



# SYNCHRONIZATION IN THE MOBILE STANDARDS

WSTS – 2013, San Jose

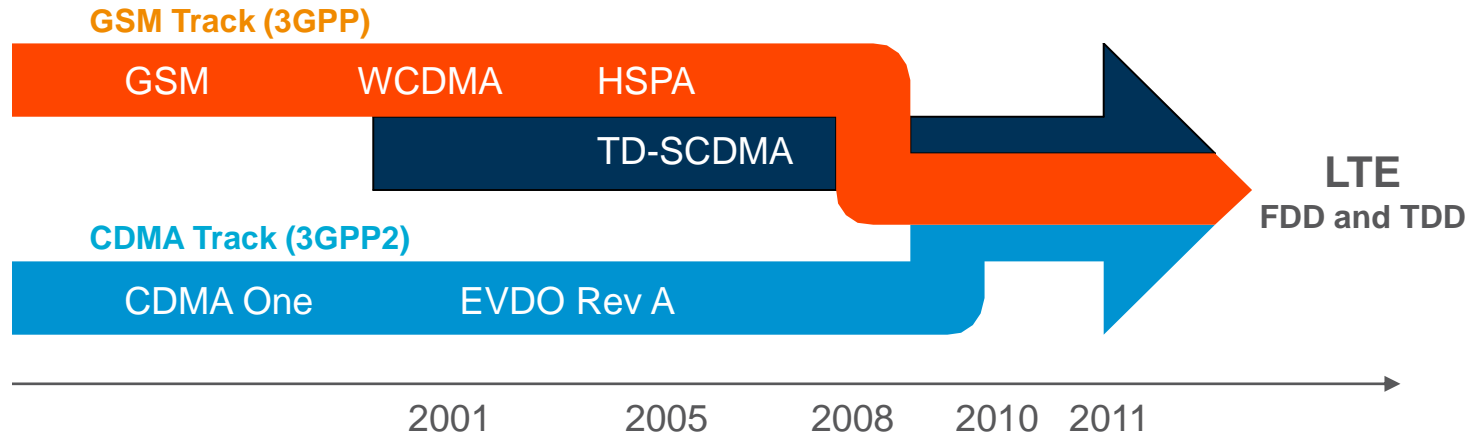
Stefano Ruffini, Ericsson

# MOBILE APPLICATIONS AND SYNCHRONIZATION

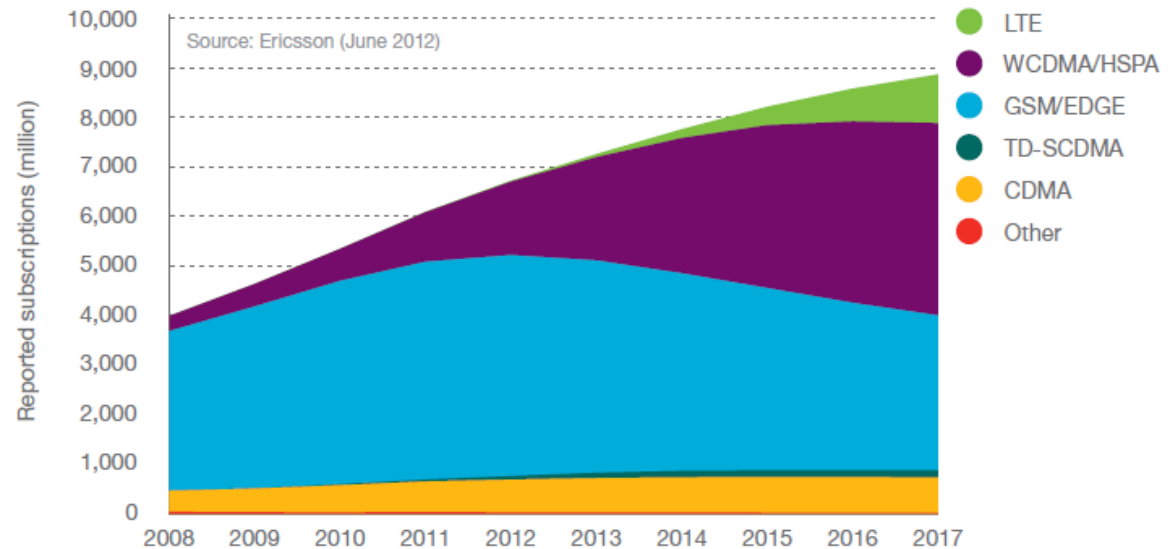


- › The needs of mobile networks are driving most of the current synchronization related efforts in the standards
- › 3GPP is the main body for mobile applications
  - Increased interaction with ITU-T Q13/15
- › New services and architectures may lead to new sync requirements
  - CoMP (Coordinated Multiple Point transmission and reception)
  - Heterogeneous networks/Small Cells
  - Etc.

# EVOLUTION OF MOBILE TECHNOLOGIES



Mobile subscriptions by technology



Source Ericsson, Traffic and Market Report, <http://www.ericsson.com/traffic-market-report>

# INTERNAL STRUCTURE OF 3GPP



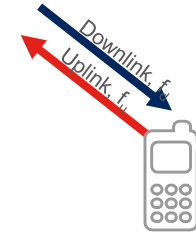
Developing Technical Specifications and Reports with sync related contents

# THE NEED FOR SYNC (IN THE RADIO ACCESS NETWORK)



## › Frequency Synchronization

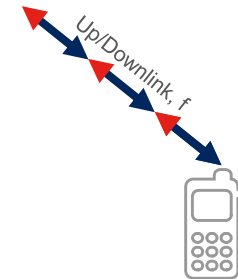
- 3GPP specifies frequency stability on 50 ppb on the air interface
- Minimize disturbance on air interface and secure handover between RBSs
- Fulfill tough regulatory requirements connected to the frequency license



FDD - Frequency Division Duplex

## › Phase (Time) Synchronization:

- Additional air interface requirements for phase (and time) synchronization
- Synchronize transmission from different base stations to prevent interference in TDD mode, optimize bandwidth usage and enhance network capacity
- Support billing and alarm functions (less stringent requirements)



TDD – Time Division Duplex

**Bad synchronization will lead to poor (or no) performance in the RAN**

# SYNCHRONIZATION REQUIREMENTS

## RELEVANT SPECIFICATIONS



Technologies	Document	Notes
<b>CDMA2000</b>	3GPP2 C.S0002-E 3GPP2 C.S0010-C	System Clock requirements
<b>W-CDMA</b>	TS 25.402, TS 25.411 TS 25.104 ,TS 25.105 TS 25.427, TS 25.435, TS 25.415 TS 25.346 TR 25.866	General, Network Interfaces RF Characteristics Node Synchronisation MBSFN Home NodeB TDD Mode
<b>TD-SCDMA</b>	TS 25.123	NodeB (TDD Mode)
<b>LTE &amp; LTE-A</b>	TS 36.300 , TS 36.401, TS 36.211 TS 36.104 TS 36.133 TR 36.922 TR 36.814	General, Network Interfaces RF Characteristics TDD mode (Phase sync) Home Base Station Future applications (new Req.?)

# WCDMA BASE STATION TX FREQUENCY ERROR



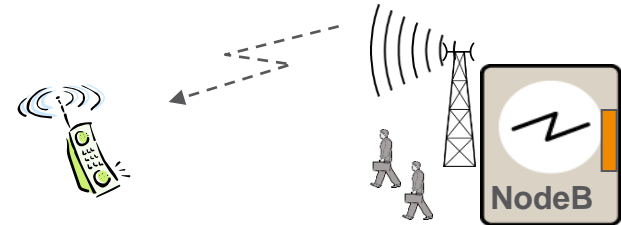
## TS 25.104/5:

“Base Station (BS) radio transmission and reception (FDD/TDD)”

- The Base Station shall use the same frequency source for both RF frequency Generation and the chip clock .
- The modulated carrier frequency is observed over a period of one timeslot for RF frequency generation

BS class	Accuracy
Wide Area BS	$\pm 0.05$ ppm
Medium Range BS	$\pm 0.1$ ppm
Local Area BS	$\pm 0.1$ ppm
Home BS	$\pm 0.25$ ppm

$Y < 0.05-0.25$  ppm



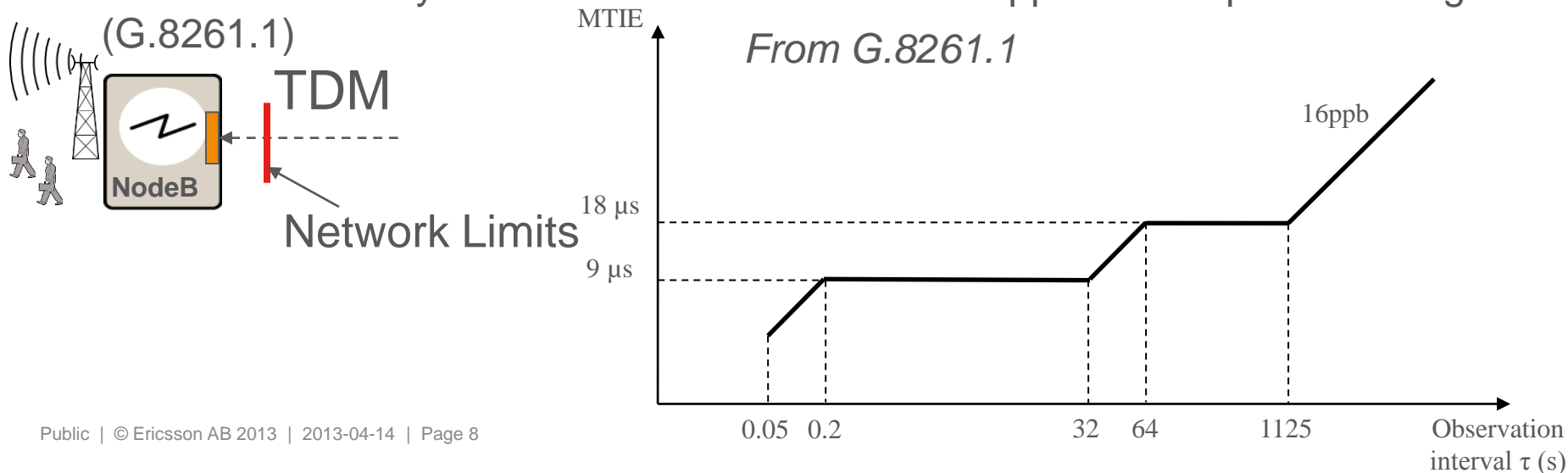
**[ The requirement applies to the radio interface ]**

# BASE STATION TOLERANCE



## **TS 25.411: “UTRAN Iu Interface Layer 1”**

- › The synchronisation reference extracted from the Iu may be used as UTRAN synchronisation reference.
- › The jitter and wander on the interface in accordance with network limits for output wander at traffic interfaces of ITU-T Rec. G.823 or G.824
- › General recommendation is to supply a traceable synchronisation reference according to reference ITU-T Rec. G.811
  - In principle (and in any case during loss of traceability from PRC), lower accuracy is sufficient (e.g. 16 ppb, as per Stratum 2).
  - ITU-T has recently defined an MTIE mask that is applicable to packet timing



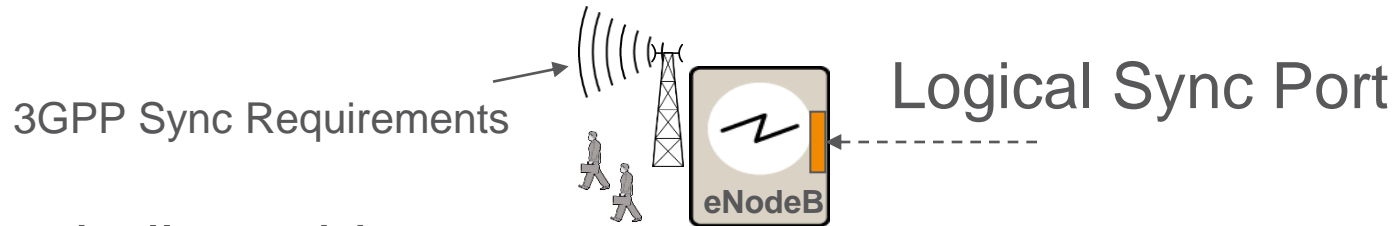


# LTE GENERAL NETWORK SYNCHRONIZATION ASPECTS



**TS 36.401**; “*Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description*”

- › The eNB shall support a logical synchronization port for phase, time and frequency synchronization as required



- › This port shall provide:
  - accuracy that allows to meet eNB phase requirements TDD and MBSFN;
  - continuous time without leap seconds traceable to common time reference;
- › Common SFN (System Frame Number) initialisation time shall be provided for all eNBs.

**No specific synchronization solution is recommended by 3GPP**

# LTE BASE STATION TX FREQUENCY ERROR

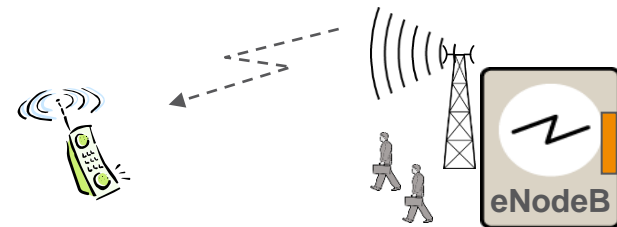


**TS 36.104:** “Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception

- › Frequency Synchronization (Radio Interface) requirements:
  - The same source shall be used for RF frequency and data clock generation.
  - The modulated carrier frequency of the BS observed over a period of one subframe (1ms) shall be accurate to within

BS class	Accuracy
Wide Area BS	$\pm 0.05$ ppm
Local Area BS	$\pm 0.1$ ppm
Home BS	$\pm 0.25$ ppm

$Y < 0.05-0.25$  ppm



Requirements at the input of the eNodeB depends on the actual implementation

**[ The requirement applies to the radio interface ]**

# LTE-TDD PHASE SYNCHRONIZATION REQUIREMENTS



**TS 36.133:** “Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management

**TS 36.922:** “Evolved Universal Terrestrial Radio Access (E-UTRA); TDD Home eNode B (HeNB) Radio Frequency (RF) requirements analysis”

	<b>Maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas</b>
<b>LTE-TDD</b> (Wide-Area BS)	- <b>3usec</b> for small cell (< 3km radius), - <b>10usec</b> for large cell (> 3km radius)
<b>LTE-TDD</b> (Home-Area BS)	- <b>3 usec</b> for small cell (< 500m radius). - <b>1.33 + <math>T_{propagation}</math> <math>\mu</math>s</b> , for large cell (> 500m radius), <i>T<sub>propagation</sub></i> : propagation delay between the Home BS and the cell selected as the network listening synchronization source
<b>LTE-TDD to CDMA handovers</b> (Synchronized E-UTRAN)	- eNodeB shall be synchronized to GPS time. - With external source of CDMA system time disconnected, the eNodeB shall maintain the timing accuracy within $\pm 10$ usec of CDMA system time for a period of not less than 8 hours

# FUTURE REQUIREMENTS (LTE ADVANCED)



**TR 36.814:** “ *Evolved Universal Terrestrial Radio Access (E-UTRA);  
Further advancements for E-UTRA physical layer aspects*”

- › Phase/Time requirements for the applications listed below are currently under study:
  - › Carrier Aggregation
  - › Coordinated Multipoint Transmission (aka Network-MIMO)
  - › Relaying function
- › Increased interest on Small Cells scenarios
  - › Possible specific synchronization requirements (eICIC, Coordinated Scheduling, DL Joint Transmission, etc.)
- › Recent feedback from 3GPP (TD710/3, Geneva 09/2012):  
*RAN WG4 has currently not defined any new synchronization related requirement with a potential impact on the solutions for synchronisation in packet networks (i.e. Frequency error on the transmitted signal as per TS 36.104, or cell phase synchronization accuracy as per TS 36.133 still apply).*

# OTHERS



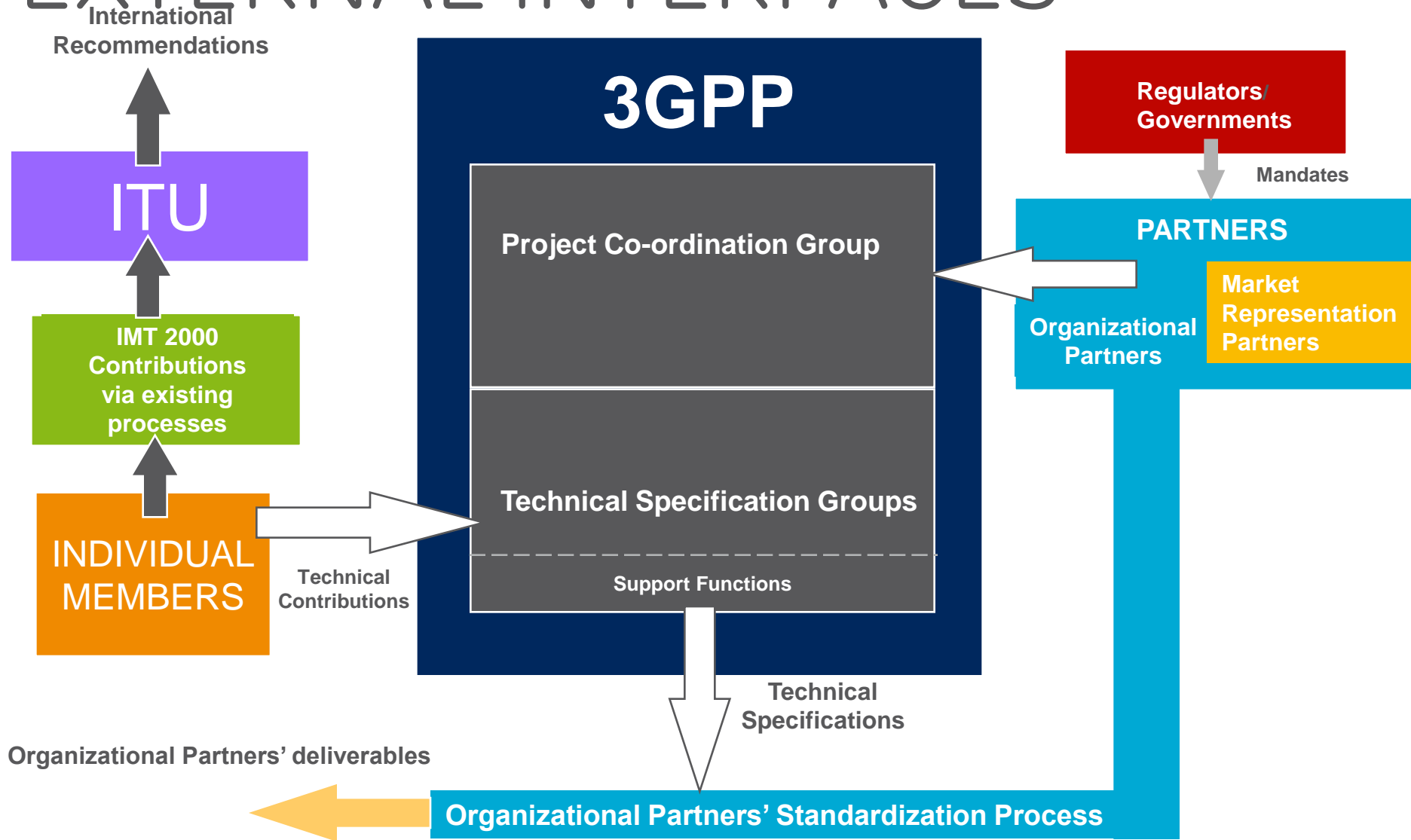
- › Mobile sync needs are addressed in several others Standardization Bodies; a few examples follow
- › MEF: industry alliance promoting the adoption of Carrier-class Ethernet networks.
  - Application of Carrier Ethernet Networks to Mobile Backhaul applications is one of the main study point in MEF
  - MEF 22.1 Mobile Backhaul IA includes details frequency synchronization
  - MEF 22.2 (Phase 3 projected for 2014 approval) includes time/phase synchronization as one of the main items in the scope.
  - Ongoing Project on PDV Metric to map FPP (Floor Packet Percentage) to MEF metrics
- › BBF: Consortium aiming at driving broadband wireline solutions.
  - WT-221 MPLS Mobile Backhaul - Architectural studies involving sync aspects
- › Small Cell Forum (former Femto forum), supports the wide-scale adoption of small cells
  - Ongoing work on Sync White Paper (Synchronization for LTE Small Cells)



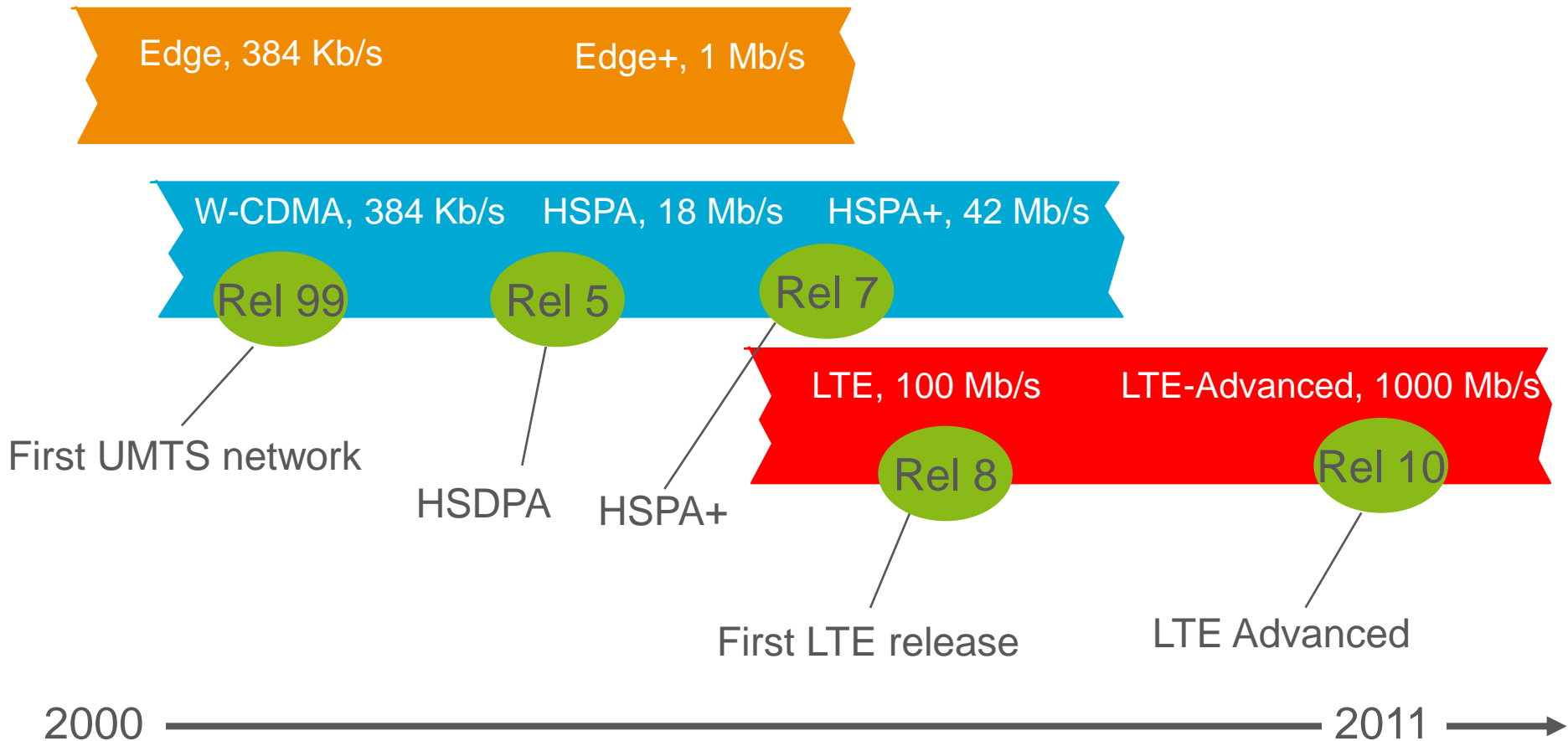
**ERICSSON**

# ADDITIONAL INFORMATION

# OVERVIEW SHOWING EXTERNAL INTERFACES



# STANDARD AVAILABILITY





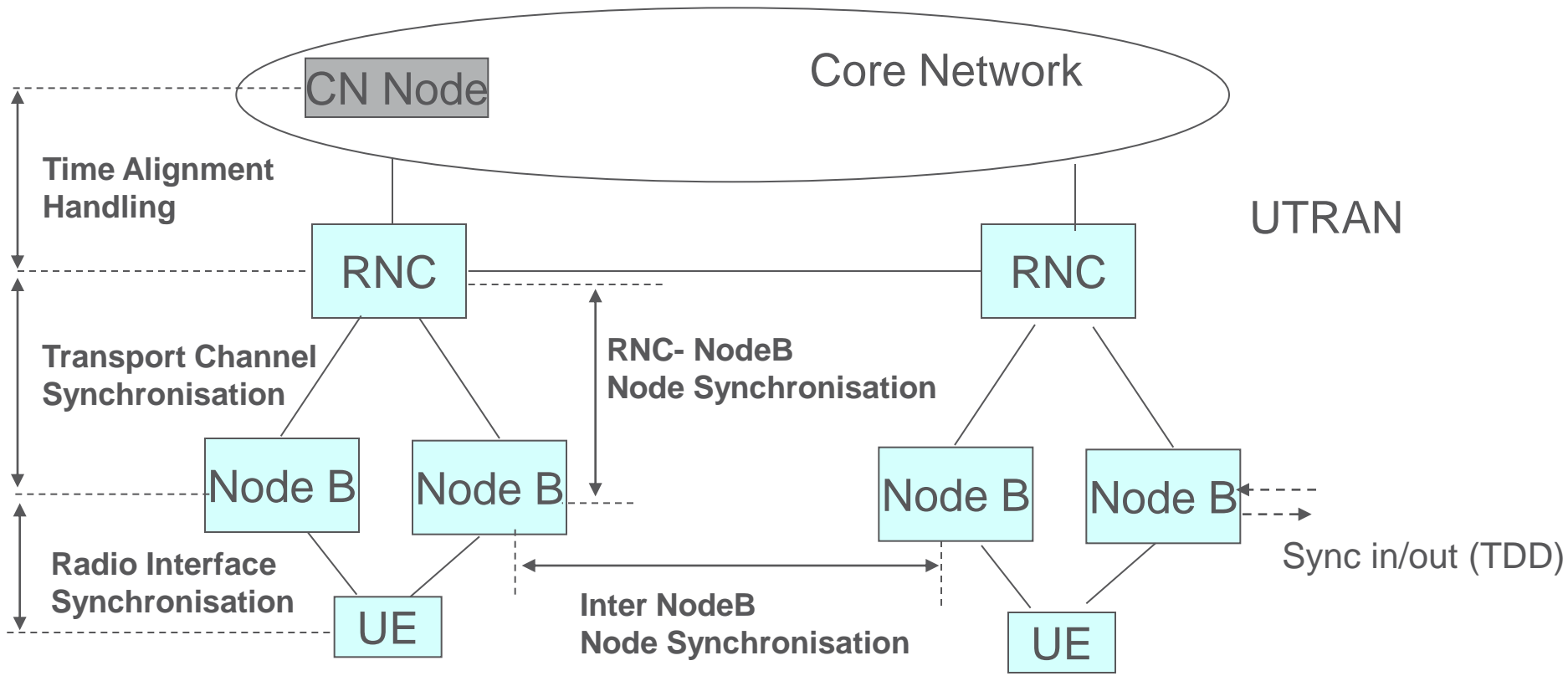
# SYNCHRONIZATION IN THE UTRAN



TS 25.402: "Synchronisation in UTRAN Stage 2"

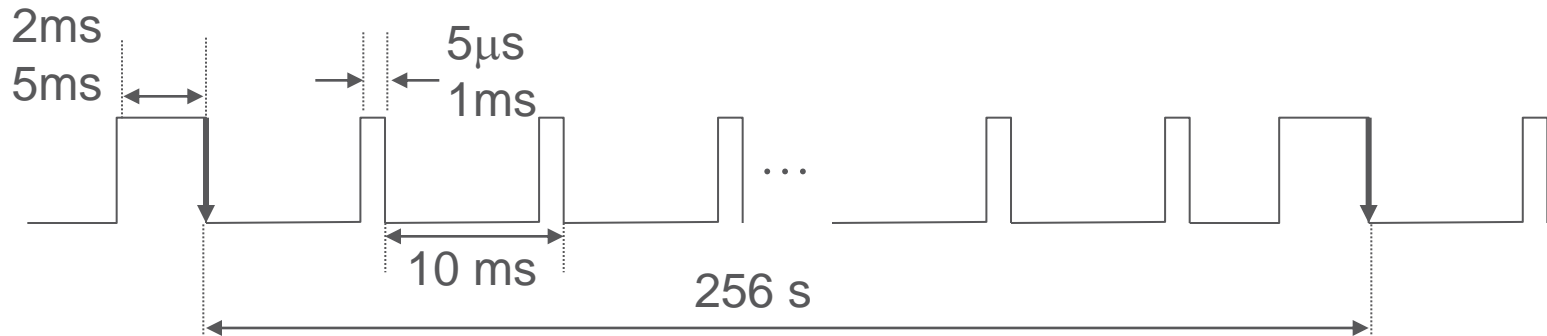
PRC

Network Synchronisation



# ADDITIONAL SYNC REQUIREMENTS FOR TDD MODE

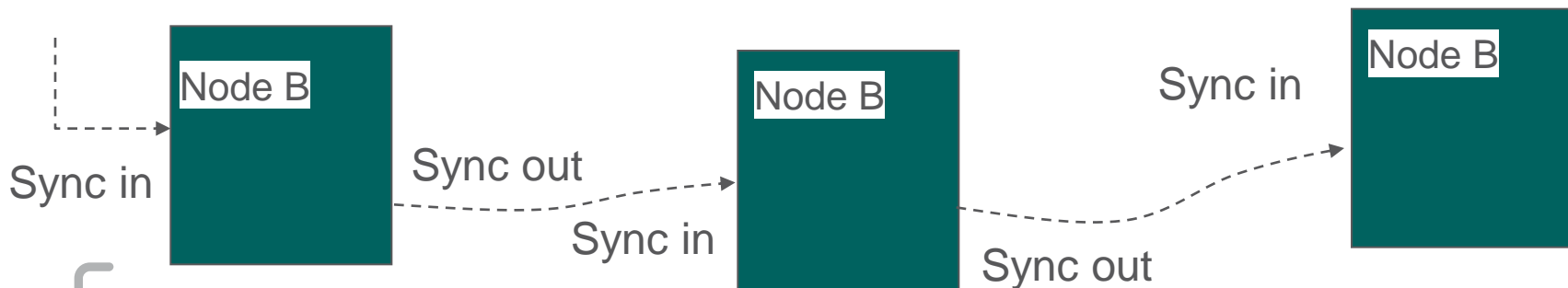
Phase Synchronization (Radio Interface) requirements are defined in TS 25.402  
These apply to UTRA-TDD systems (e.g. TD-CDMA, TD-SCDMA)



*The relative phase difference of the synchronization*

*Signal shall not exceed 2.5 μs (3 μs is mentioned for TD-SCDMA)*

External sync Source (e.g. GPS)



**The Requirements is +/-1.25 μs for independent inputs to the NodeBs**

# ADDITIONAL SYNC REQUIREMENTS IN CASE OF SPECIAL SERVICES: MBSFN



- › MBMS (Multimedia Broadcast Multicast Service) is part of the WCDMA evolution standardized by 3GPP
  - technology for broadcast of content over cellular networks to small terminals (handsets) e.g. for mobile TV.
- › Ordinary MBMS requires time accuracy in the order of tens of ms
- › When MBMS is based on SFN (single-frequency network) mode (MBSFN), a simulcast transmission technique is realised by transmission of identical waveforms at the same time from multiple cells.
- › This is combined by the terminal as multi-path components of a single cell: requirement driven by the length of the OFDM symbol
- › Base Station budget should be a portion of this
  - WCDMA: 12.8 microseconds (TS 25.346)
  - Under study for LTE (e.g. up to +/- 10 microsecond)

# DEFINITIONS



- › **UMTS** (Universal Mobile Telecommunication System) is one of the third-generation (3G) mobile systems being developed within the ITU's IMT-2000 framework. Ordinary UMTS is implemented with WCDMA (Wideband Code Division Multiple Access) technology and Frequency Division Duplexing (FDD)
- › The term **WCDMA** also refers to one of the ITU's IMT-2000 standards, a type of 3G cellular network.
- › **UMTS-TDD** is a mobile standard built upon the UMTS 3G standard, using a TD-CDMA, TD-SCDMA, or other 3GPP-approved, air interface that uses Time Division Duplexing (TDD).
- › **HSPA** (High Speed Packet Access) is a collection of mobile telephony protocols that extend and improve the performance of WCDMA
- › **SAE**, System Architecture Evolution is the core network architecture of 3GPP's LTE wireless communication standard.
- › **LTE** (Long Term Evolution) and has been introduced in 3GPP Release 8 improving latency, capacity and throughput.
- › **LTE Advanced**: is the last major step in mobile radio communications, defined in Rel10 release meeting the IMT-Advanced requirements

