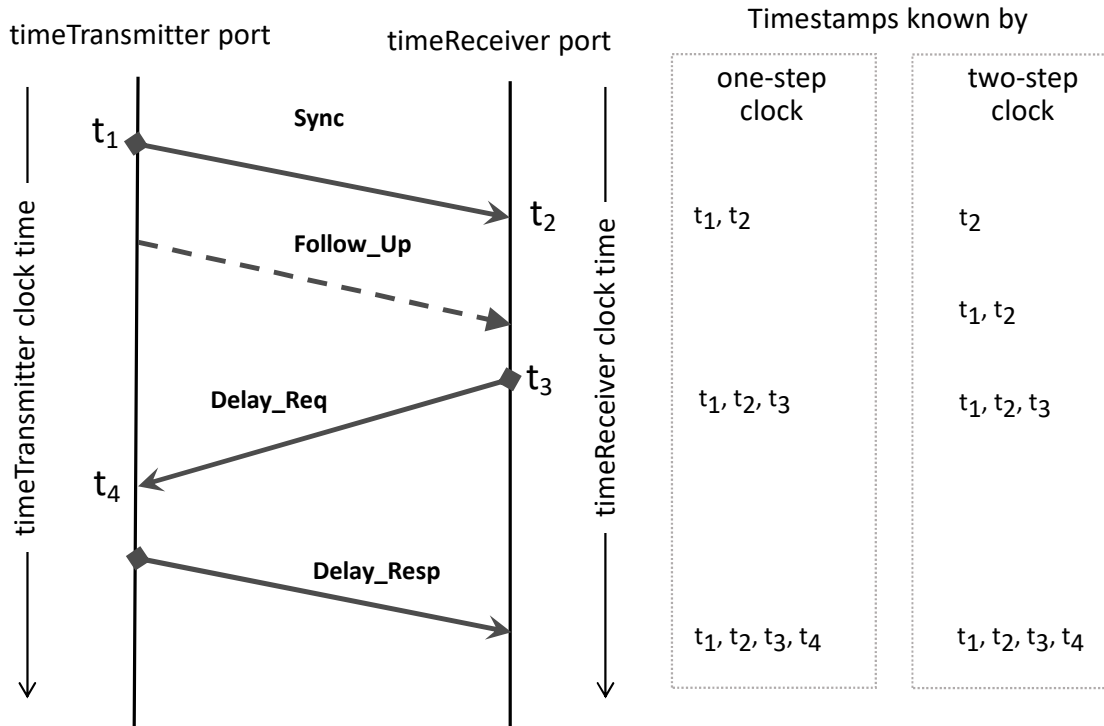


Time/Phase/Frequency Synchronized



Credits: Figures 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))



Offset:

(timeReceiver clock error and one-way path delay)

$$\text{Offset}_{\text{SYNC}} = t_2 - t_1$$

$$\text{Offset}_{\text{DELAY_REQ}} = t_4 - t_3$$

We assume path symmetry, therefore

$$\text{Mean Path Delay} = [(t_2 - t_1) + (t_4 - t_3)] \div 2$$

$$\text{timeReceiver Clock offset} = [(t_2 - t_1) - (t_4 - t_3)] \div 2$$

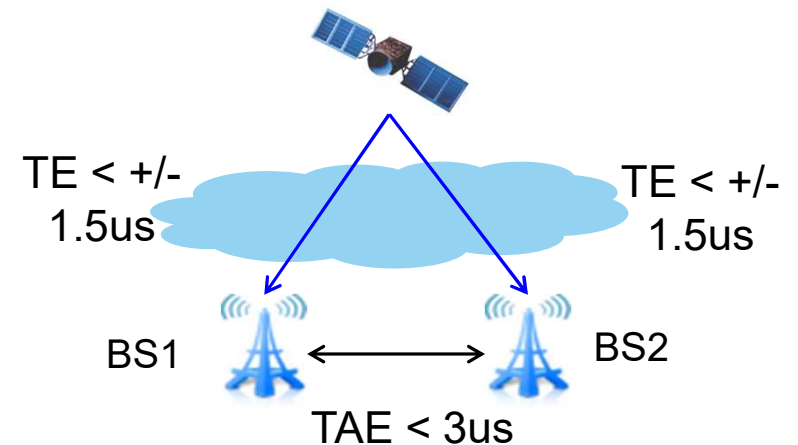
Notes:

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

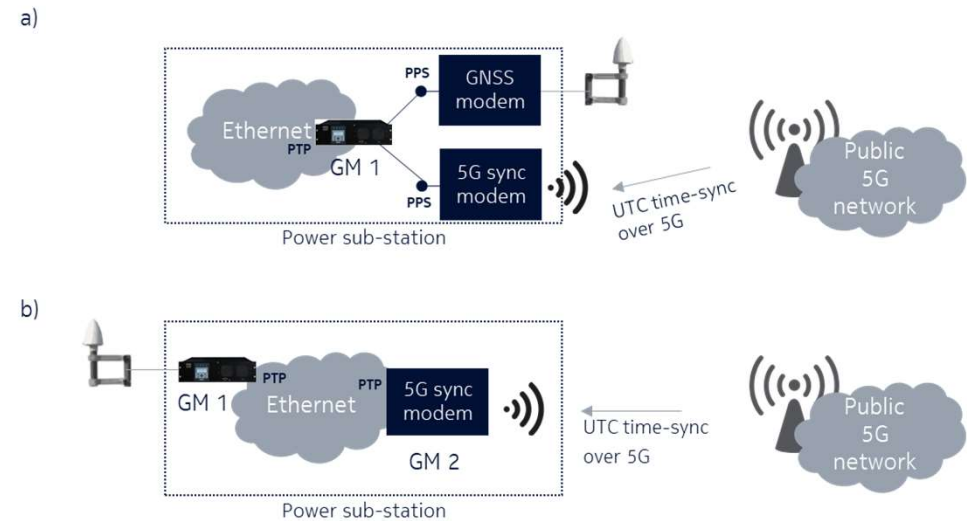


Need for Resiliency

- 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)

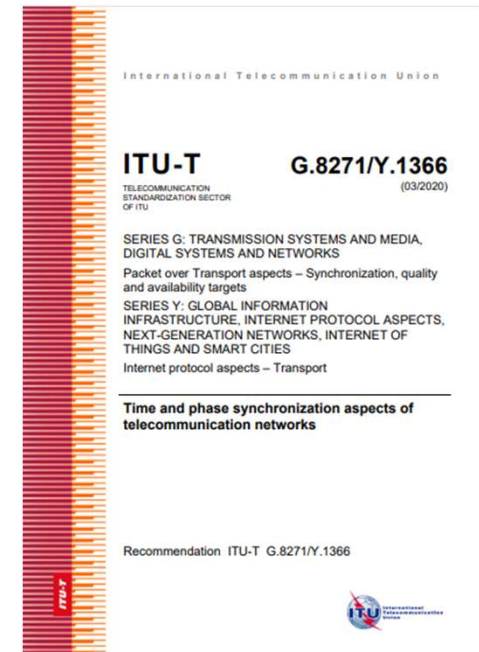


**From TR 22.878 Figure 4.1.3-2:
5G integration into system – resilience and alternative mode**

ITU-T Q13 Synchronization

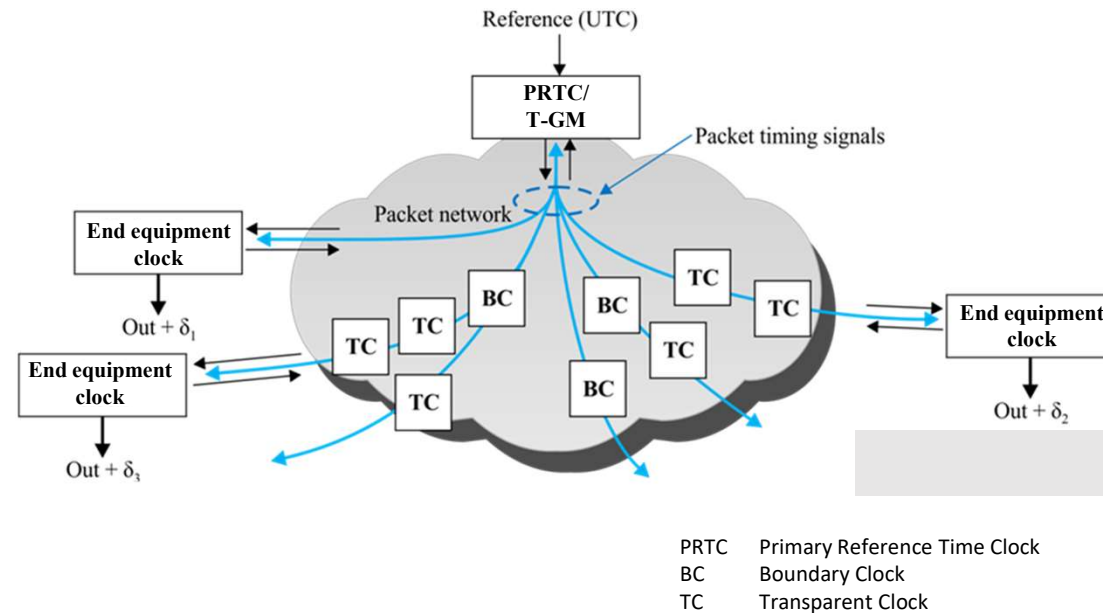
Outputs from Q13

- 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



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

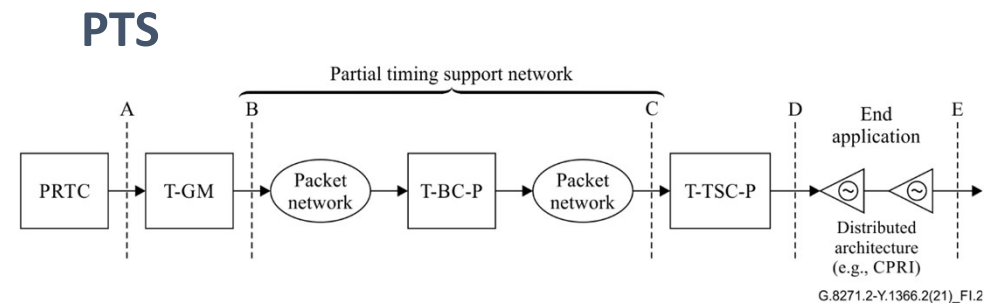
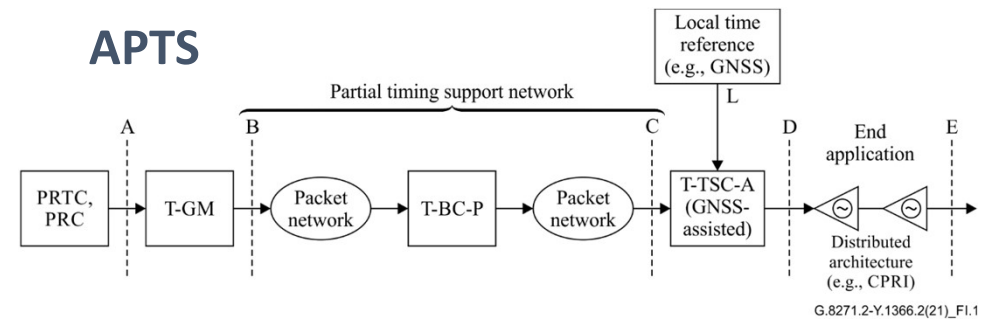
- Profile for applications that need accurate phase/time synchronization
- Based on the full timing support from the network (i.e., Telecom Boundary Clocks (T-BCs) and Telecom Transparent Clocks (T-TCs) are used in every node)
- Several ITU-T Recommendations, G.827x series, G.781.1, have been developed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



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

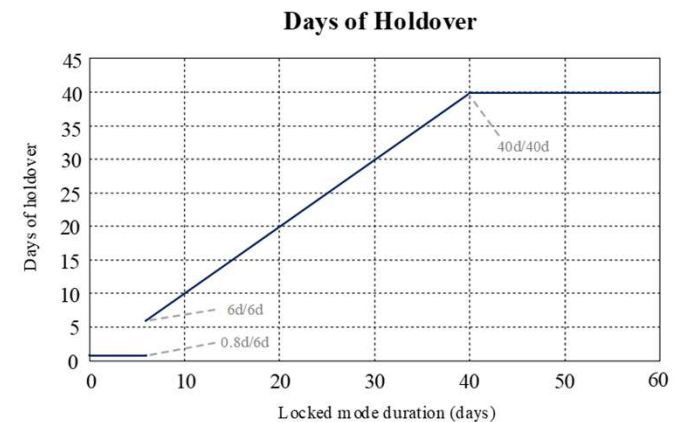
- Assisted Partial Timing Support (APTS) – GNSS is co-located with the T-TSC-A
 - PTP is used as a backup for GNSS failures
- Partial Timing Support (PTS) – without the GNSS co-located with T-TSC-P
 - Only PTP is used for timing
- Several ITU-T Recommendations, G.827x series, G.781.1, have been developed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



Q13 Ongoing Studies

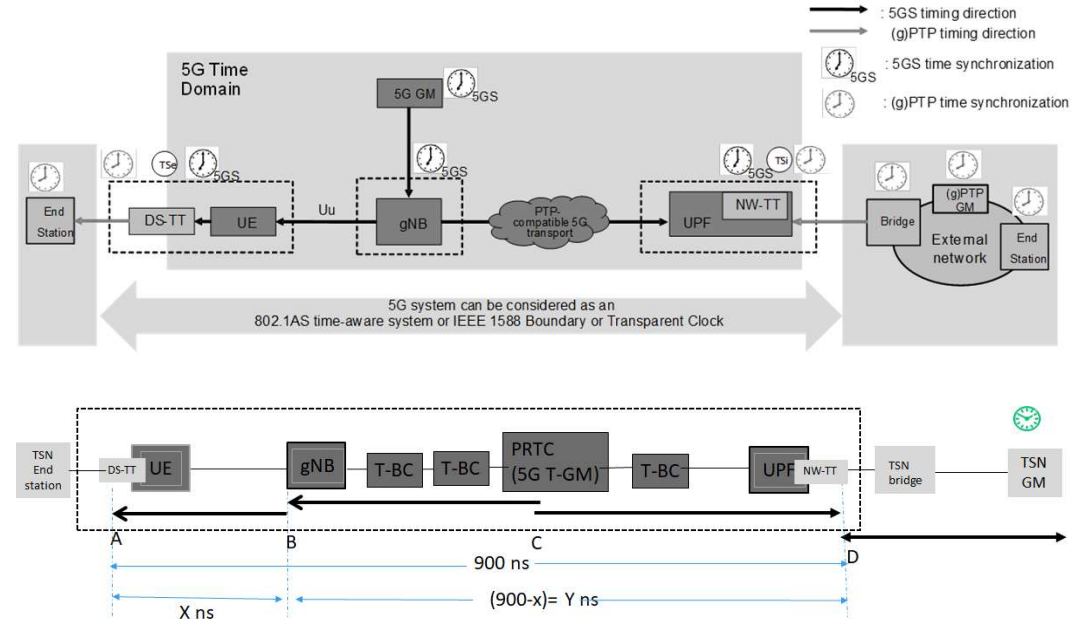
- PTP Profiles evolution
- MTN (Metro Transport Network)
 - Layer one transport network for 5G Transport technology specified in the G.83xx series
- Enhanced Primary Reference Time Clock (ePRTC)
- cnPRTC (Coherent PRTC):



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)