Deutsche Telekom @ITSF2014

Synchronization Network Migration
with focus on coherent network Primary Reference Time Clocks (cnPRTC)

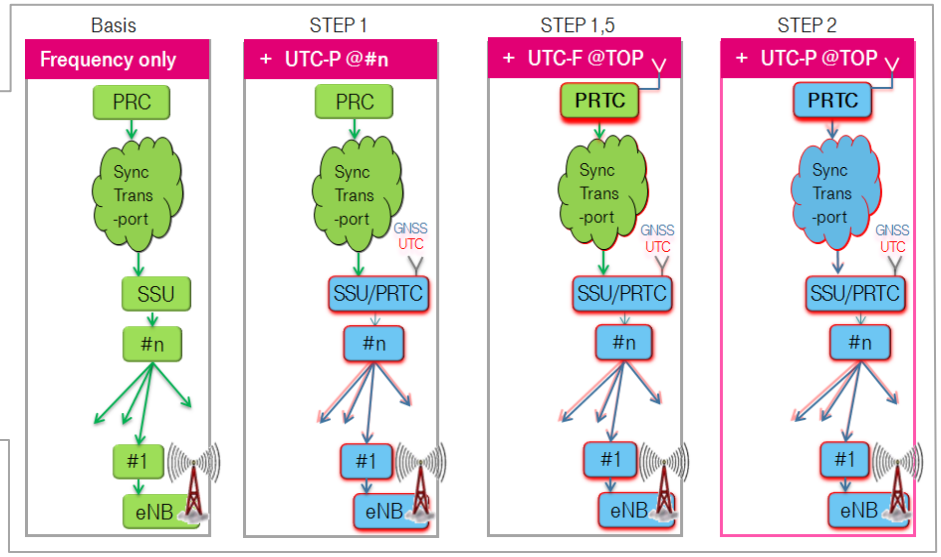
Helmut Imlau, 4.11.2014

LIFE IS FOR SHARING.

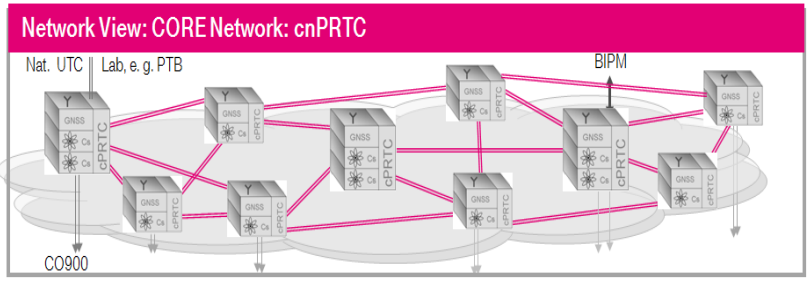
Synchronization Network Migration with focus on cnPRTC Agenda

❶ Synchronization Network Migration Steps

From “frequency only” synchronization network to a coherent frequency and phase synchronization network.



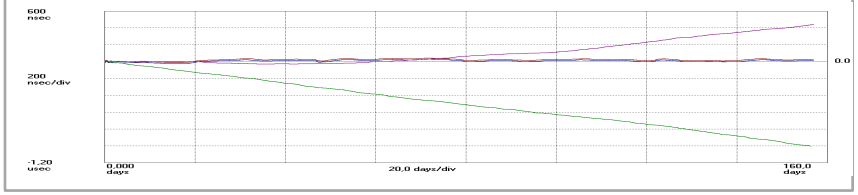
❷ The coherent network PRTC idea.



❸ PRTC ensemble types

Type	Available Time & Timing Sources: Time scale generation	Stable frequency generation: Intern oscillator	Stable frequency generation: External oscillator(s)	Time transfer from other PRTC's	Function acc. to ITU-T SG15 Q13: Recommendation Name	Recommendation No.	Work status and ongoing activities	Needed for migration step ....
Basis	GNSS or BIPM reg. UTC lab	OCXO Rb CSAC..			Primary Reference Time Clock (PRTC)	G.82 72	10/2012: Published for phase/time, **NEW:** Next version planned for 12/2014: For phase/time and frequency	1.5
1	GNSS or BIPM reg. UTC lab	OCXO Rb CSAC..	1 or 2 Cs G.811+		Primary Reference Time Clock ensemble (PRTCe)?	G.82 72.x	**NEW:** New study item. From DT contributions WD36+37 (09-2014): Successfully tested, result within ±30ns	1.5
2	GNSS or BIPM reg. UTC lab	OCXO Rb CSAC..	1 or 2 Cs G.811+	3* PTP	coherent network PRTC ensemble (cnPRTCe)	G.82 72.y?	**NEW:** Will be proposed for ITU-T to be specified	2
3	GNSS	OCXO Rb CSAC..		1* PTP	APSC (Assisted Partial Timing Support Clock)	G.82 73.4	Ongoing, planned for consent 12-2014	1 1.5 2

❹ PRTC ensemble measurement results

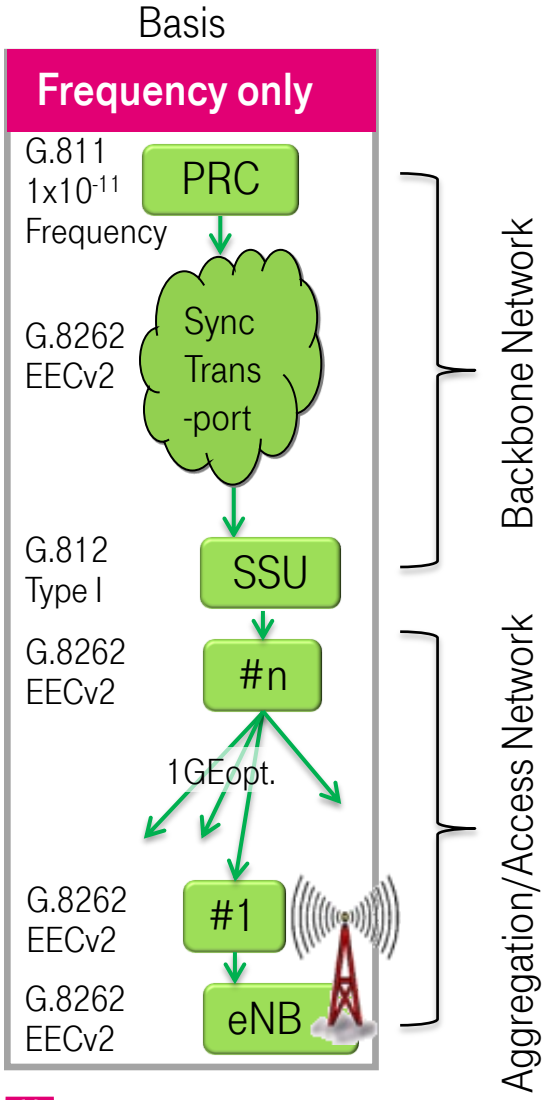


PRTC = Primary Reference Time Clock (ITU-T), cnPRTC = coherent network PRTC (DT), PRTCe = PRTClock ensemble (DT)

Synchronization Network Migration with focus on cnPRTC

❶ Migration steps

GREEN: FREQUENCY, BLUE: FREQUENCY/PHASE/TIME, RED SHADOW: UTC TRACEABLE



Basis:

- Existing frequency synchronization network
  - ➔ Using SyncE and SDH
  - ➔ For base station synchronization in FDD mode (Frequency Division Duplex)
- Components:
  - ➔ PRC Primary Reference Clocks
  - ➔ SSU Synchronization Supply Units
  - ➔ EEC/SEC Ethernet and SDH Equipment Clocks
- It consists of
  - ➔ backbone network and
  - ➔ aggregation network
  - ➔ with a SSU's between both

Synchronization Network Migration with focus on cnPRTC

❶ Migration steps

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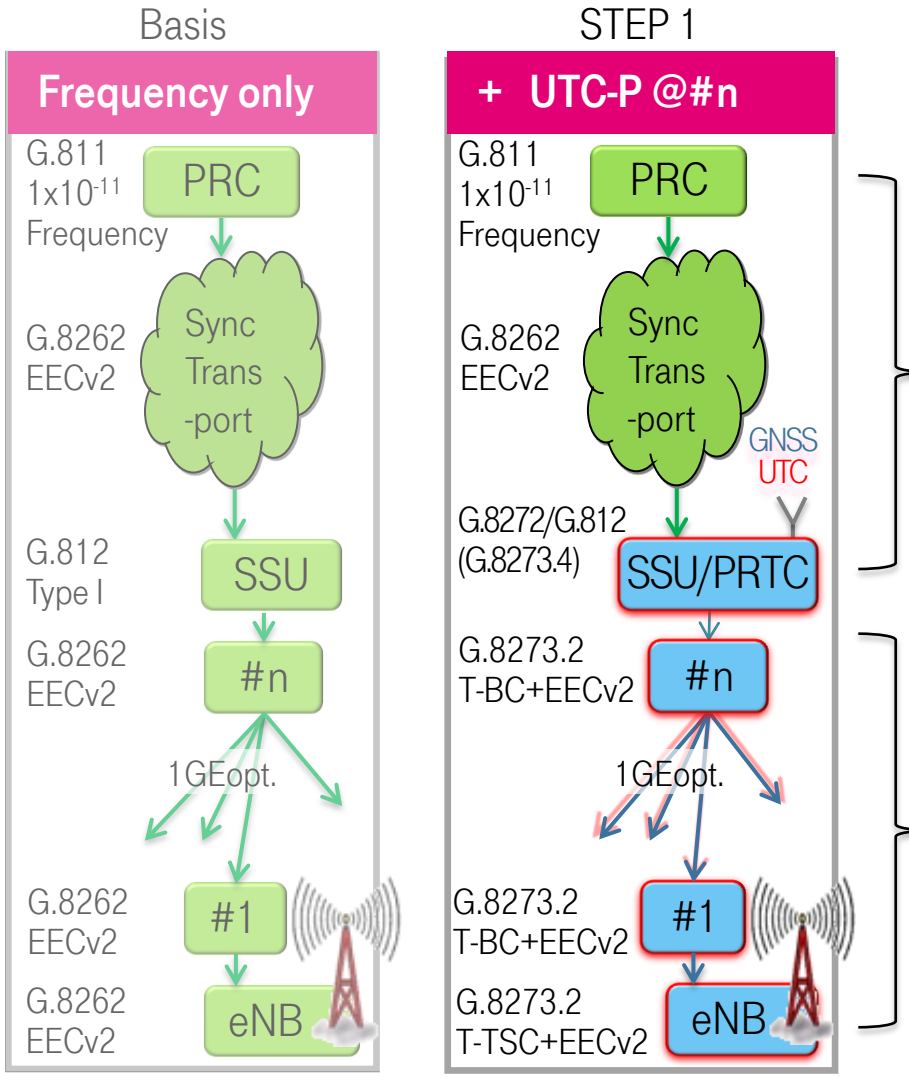

1st migration step:

➔ UTC traceable phase synchronization at aggregation level for base station synchronization

Needed for

- mobile TDD (Time Division Duplex) or
- LTE-Advanced features like CoMP Joint Processing or
- eICIC (enhanced Inter-Cell Interference Cancellation) e. g. for HetNet

Synchronization Network Migration with focus on cnPRTC

❶ Migration steps

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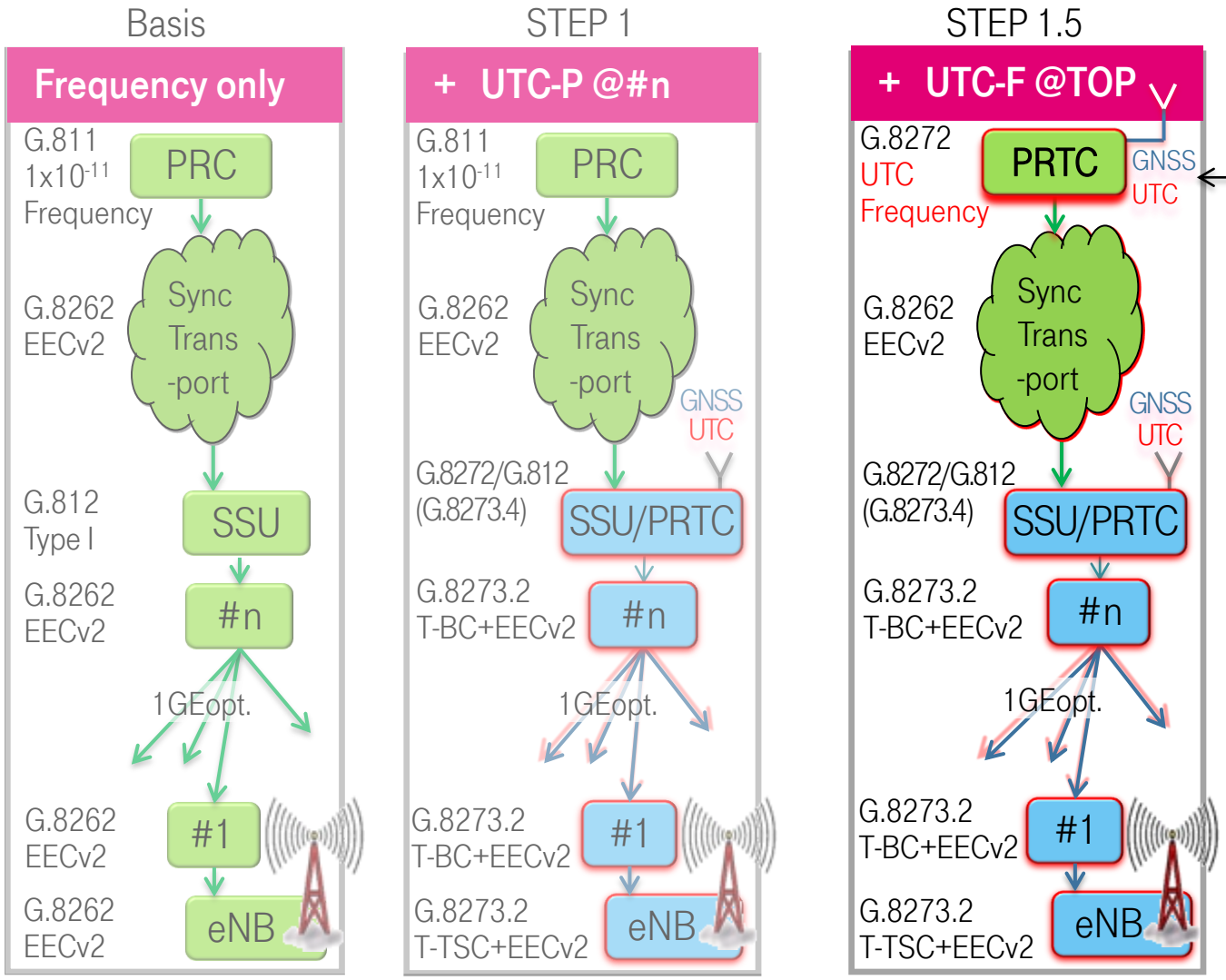

Intermediate step (1.5):

➔ To make the frequency synchronization network UTC traceable

- Preparation for STEP 2
- Requirement for HetNet Over-The-Air (OTA) synchronization approach
- To improve time holdover based on frequency

Synchronization Network Migration with focus on cnPRTC

❶ Migration steps

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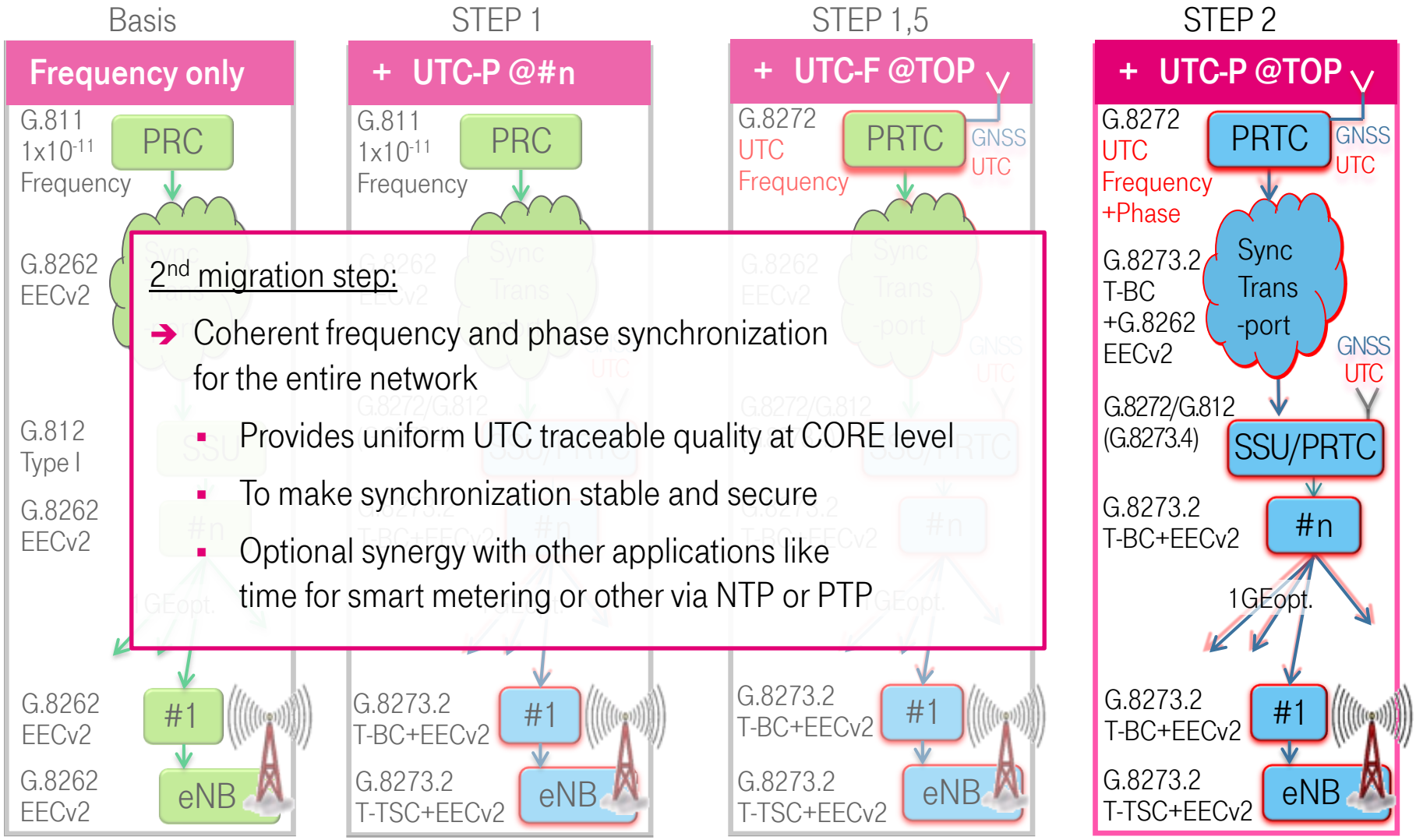


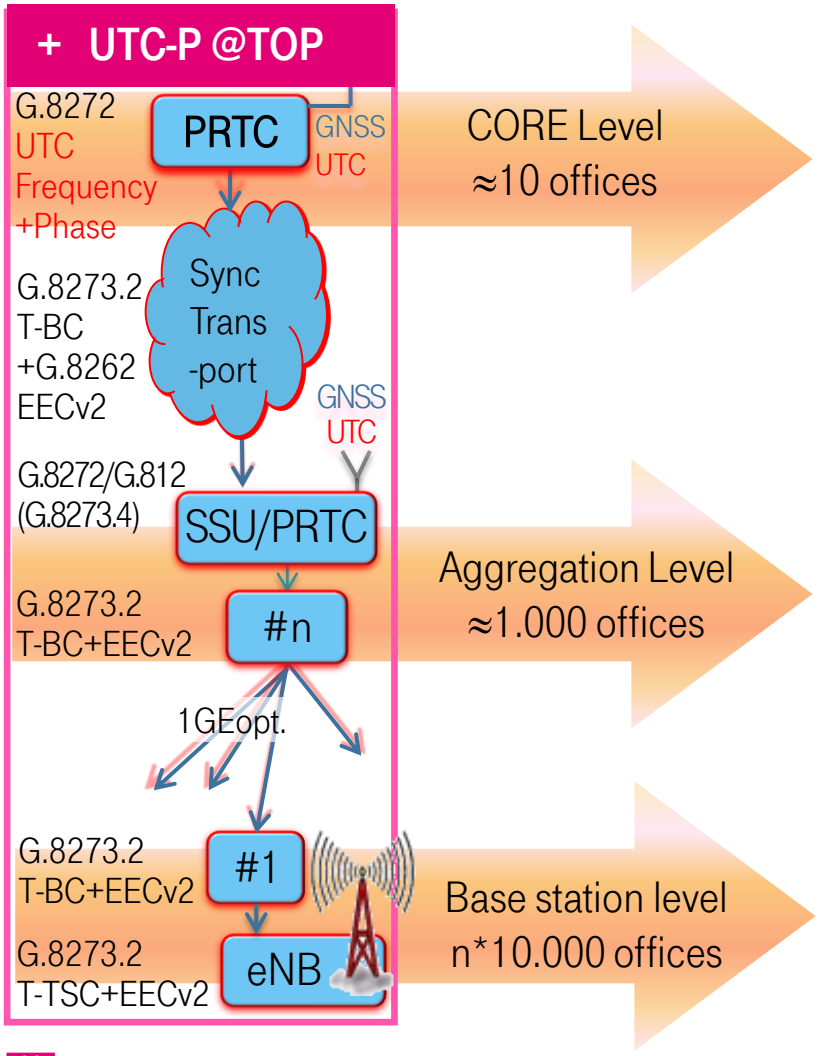
2nd migration step:

- ➔ Coherent frequency and phase synchronization for the entire network
  - Provides uniform UTC traceable quality at CORE level
  - To make synchronization stable and secure
  - Optional synergy with other applications like time for smart metering or other via NTP or PTP

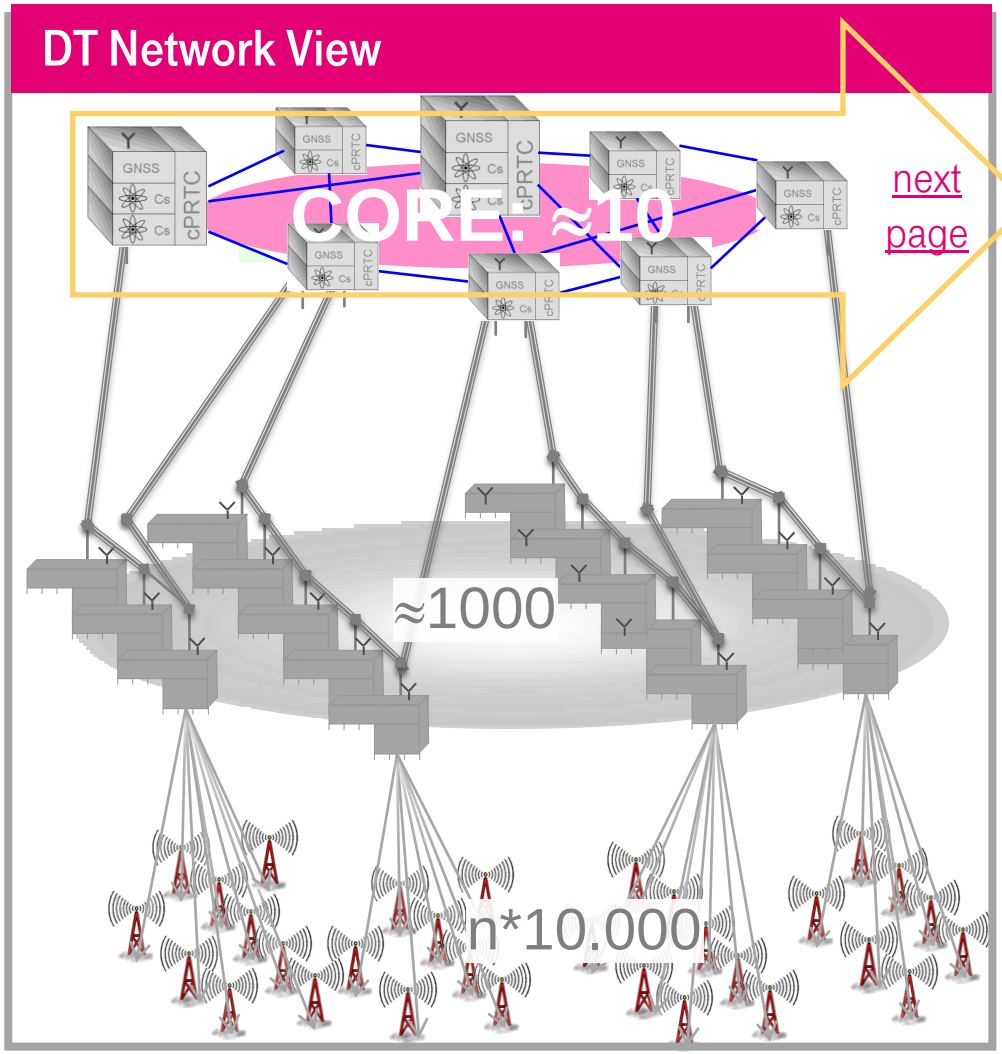
Synchronization Network Migration with focus on cnPRTC

❷ The coherent network PRTC idea.

STEP 2

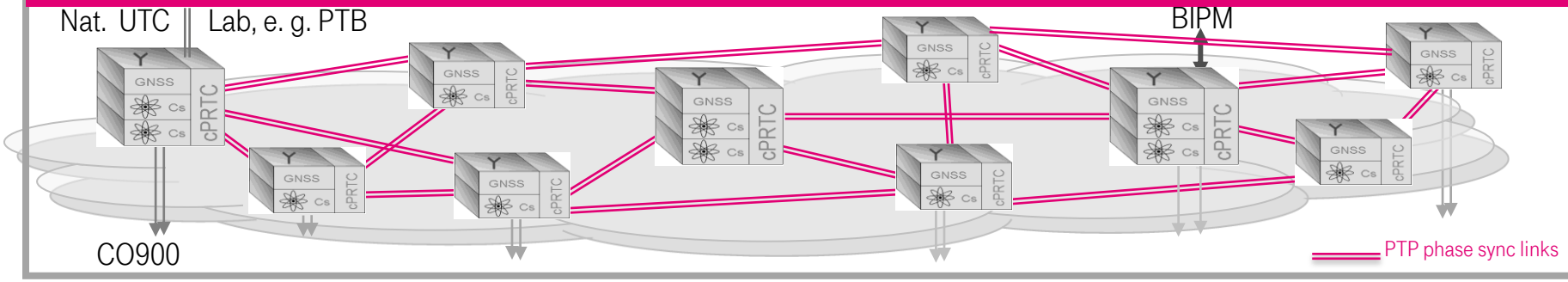


DT Network view



Synchronization Network Migration with focus on cnPRTC
❷ The coherent network PRTC (cnPRTC) idea.

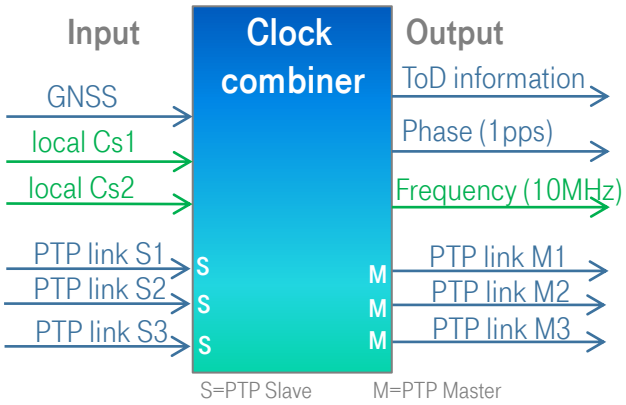
Network View: All CORE location with coherent network PRTC functions



cnPRTC function consists of:

- Clock combiner with adequate calculation and steering algorithm to generate frequency, phase and time
- GNSS (e. g. GPS+Galileo) for time, phase , frequency
- 1 or 2 Cesium (G.811+) for stability, to eliminate GNSS noise
- PTP phase links providing time, phase and frequency from and to neighborhood CORE locations
- For PTP links: GNSS based asymmetry compensation used
- Optional: UTC/BIPM monitor system using UTC(DTAG)

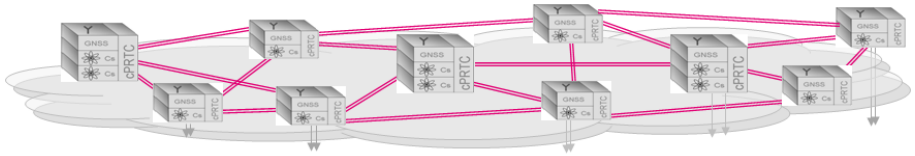
BIPM = Bureau International des Poids et Measures (Paris)



Synchronization Network Migration with focus on cnPRTC
❷ The coherent network PRTC (cnPRTC) idea.

cnPRTC advantage:

- Uniform UTC traceable network sync quality @ CORE level
  - ➔ as basis for all services with frequency, phase and/or ToD supply



- Better than PRTC G.8272 per design:
  - ➔ max|TE| <30ns instead of <100ns, no noise impact from GNSS
- Failure tolerance:
  - ➔ After initial synchronization fully GNSS independent, if needed
  - ➔ Jamming, spoofing and GNSS shutdown would not be a risk anymore (Definition of the second is based on Cs)
- Performance Management:
  - ➔ Monitored acc. to BIPM procedures with UTC(DTAG)
  - ➔ may be combined with optical fiber based UTC lab connections

Synchronization Network Migration with focus on cnPRTC
❸ PRTC ensemble types

Type	Available Time & Timing Sources				Function acc. to ITU-T SG15 Q13			Needed for migration step ….
	Time scale generation	Stable frequency generation		Time transfer from other PRTC's	Recommendation		Work status and ongoing activities	
		Intern oscillator	External oscillator(s)		Name	No.		
Basis	GNSS or BIPM reg. UTC lab	OCXO Rb CSAC..	+		Primary Reference Time Clock (PRTC)	G.8272	10/2012: Published for phase/time, **NEW:** Next version planned for 12/2014: For phase/time and frequency	1.5
1	GNSS or BIPM reg. UTC lab	OCXO Rb CSAC..	1 or 2 Cs G.811+	+	Primary Reference Time Clock ensemble (PRTCe)?	G.8272.x	**NEW:** New study item. From DT contributions WD36+37 (09-2014): Successfully tested, result within ±30ns	1.5
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Synchronization Network Migration with focus on cnPRTC Acknowledgment

Acknowledgment

Thank you very much for the good cooperation during of a PRTC ensemble prequalification versus UTC(PTB) locally in Braunschweig

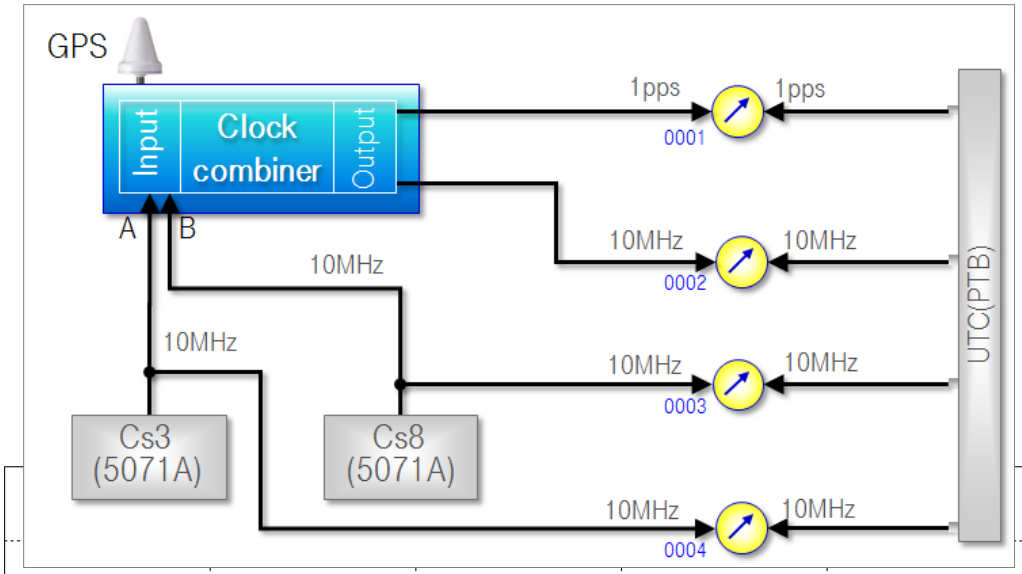
- **Dr. Andreas Bauch** *)
- **Dr. Dirk Piester**

Physikalisch-Technische Bundesanstalt Braunschweig
Time and Frequency Department, Time Dissemination Working Group

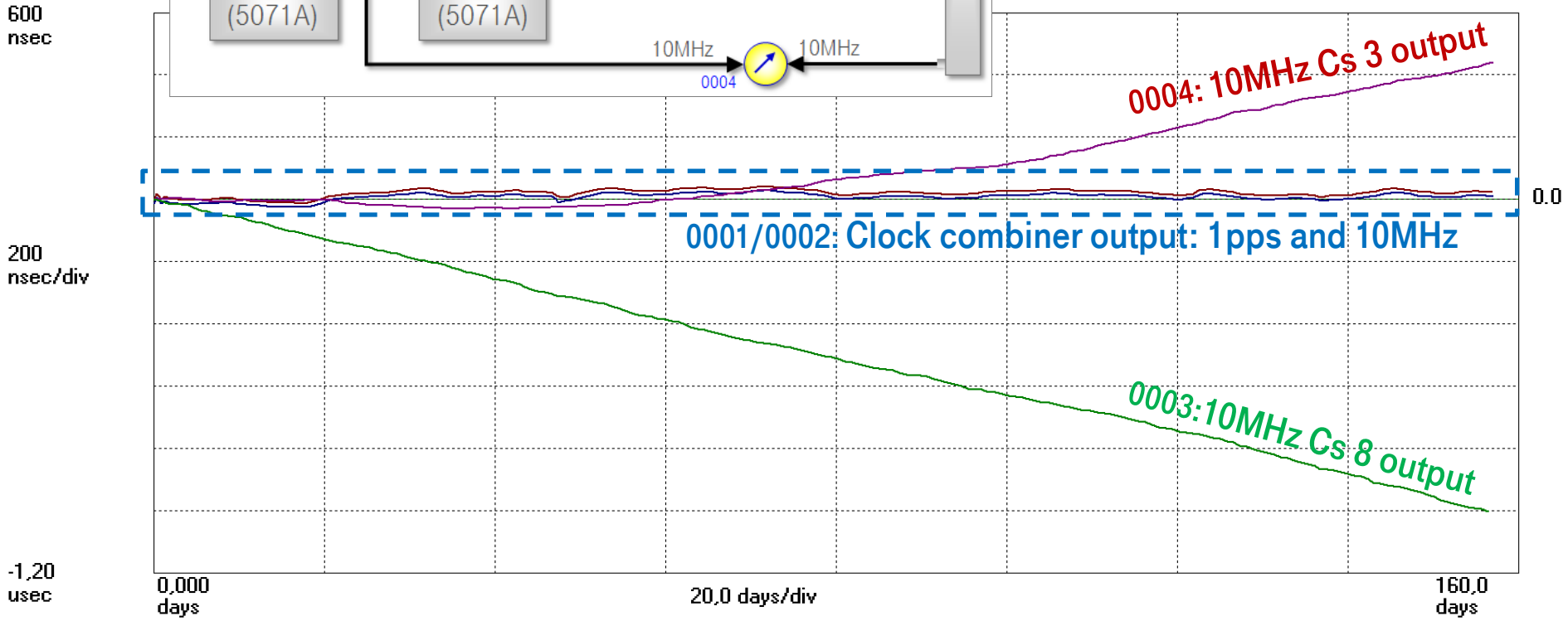
Tasks of PTB:
Operation of an atomic clock ensemble, Generation of UTC(PTB) and legal time for Germany, Time transfer using TWSTFT and GPS, Dissemination of legal time (DCF77, telephone service, ntp)

*) Head of Time Dissemination Working Group

Synchronization Network Migration with focus on cnPRTC

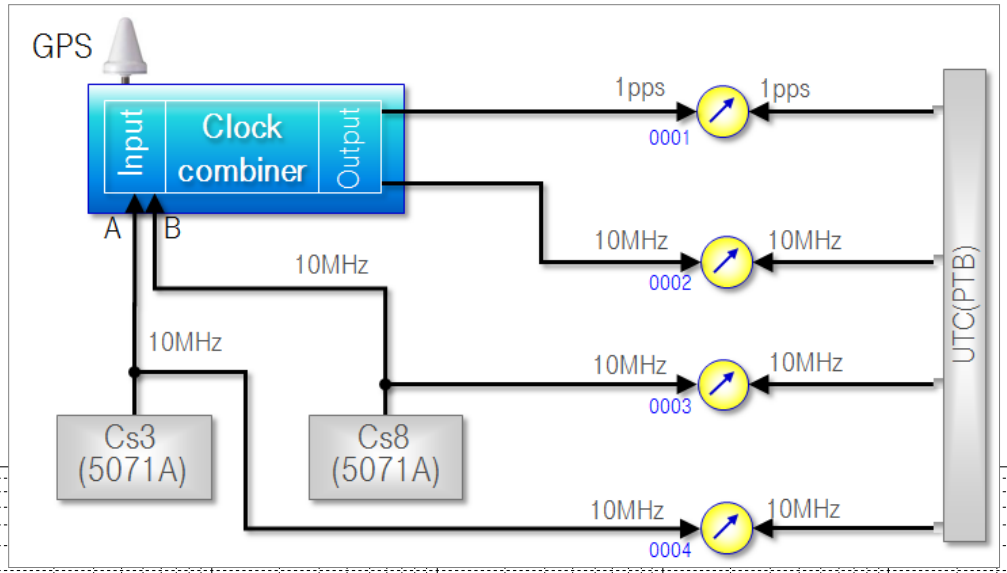


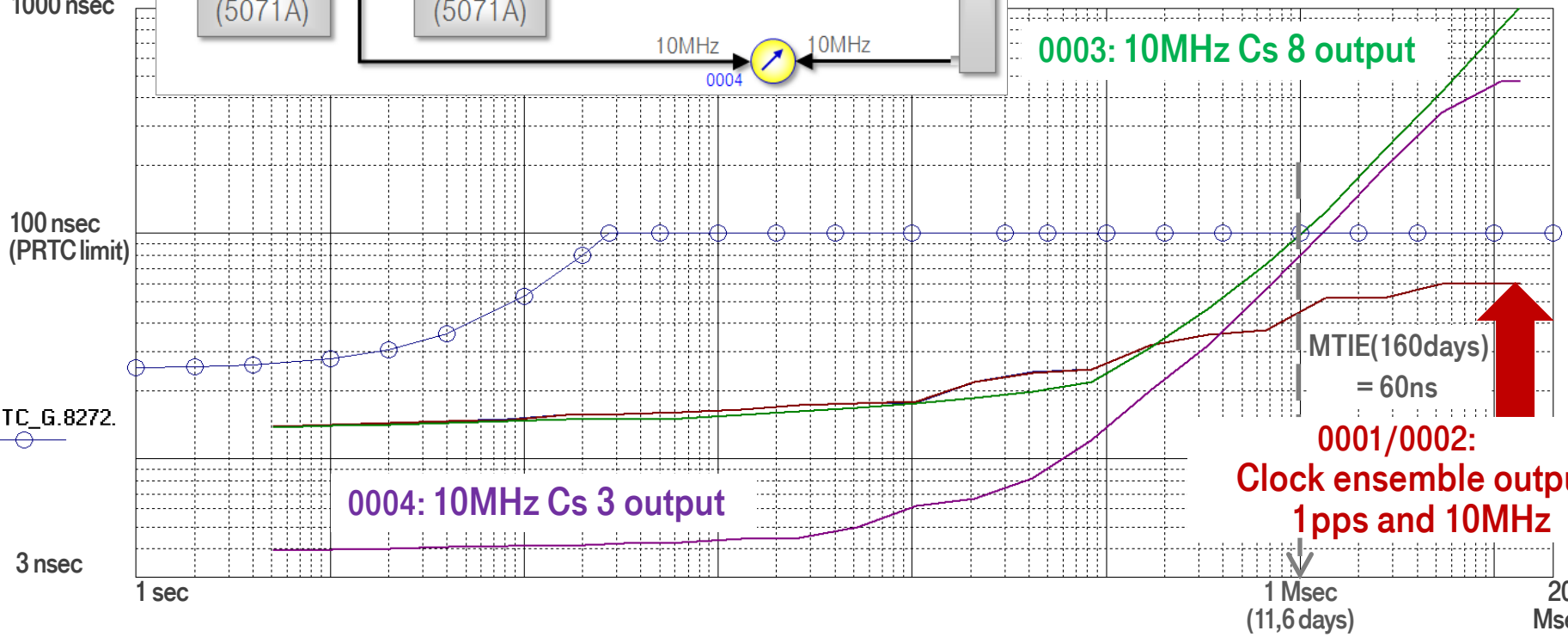
❹ cnPRTC (local system) measurement results as TE/TIE



Synchronization Network Migration with focus on cnPRTC

❹ cnPRTC (local system) measurement results as MTIE





Synchronization Network Migration with focus on cnPRTC

1 Synchronization Network Migration Step Options

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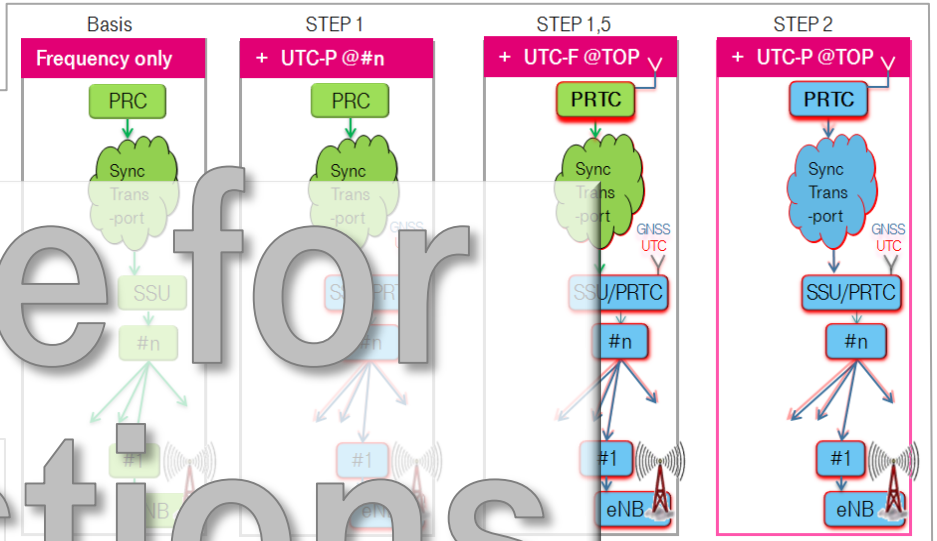
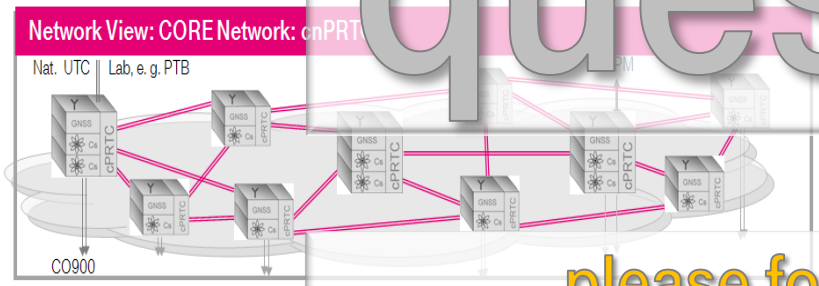


2 The coherent network PRTC deployment



3 PRTC ensemble types

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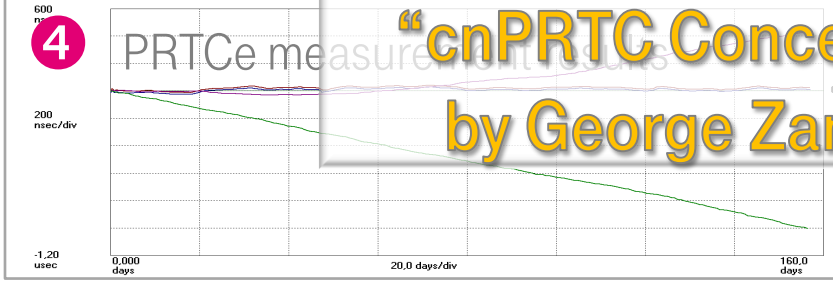
4 PRTCe measurement results



Time for questions

.... please follow the next talk

"cnPRTC Concept and Technology"

by George Zampetti (Microsemi)

Synchronization Network Migration with focus on cnPRTC Abbreviations

1 PPS	1Pulse per Second
APSC	Assisted Partial Timing Support Clock
BIPM	Bureau International des Poids et Measures (Paris)
CoMP	Coordinated Multi-Processing Transmission and Receiving
CSAC	Chip-Scale atomic Clock
cnTRTC	coherent network PRTC
Cs	Cesium atomic clock
DCF77	Radio transmitter station identification code, given by ITU, “D” for Deutschland (long-wave transmitter for dissemination of legal time Germany, 77,5MHz)
eICIC	enhanced Inter-Cell Interference Cancellation
eNB	envolved NodeB (LTE basestation)
EEC	Ethernet Equipment Clock
FDD	Frequency Division Duplex
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HetNet	Heterogeneous network (macro – small cell overlap)
ITU	International Telecommunication Union
ITU-T	ITU - Telecommunication Standardization Sector
MTIE	Maximum Time Interval Error
NTP	Network Time Protocol
OCXO	Oven-Controlled Crystal Oscillator
OTA	Over-The-Air (Synchronization)
PRC	Primary Reference Clock
PRTC	Primary Reference Time Clock
PRTCe	PRTC ensemble
PTB	Physikalisch-Technische Bundesanstalt Braunschweig
PTP	Precision Time Protocol
Q	Question (ITU-T, Q13 = Timing & Synchronization)
Rb	Rubidium atomic clock
SDH	Synchronous Digital Hierarchy
SG	Study Group (ITU-T)
SSU	Synchronization Supply Unit
SyncE	Ethernet Physical Layer Synchronization
TDD	Time Division Duplex
TWSTFT	Two-Way Satellite Time and Frequency Transfer
UTC	Universal Time Coordinated
UTC(PTB)	Universal Time Coordinated (Physikalisch-Technische Bundesanstalt Braunschweig)
UTC(DTAG)	Universal Time Coordinated (Deutsche Telekom AG)
UTC lab	BIPM registered official time lab contributing UTC
WD	Work Draft (acc. to ITU-T rules)