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P802.1CM SYNCHRONIZATION CONSIDERATIONS

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- Background
- Use cases, Deployment scenarios
- Applicability of the solutions
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SYNC REQUIREMENTS

› CPRI TWG contribution

	Synchronization Stream	IQ	C&M
Traffic type repartition	-	>	
Traffic pattern	-	Pe (1-	
Traffic QoS type	Very High	I	
Security	Under study	Und	
End-to-End Latency	-	<1	
FDV	-	Not	
FLR	-	<	
Synchronization timing accuracy	Class A+[1]: < 10 ns Class A[1]: < 45 ns Class B[1]: < 110 ns Class C[2]: < 1.36 µs		
Synchronization frequency error	-[3]		

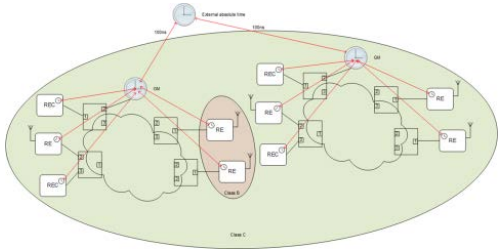
- 1) To a common GM (or common TC/BC)
- 2) To any GM
- 3) If SyncE TBD

- Class A+: < 10 ns — Nice to have
  - **MIMO, Tx-diversity**
- Class A: < 45 ns — Must have
  - **CA Intra Contiguous.**
- Class B: < 110 ns — Must have
  - **CA Intra Non-Contiguous, CA Inter**
- Class C: < 1.36 µs — Must have
  - **LTE TDD**

› "+/-" Time Error with respect to a time sync master (common master for Class A+, A, B; recognized time standard for class C)

› Frequency sync error (long and short term phase noise) under study :

- Physical layer sync reference may be used by the End Station
- Frequency may also be derived from PTP (stability requirements should apply also in this case)

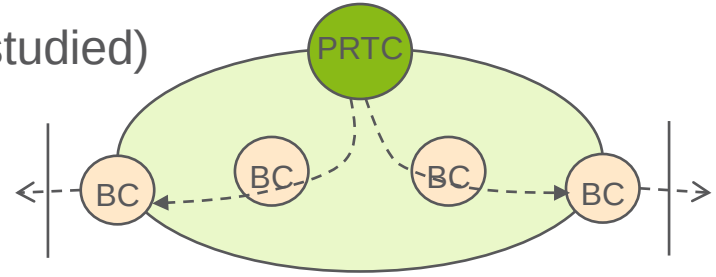


SYNC SOLUTIONS («RE» PERSPECTIVE)

Solution	Description	Characteristics
Point-to-point sync distribution (no packet switching in between)	e.g. In-Band «CPRI» or «TDM-based» fronthaul with 2-way protocol for phase alignment	Meets current CPRI needs
GNSS (Global Navigation Satellite System)	Typically GPS; other systems: Glonass, Beidou, Galileo, etc.	Need for view of the sky; Vulnerable to Jamming/spoofing +/- 100 ns typical accuracy (+/- 50 ns in the best case)
Packet Timing (PTP, Precision Time Protocol)	Time and frequency sync via packets	Depends on deployment case (see slide 5 and 11)
Physical Layer (e.g. SyncE)	Frequency sync over the physical layer	See slide 8
Radio Based Sync	Synchronization over the radio interface (e.g. RIBS under standardization in 3GPP)	Typical target: 1 microsecond level of accuracy

PTP (IEEE1588)

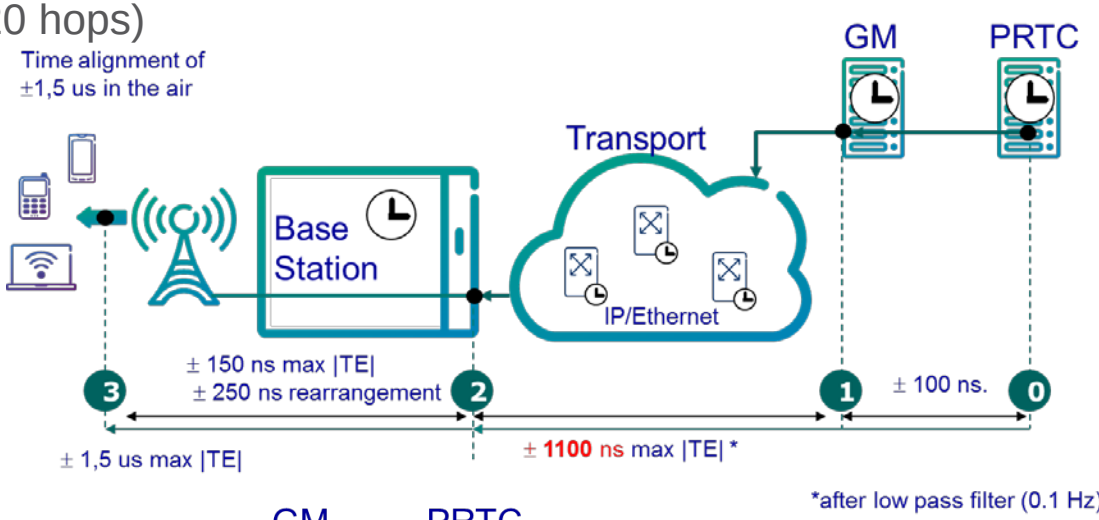
- Packet Timing:
  - PTP (Precision Time Protocol) specified by IEEE1588 (v2 from 2008; new revision planned for 2017, generally backward compatible)
- *PTP profiles* required to define how to use the protocol in a specific environment; additional performance related aspects generally also specified
- Telecom profile defined by ITU-T in the G.827x series, including network performance and clock specification; further enhancements under study (see slide 9)
- Generally (in case of «full timing support») PTP operates within a single administrative domain:
  - It could be offered as a service at the network boundaries
  - Alternatively, Transparent Clocks (not fully studied)



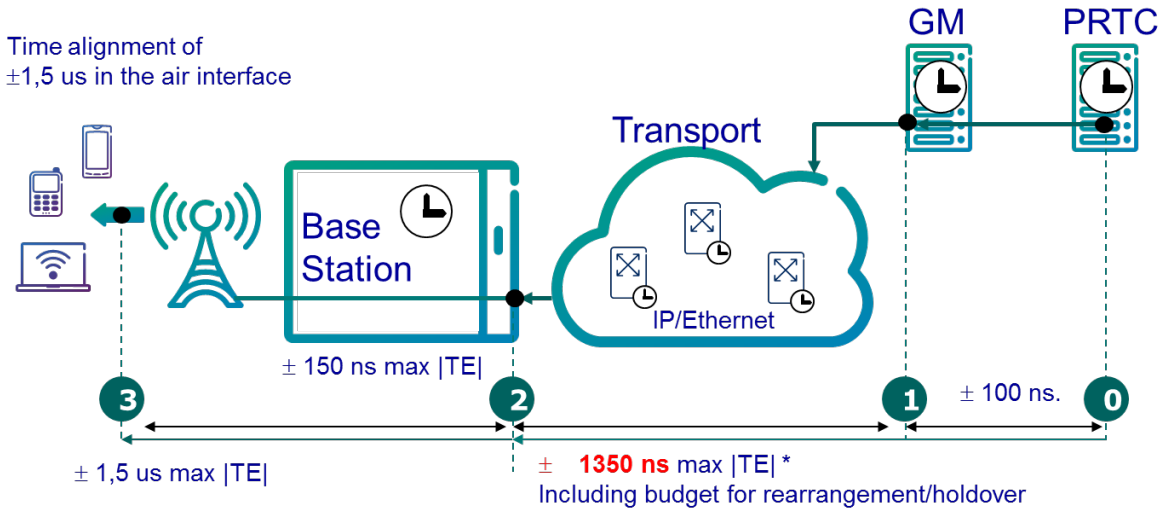
TELECOM PROFILE

- Current Target: +/-1.5 us on the radio interface;
- Budgeting includes: End Application own budget (150 ns), master error (100 ns), network rearrangements / holdover, link asymmetries, Clocks accuracies
- Potentially over long chain (10 – 20 hops)

- *Rearrangements/Holdover handled by the End Station*



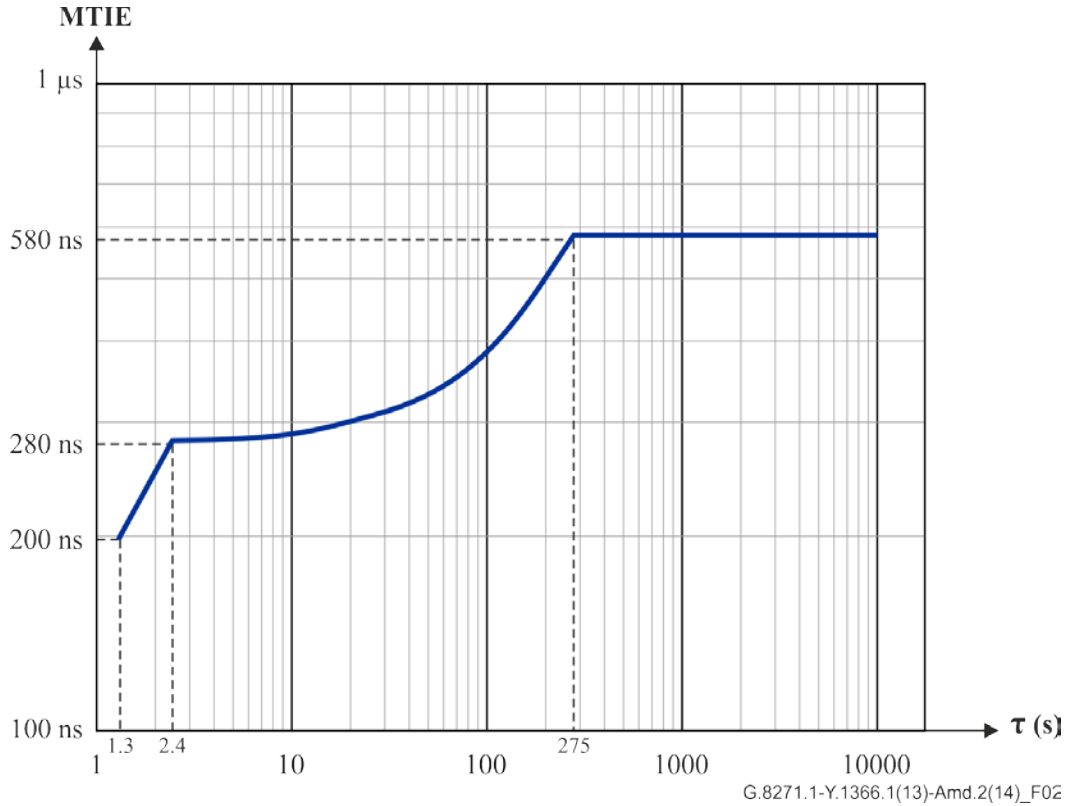
*after low pass filter (0.1 Hz);



- *Rearrangements handled in the network*

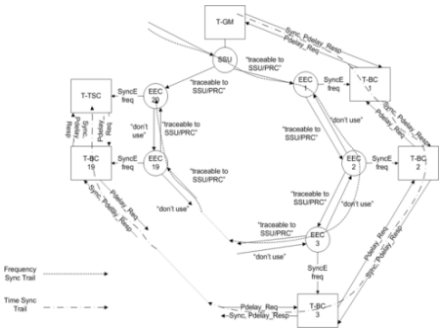
NETWORK REQUIREMENTS

- Network Requirements expressed in terms of:
  - Max absolute Time Error (max|TE| < 1.1 us)
  - High frequency noise (> 0.1 Hz): peak-to-peak TE amplitude < 200 ns
  - Wander (MTIE) (< 0.1 Hz):

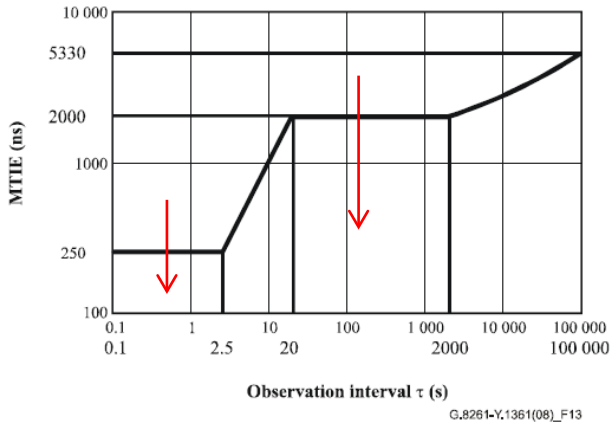


SYNCHRONOUS ETHERNET (SYNCE)

- Specified by ITU-T (G.8261, G.8262, G.8264) as a way to deliver frequency sync over the physical layer
  - Based on SDH → relatively noisy but sufficient for 1.5 us level of requirement (note: every 1/16 s, SyncE is «corrected» by PTP)
  - Providing stability and «time sync holdover» (during loss of PTP/ GNSS);
- SyncE noise contribution to PTP
  - About 100ns as random noise. About 200 during network rearrangements (SyncE rings)
  - Mostly related to the EEC 120 ns phase jumps
- SyncE support is currently assumed in 8275.1 based networks (and 8273.2 clocks);
  - Ongoing study on PTP network without SyncE
- Limited to single administrative domain, but can be offered as a service
- End Station may or may not use it
- Enhanced SyncE version being developed
  - Expected significantly better performance

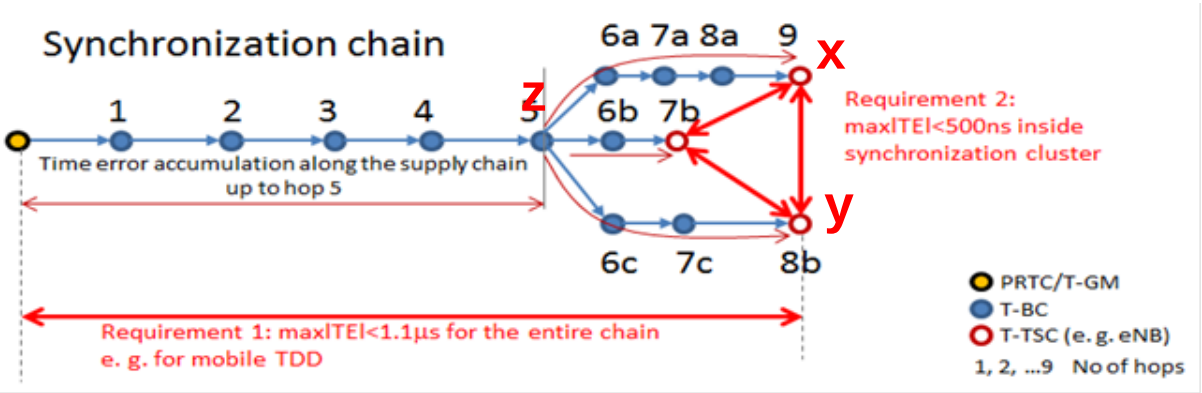


From WD30, (Boulder, 2012)



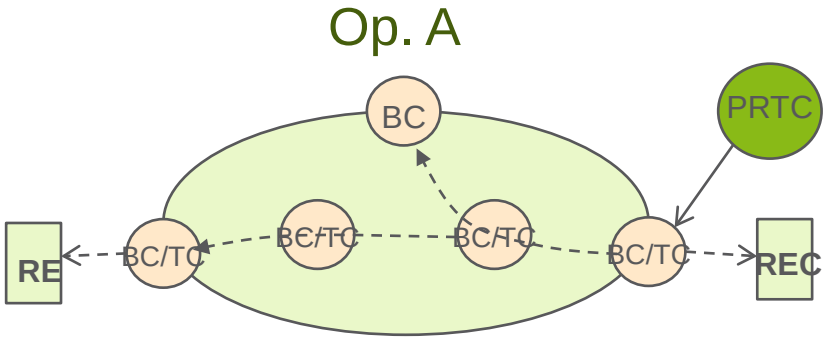
NEXT STEPS IN ITU-T

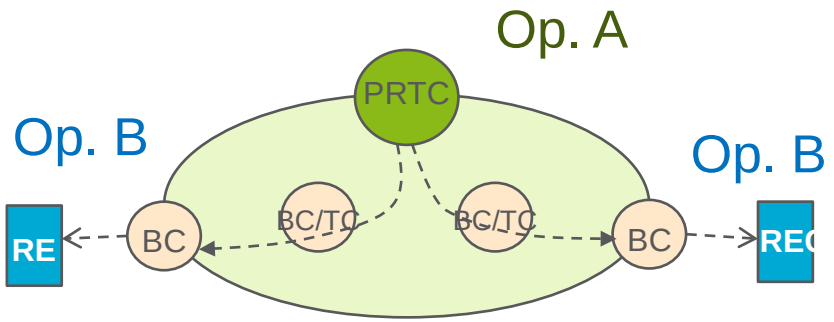
- Enhanced SyncE (G.8262.1, revised G.8271.1, based on an «enhanced Hypothetical Reference Model», HRM)
- Enhanced PRTC (G.8272.1): +/- 30 ns
- Targeting applications in the 100 ns range, see Liaison from ITU-T: *work on defining solutions to carry more accurate time synchronization, including cases when meeting a maximum relative phase deviation might be sufficient (the target requirement is still under discussion, values as low as +/- 100 ns have been suggested). This work also includes the definition of an enhanced version of Synchronous Ethernet*
- Concept of relative time error (similar to «nearest BC»): $\max|TE_{xy}(t)| = \max|TE_x(t) - TE_y(t)| = \max|\ TE_{xz}(t) - TE_{yz}(t)\ |$



USE CASES - NETWORK OWNERSHIP

- Various use cases in terms of Network Ownership
  - Same network operator
  - Different Transport Network and Mobile Network operators
  - Different Transport Network and several Mobile Network operators
- Master location depends on the use cases
- PTP Performance depends on length of the chain
  Highest performance assume full timing support (1588 support in every node)
- Concept of “Nearest BC” may not be applicable to the case of multi-operator / Sync service
  - Requires full control over network topology
  - Common master and short chains required (it depends on the target requirement)
- SyncE or not SyncE:
  - Some “1588 profiles” may assume SyncE in the time distribution network
  - Different performance objectives (enhanced syncE being specified)
  - Radio nodes (End Stations) may or may not use it





DISCUSSION: APPLICABILITY TO FRONTHAUL («RE» SYNC)

	Point-to-point Sync (from remote common master)	PTP, short network (e.g. nearest BC; common master) / enhanced HRM	Co-located common master at the RE (e.g. PTP GM); *Note: applicable in case of co-located REs*	PTP, «long HRM/current G.8271.1» (different masters are possible)	GNSS (at the REs)	RIBS (at the REs)
Class A+	yes, with accurate asymmetry control (also generated in the links by the use of different lambdas)	No	yes, with very accurate local asymmetry control and phase noise control (mainly internal in the nodes, including the PTP master)	No	No	No
Class A	yes, with accurate asymmetry control	To be studied (challenging) (common master and nearest BC not feasible in case of Multioperator?)	yes, with accurate local asymmetry control (mainly internal in the nodes)	No	No	No
Class B	yes, with accurate asymmetry control	Yes , with common master and small network with accurate asymmetry control (common master and nearest BC not feasible in case of Multioperator?)	yes, with accurate local asymmetry control (mainly internal in the nodes)	No	Yes (with accurate GNSS Cabling and installation)	To be studied
Class C	yes	Yes (common master and nearest BC not feasible in case of Multioperator? Not an issue for this class)	Yes (note: the local master needs to be traceable to the network master)	yes	yes	yes

Note for GM sync: Class C requires «internationally recognized master» e.g. GPS;
Other Classes: stable master is sufficient

PROPOSALS; FOR DISCUSSION

- Various sync methods exist; not all suitable for all cases. In general always very careful design is needed
  - See table from slide 11 for discussion
- Case of multi-operator may be addressed via sync as a service
- Way Forward :
  - Check sync requirements in the 802.1CM Draft; Add some notes on Frequency sync related requirements
  - Add some information in Section 6 on sync solutions (with relevant standard references) and their applicability (e.g. which one are recommended, warnings etc.)
  - Provide updates to ITU-T via liaison (e.g. status of the work, target requirements, architecture, etc.), as well as ask for updates on the sync enhancements being studied

REFERENCES

- Packet Timing in ITU-T: ITU-T G.826x series, G.827x series,
- ITU-T general definitions: G.810, G.8260
- PTP: IEEE 1588-2008
- 3GPP, TR 36.898, Network Assistance for Network Synchronization

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