TIME SYNC IN ITU-T Q13/15: G.8271 AND G.8271.1

ITSF - 2012, Nice

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TIME SYNCHRONIZATION: SCOPE AND PLANS

- The work recently started in ITU-T Q13/15
- The following main aspects need to be addressed
  - Network Requirements
  - Architecture
  - PTP Profiles
  - Clocks
- The work is tentatively planned to be completed in the 2013/2014 time frame
- Several aspects also involving other Questions, e.g.:
  - Time sync Interfaces
  - Time sync over access technologies
  - Time sync over OTN

TIME SYNC: Q13/15 RECOMMENDATIONS

- Analysis of Time/phase synchronization in ITU-T Q13/15:
  - G.8260 (definitions related to timing over packet networks)
  - G.827x series

	Frequency	**Phase/Time**
General/Network Requirements	G.8261 G.8261.1	G.8271 G.8271.1
Architecture and Methods	G.8264 G.8265	G.8275
PTP Profile	G.8265.1	G.8275.1, G.8275.2
Clocks	G.8262 G.8263	G.8272 G.8273 G.8273,.1,.2,.3

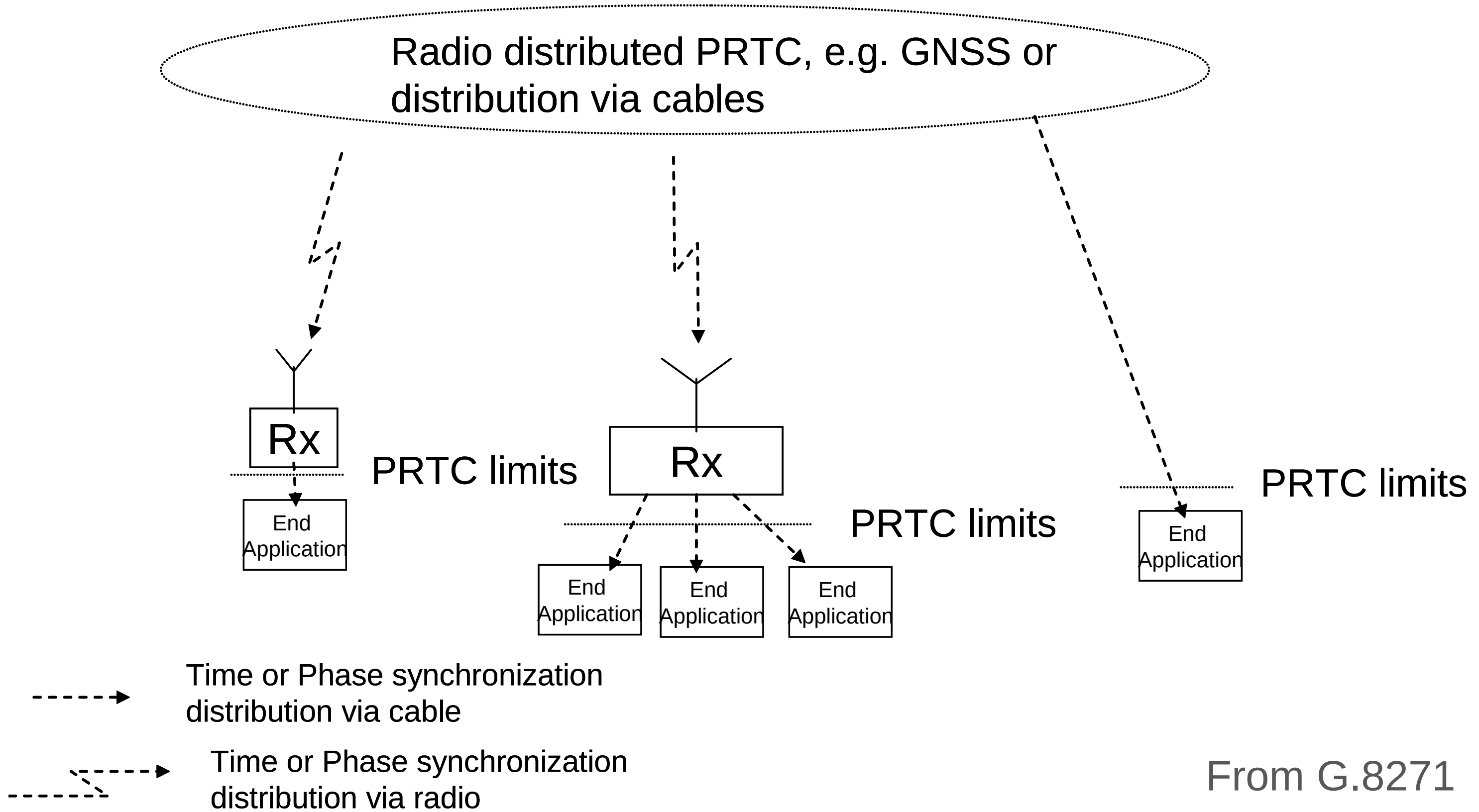
G.8271: Time and Phase Sync Aspects of Packet Networks

- G.8271 scope
  - Time and phase synchronization aspects in packet networks
    - Target applications
    - Methods to distribute the reference timing signals
- It also specifies the relevant time and phase synchronization interfaces and related performance.
  - *Physical characteristics to be moved into G.703*
- G.8271 is the first document of the G.827x series to be released (Published in 02/2012)
  - Amendment planned for 2013 (additional details and alignments with G.8271.1)

TARGET APPLICATIONS

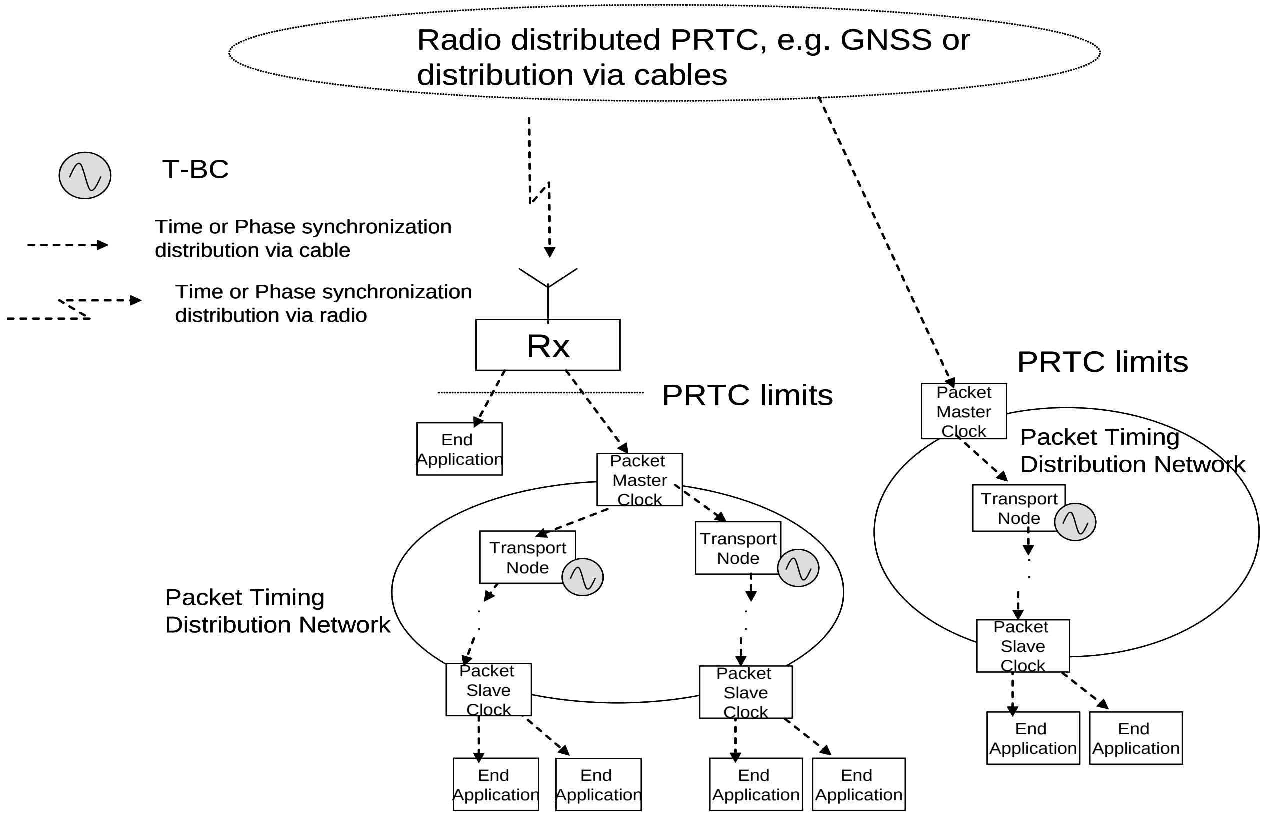
Level of Accuracy	Range of requirements (with respect to ideal reference)	Typical Applications
1	1 ms – 500 ms	Billing, Alarms
2	5 μs – 100 μs (Note 1)	IP Delay monitoring
3	1.5 μs -5 μs	LTE TDD (large cell) Wimax-TDD (some configurations)
4	1 μs - 1.5 μs	UTRA-TDD, LTE-TDD (small cell)
5	x ns - 1 μs (x ffs)	Wimax-TDD (some configurations)
6	< x ns (x ffs)	Some LTE-A features (Under Study)

METHODS: DISTRIBUTED PRTC



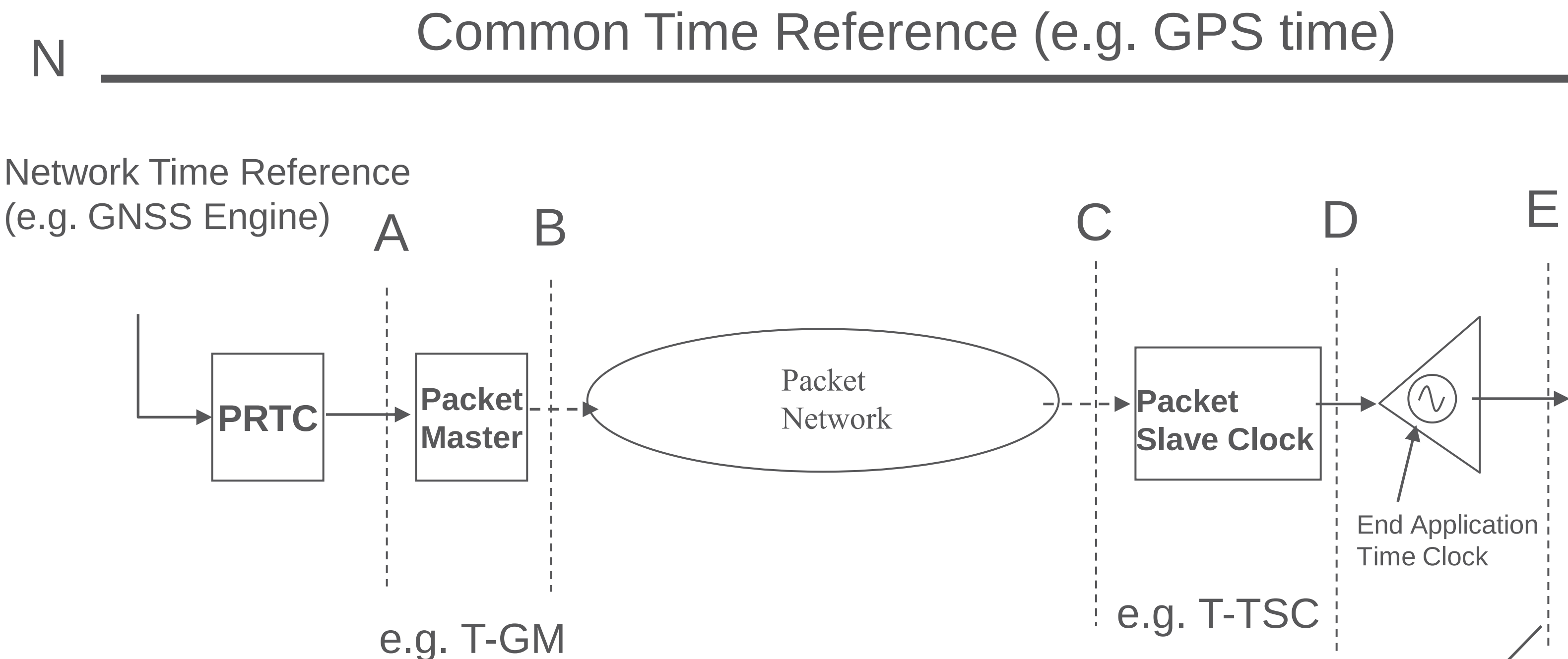
From G.8271

METHODS: PACKET BASED METHODS



From G.8271

NETWORK REFERENCE MODEL

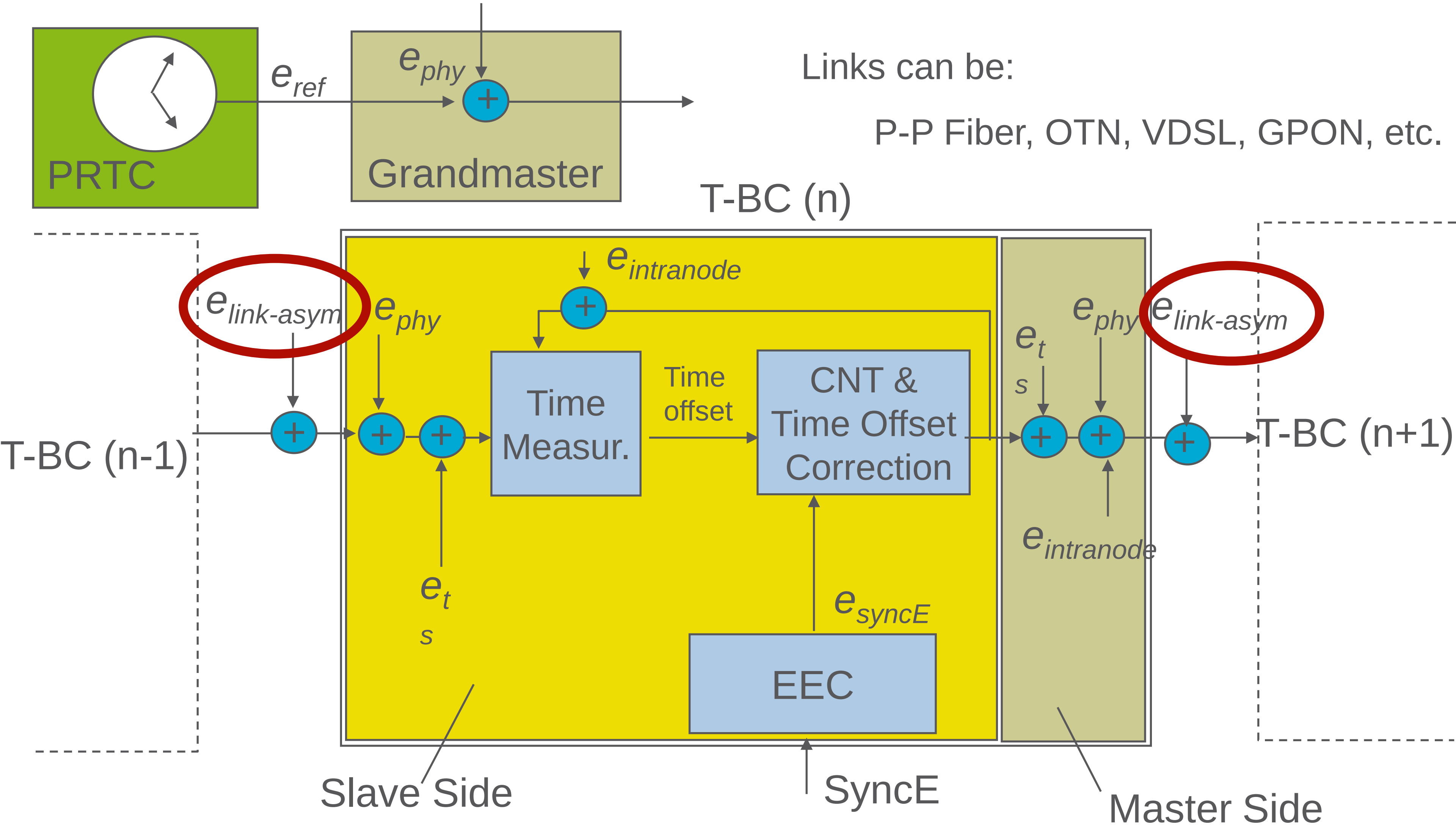


Typical Target Requirements $TE_E < 1.5\ \mu s$
(LTE TDD, TD-SCDMA)

PRTC: Primary Reference Time Clock
T-GM: Telecom Grandmaster
T-TSC: Telecom Time Slave Clock

Note: to be moved into G.8271.1

NOISE SOURCES



Links can be:

P-P Fiber, OTN, VDSL, GPON, etc.

NOISE ACCUMULATION

- Total Error TE_{TOT} is the sum of a constant time error component and a dynamic time error component
  - it is assumed that frequency offset and drift components are not present

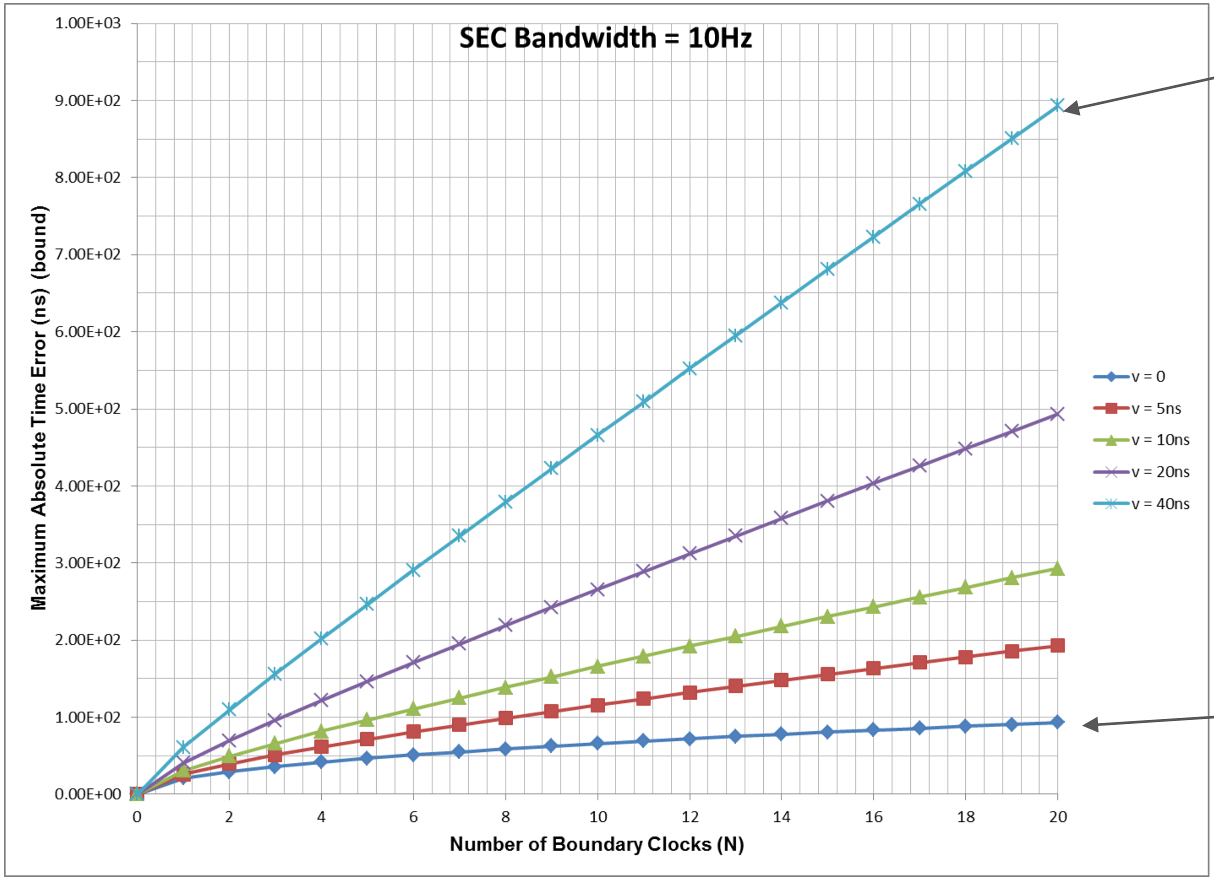
$$\left(\sqrt{M}\right)\cdot TE_{DYNPP} \le TE_{TOT} \le \left(\left(\sqrt{M}\right)\cdot TE_{DYNPP} + M \cdot TE_{CONST} + \Delta_{LINKASYM}\right)$$

TE_{CONST} = absolute value of the constant time error introduced in any clock in the chain
TE_{DYNPP} = peak-to-peak range of the random time error component introduced in any clock in the chain;
$\Delta_{LINKASYM}$ = total link asymmetry component resulting from the interconnection between the clocks in the chain

EXAMPLE OF TIME ERROR ACCUMULATION

Accumulation of maximum absolute time error over a chain of boundary clocks for different values of asymmetry bias.

The physical layer assist involves SEC/EEC chain with bandwidth 10Hz.



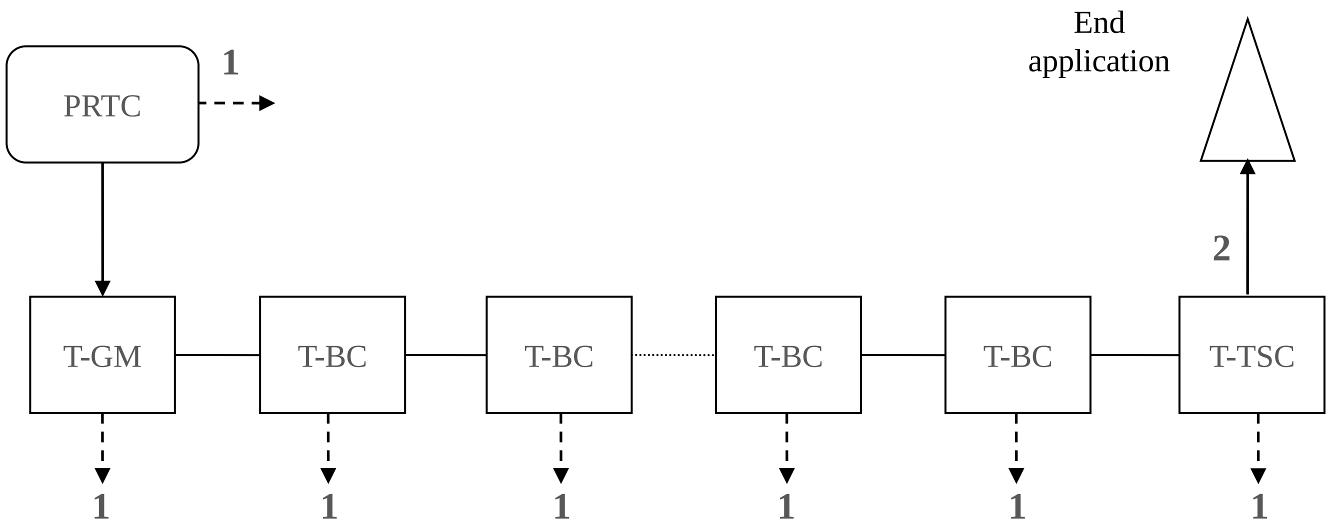
40 ns asymmetry per hop

Source: WD25 (Anue), York, September 2011

no asymmetry

v = max asymmetry per hop

TIME INTERFACES



From G.8271

Reference point 1: measurement interfaces
Reference point 2: distribution interface

Specified in G.8271:
- 1PPS V.11 interface
- 1PPS 50Ω phase synchronization measurement interface

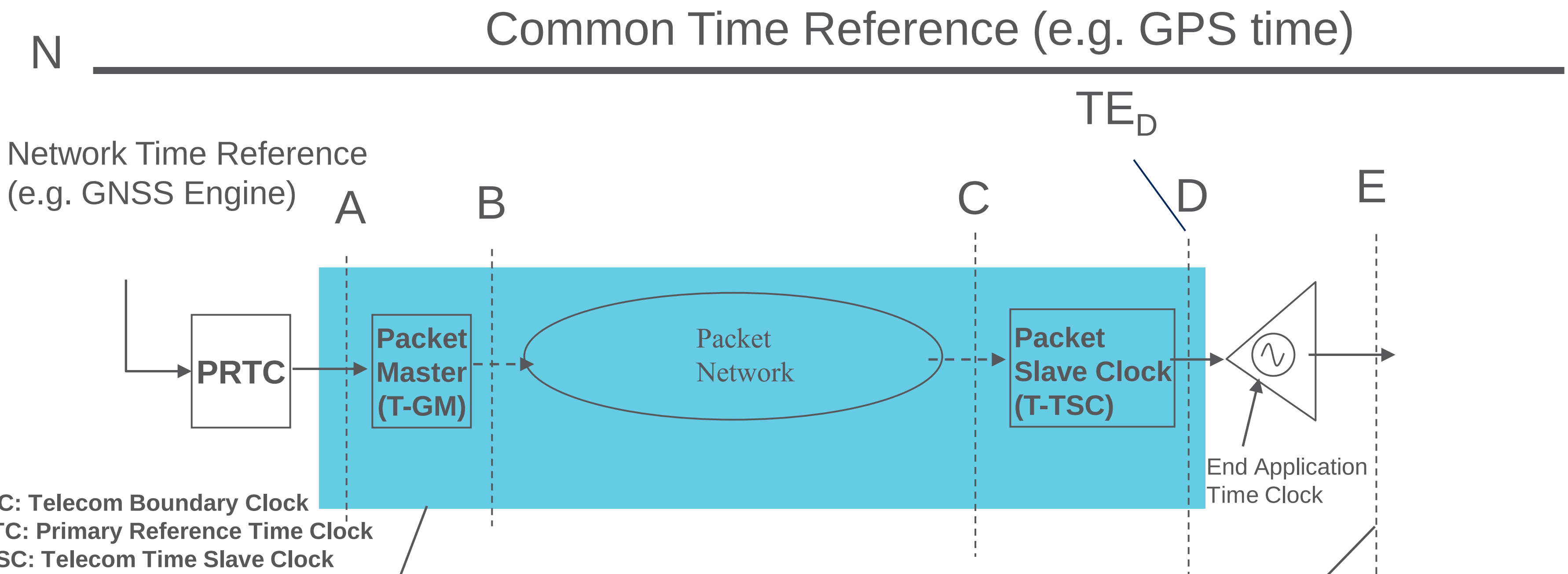
Physical and connector details planned to be included in G.703

G.8271.1: NETWORK LIMITS

- Scope
  - maximum network limits of phase and time error that shall not be exceeded.
  - minimum equipment tolerance to phase and time error that shall be provided at the boundary of these packet networks at phase and time synchronization interfaces.
  - Related Information (HRM, Simulation assumptions, etc.)
- Draft Available (WD8271.1ND)
  - Planned for consent in July 2013
- Details on Simulations in G.Supp
  - Planned for 2013

NOISE (TIME ERROR) BUDGETING ANALYSIS

Focus on Max absolute Time Error



T-BC: Telecom Boundary Clock
PRTC: Primary Reference Time Clock
T-TSC: Telecom Time Slave Clock
T-GM: Telecom Grandmaster

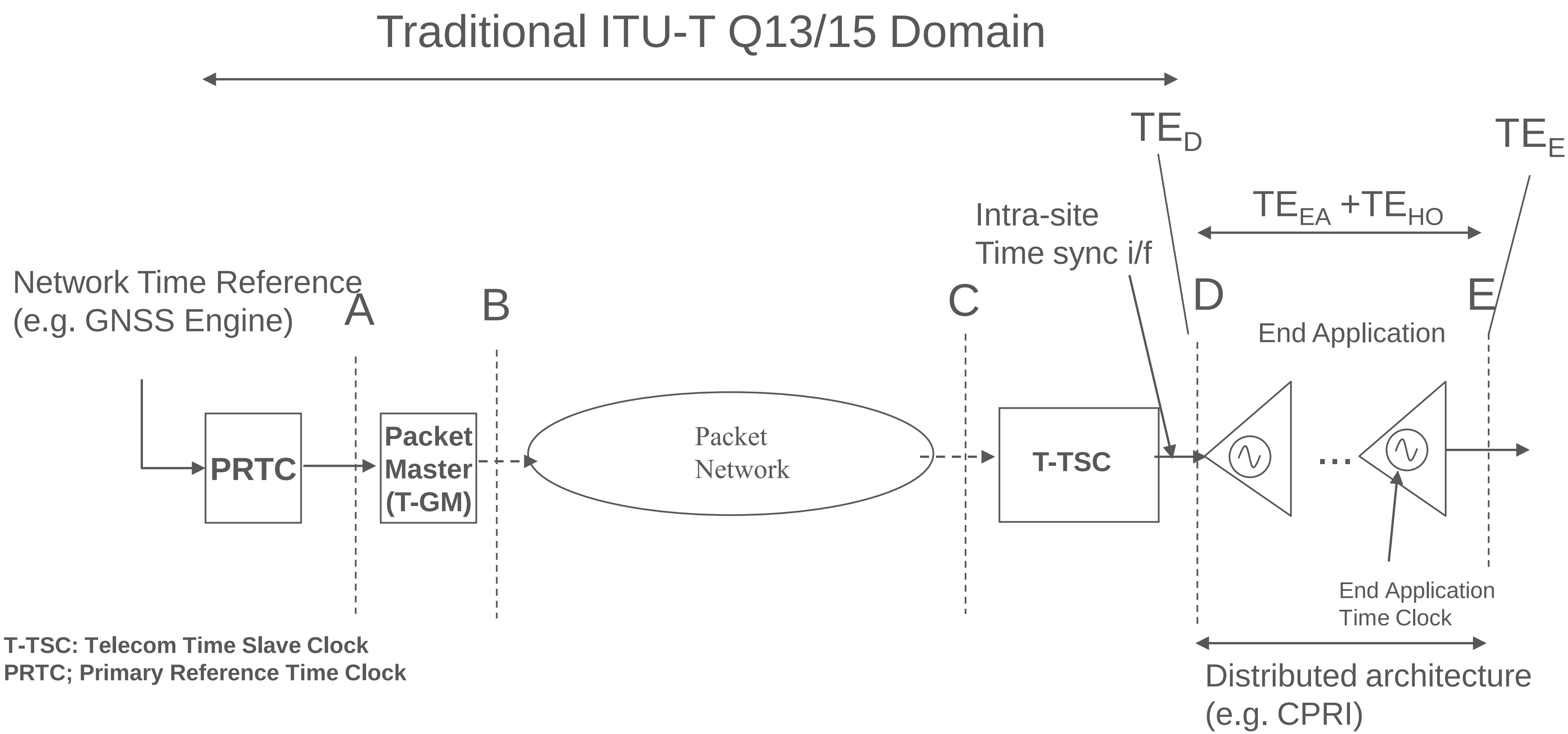
Simulation Reference Model:

Typical Target Requirements TE_E < 1.5 µs
(LTE TDD, TD-SCDMA)

- chain of T-GM, 20 (or 10) T-BCs, T-TSC
- with and without SyncE support

Limits in “D” (TE_D) applicable only in case of External Packet Slave Clock

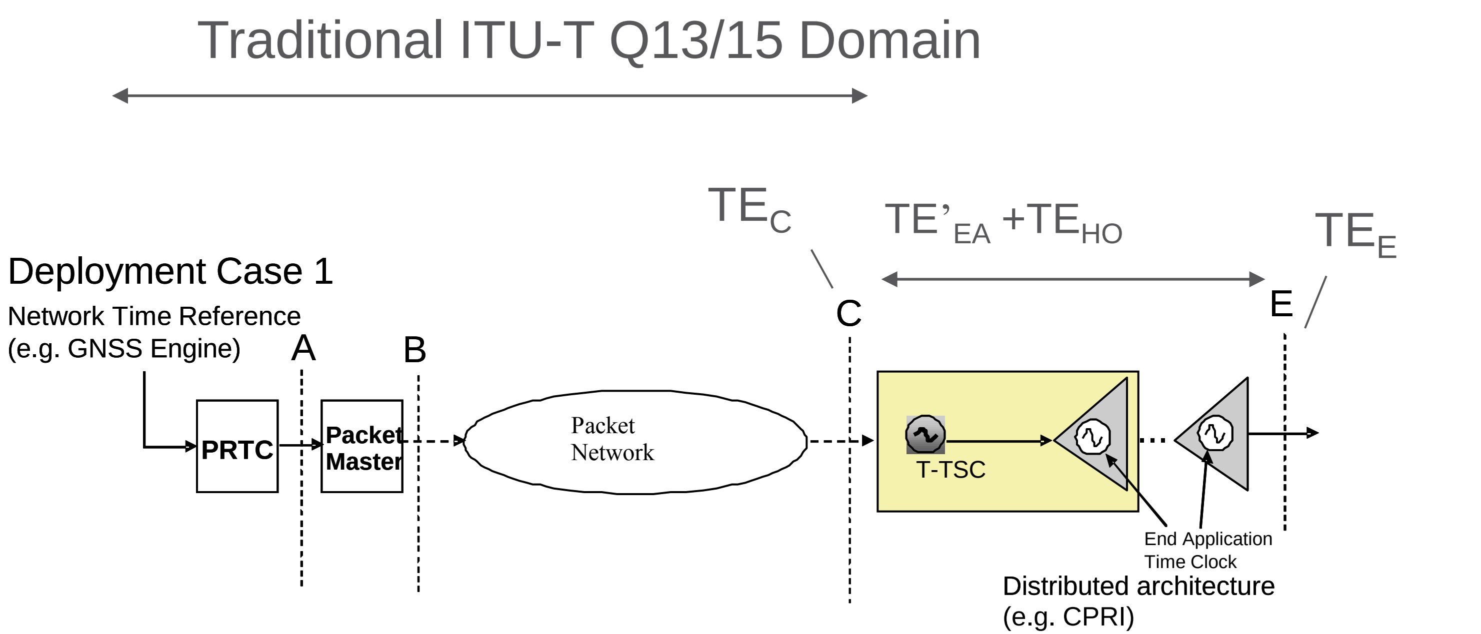
DEPLOYMENT CASE 2: EXTERNAL T-TSC



T-TSC: Telecom Time Slave Clock
PRTC; Primary Reference Time Clock

$$\text{Max } |TE_E| = TE_D + TE_{EA} + TE_{HO} \text{ (Holdover, Rearrangements)}$$

DEPLOYMENT CASE 1: T-TSC INTEGRATED IN THE END APPLICATION



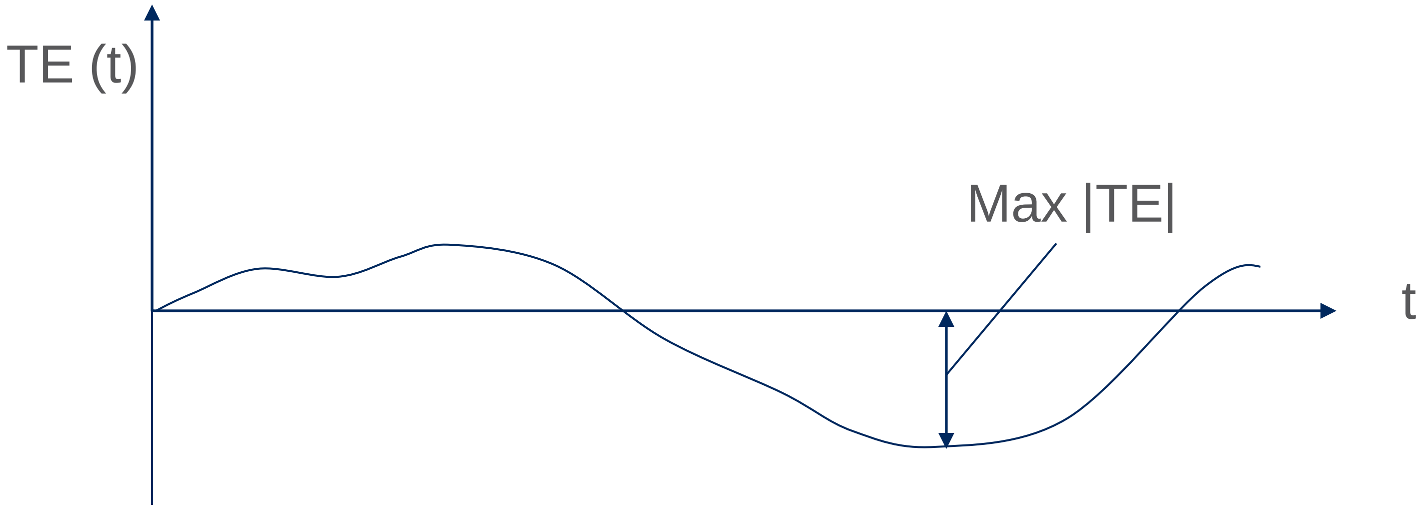
$$TE'_{EA} = TE_{EA} + TE_{TTSC}$$

Max $|TE_E| = TE_C + TE'_{EA} + TE_{HO}$ (Holdover, Rearrangements)

Ongoing discussions on how to define the network limits in this case

METRICS FOR NETWORK LIMITS?

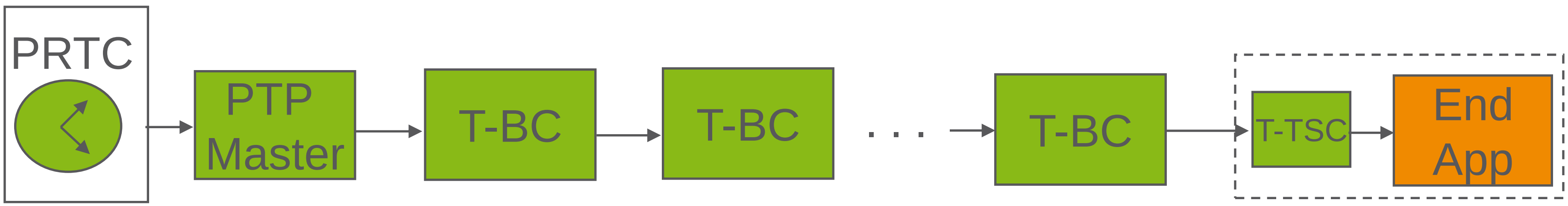
- Main Focus is Max Absolute Time Error (Max |TE|)
  - Measurement details (measurement duration, tolerance in the measurement, e.g. 6 sigma) need further discussion



- Stability aspects also important
  - MTIE? TDEV?
  - Related to End Application filtering capability (Max |TE| is derived from requirements applicable to the radio interface)
  - Different considerations depending where measurement is made (ongoing discussion especially for Deployment case 1)

SIMULATIONS: REFERENCE CHAIN WITH BC IN EVERY NODE

› Removal of PDV and asymmetry in the nodes by means of IEEE1588 support (e.g. Boundary Clock in every node).



PRTC : Primary Reference Time Clock

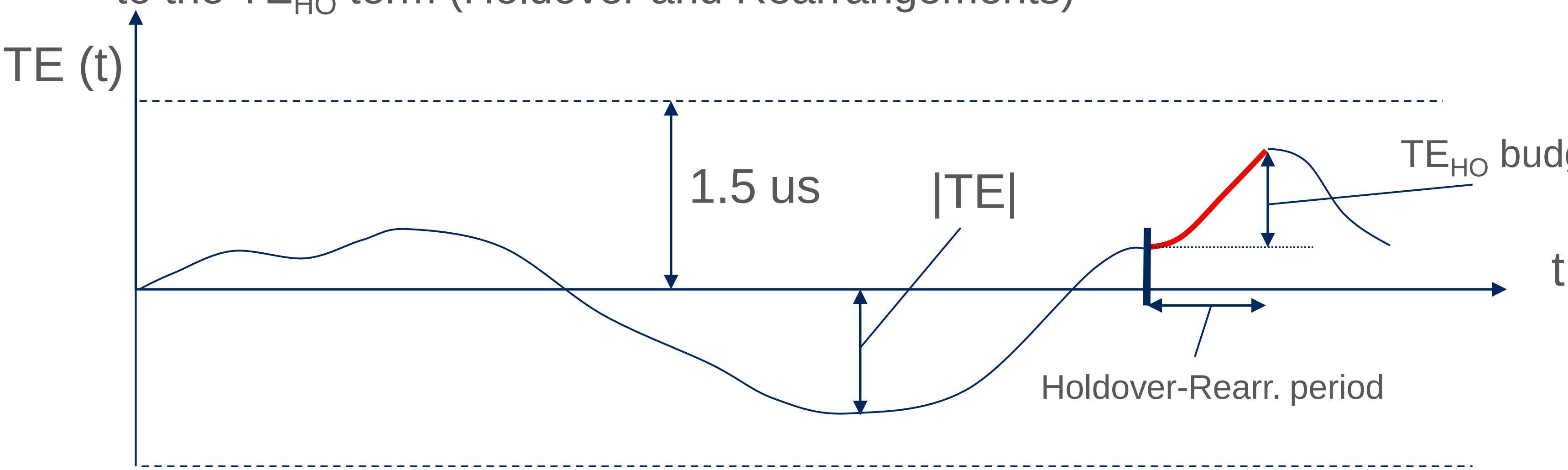
T-BC: Telecom - Boundary Clock

T-TSC: Telecom Time Slave Clock

› Ideally the full support can provide very accurate timing, however several sources of errors still remains:
  › Simulations are developed to analyse the “Random Component” during normal conditions and during rearrangements; with and without SyncE
  › Considerations on the “Static Component” are made separately
› Simulations with partial timing support will require the definition of new HRMs (in G.8271.1 or 8271.2?)

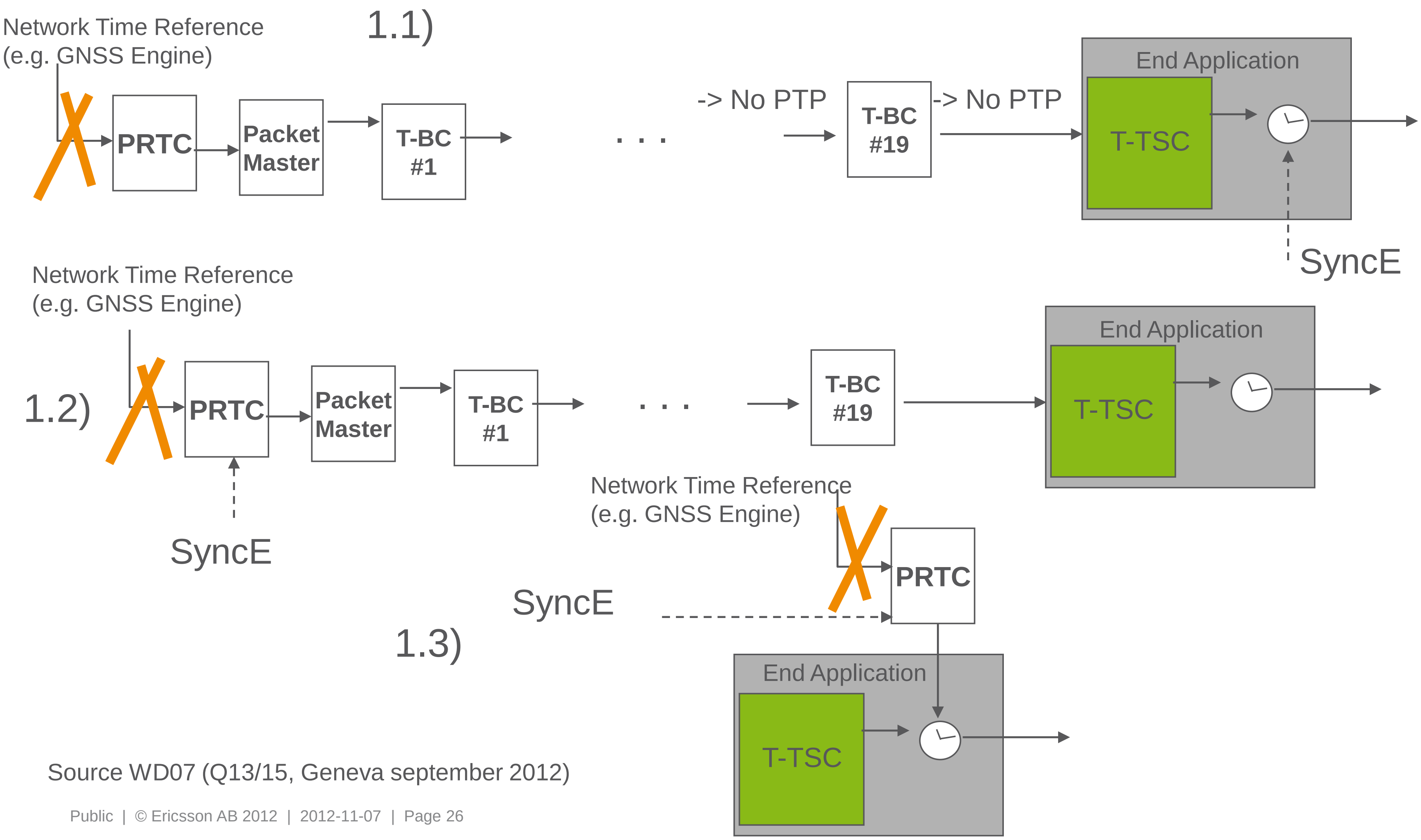
REARRANGEMENTS AND HOLDOVER

- The full analysis of time error budgeting includes also allocating a suitable budget to the TE_{HO} term (Holdover and Rearrangements)



- Holdover
  - **Scenario 1**: PTP traceability is lost and and the End Application or the PRTC enters **holdover** using SyncE or a local oscillator
- Rearrangements
  - **Scenario 2**: PTP traceability to the primary master is lost; the End Application **switches** to a backup PTP reference **with** physical layer frequency synchronization support
  - **Scenario 3**: PTP traceability to the primary master is lost; the End Application **switches** to a backup PTP reference **without** physical layer frequency synchronization support

ANALYSIS OF TIME HOLDOVER (SCENARIO 1)



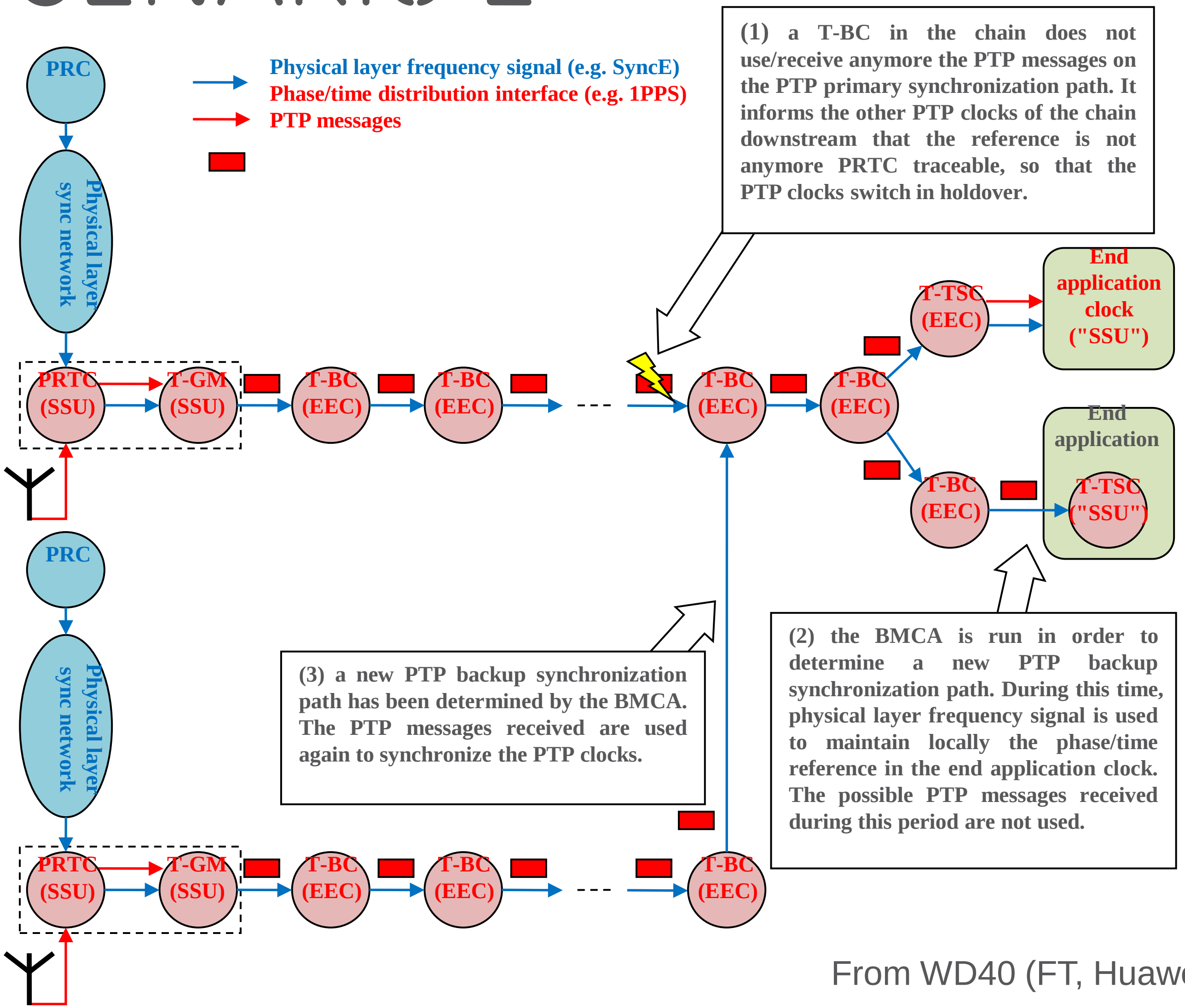
Source WD07 (Q13/15, Geneva september 2012)

TIME HOLDOVER SCENARIOS

Protection Scenario	**Short Holdover period** e.g. 5 min max (e.g. for short Interruptions)	**Long Holdover period** e.g. 3-8 hours (e.g. for Long Interruptions)	**Very long Holdover period** e.g. 1-3 days (e.g. for Very Long Interruption)	**Available Budget** (for 1.5 µs use case)	**Considerations**
1.1	OK according to simulations, both G.812 Type III in holdover or use of SyncE are applicable	**NOK** according to current simulations	**NOK** according to current simulations	TBD (e.g. values in the order of 400ns have been proposed)	Very long period holdover looks challenging at the moment with current assumptions.
1.2	OK according to simulations, both G.812 Type III in holdover or use of SyncE are applicable	**NOK** according to current simulations	**NOK** according to current simulations	TBD (e.g. values in the order of 400ns have been proposed)	Very long period holdover looks challenging at the moment with current assumptions.
1.3	OK according to simulations, both G.812 Type III in holdover or use of SyncE are applicable	OK according to simulations, but only with the use of SyncE, not with G.812 Type III in holdover	Should be OK according to simulations (to be confirmed), but only with the use of SyncE, not with G.812 Type III in holdover	TBD (e.g. 1.25 µs*)	In general this use case looks ok for all holdover periods when SyncE is used

*1.25 = 1.5 – 0.25 ; where 0.25 µs = PRTC accuracy (100ns) + budget of base station (150ns)

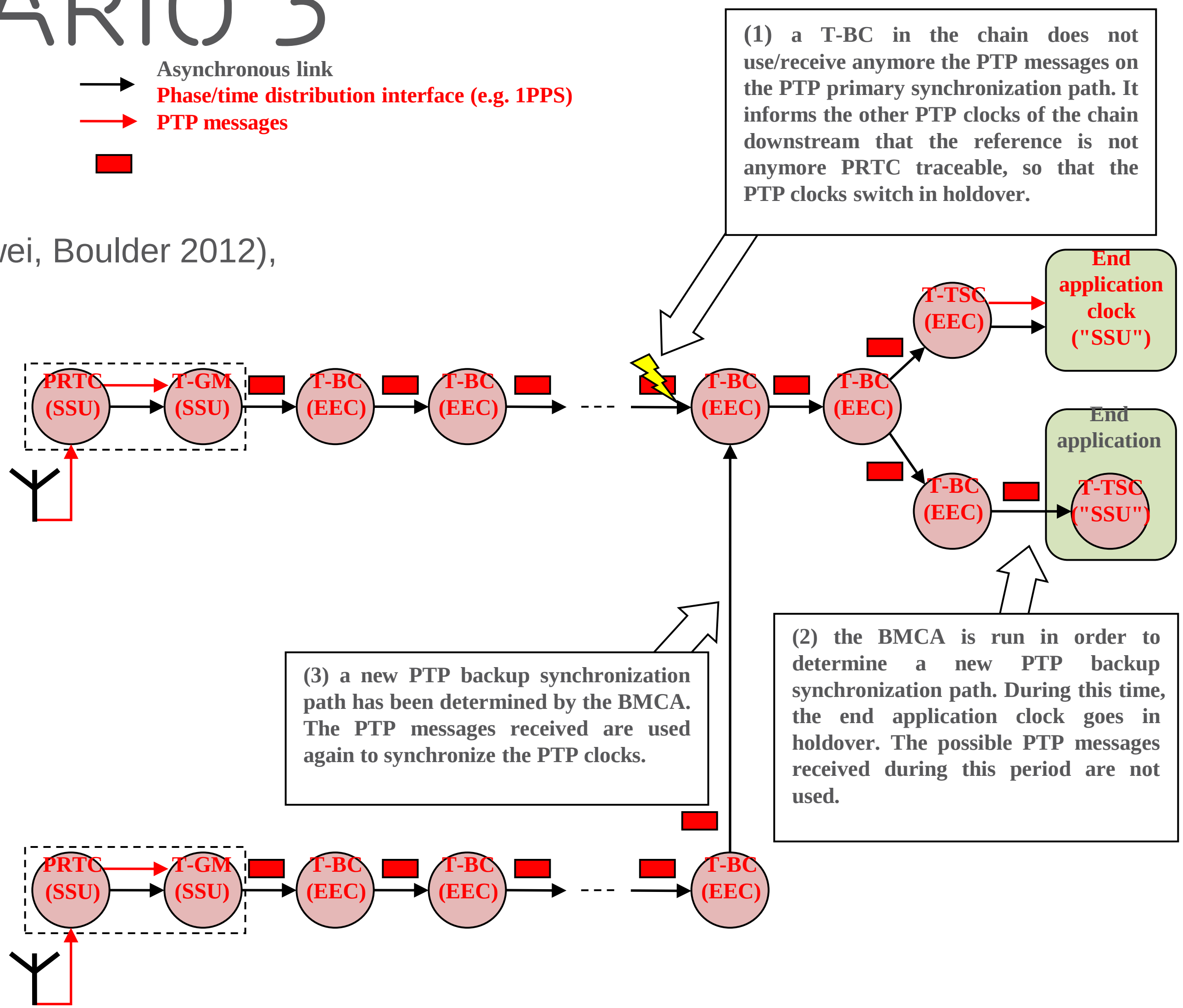
REARRANGEMENTS: SCENARIO 2



From WD40 (FT, Huawei, Boulder 2012)

REARRANGEMENTS: SCENARIO 3

From WD40 (FT, Huawei, Boulder 2012),



Rearrangements could be controlled within 150 ns assuming the Time clock allows for fast start up
If this is not possible a higher budget would be required instead (about 400 ns).

SIMULATIONS RESULTS AND TIME ERROR BUDGETING

- Several simulations have been performed using HRM with SyncE support
- The most challenging scenarios are related to ring rearrangements in SyncE network.
- It seems feasible to control the max |TE| in the 150/200 ns range
  - in the worst case a few mHz filtering would be required
- It is assumed that the nodes in a PTP chain without syncE should be designed in order to accumulate similar level of noise

Budgeting Example for Deployment case 2

TE_D =

PRTC +	100 ns
Link Asymmetries +	100 ns
BC internal errors-static +	500 ns
BC internal errors-random +	200 ns
BC clocks noise accumulation	(included in 200 ns above)
	900 ns

600 ns available for Holdover, Intra-site time sync and End Application

SUMMARY

- G.8271 and G.8271.1 provide the fundamentals for Time synchronization: methods, network requirements
  - G.8271 recently released; G.8271.1 and G.8271 Amendment planned in 2013.
- Some important aspects need to be clarified:
  - T-TSC embedded in a Base Station (where are the limits defined/measured)
  - Filtering of SyncE noise
  - Stability requirements
- The budget for the Time sync Holdover is a key parameter in the noise budgeting analysis
- Allocation of Static noise between links and network equipments
- Analysis of Partial Timing Support require the definition of new simulation models and new HRMs (in 8271.2?)

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