# Mobile standards & synchronization: 3GPP, etc.
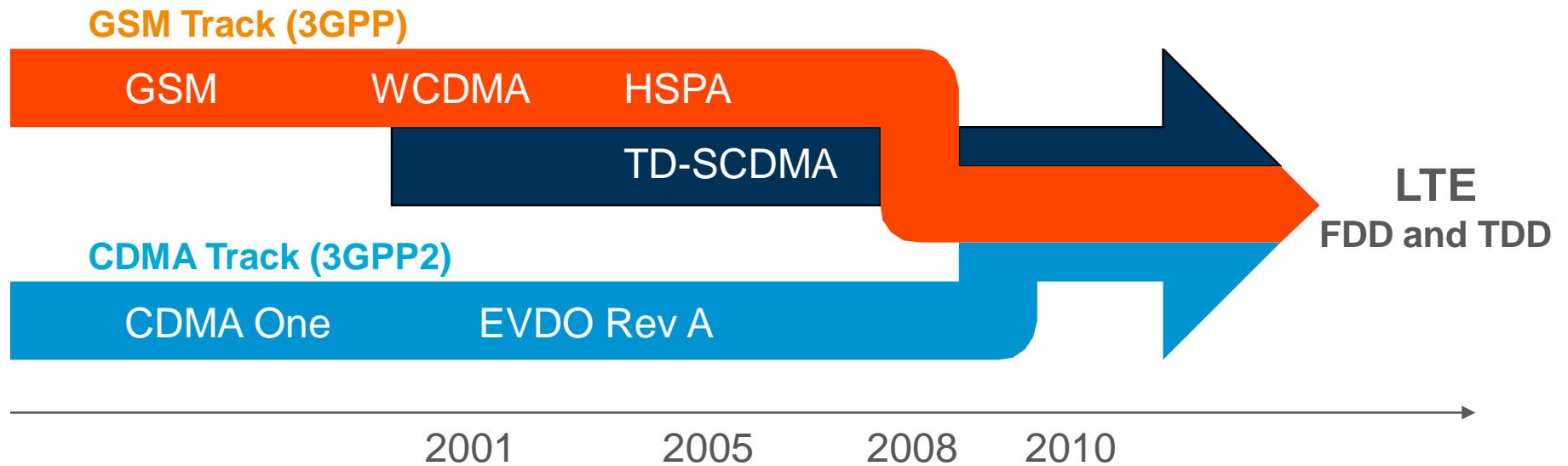
## ITSF - 2011

Stefano Ruffini, Ericsson

# Evolution of mobile technologies



GSM Track (3GPP)

GSM   WCDMA   HSPA

TD-SCDMA

CDMA Track (3GPP2)

CDMA One   EVDO Rev A

LTE
FDD and TDD

2001   2005   2008   2010

# Mobile broadband coverage



World population of 6.9 billion people

Source: Ericsson Annual Report 2010

# Mobile applications and Synchronization

› The needs of Transport and switching networks have been the main drivers for sync standardization in the 90s

  – Mobile applications only as side users (e.g. Synchronous PDH signals are used to synchronize the GSM network in frequency)

› The needs of Mobile networks are now the main drivers of the sync standardization activities in ITU-T:

  – Several bodies where synchronization is a key topic (3GPP, MEF, BBF, NGMN)

› Discussions between ITU-T and 3GPP on the sync aspects not always easy:

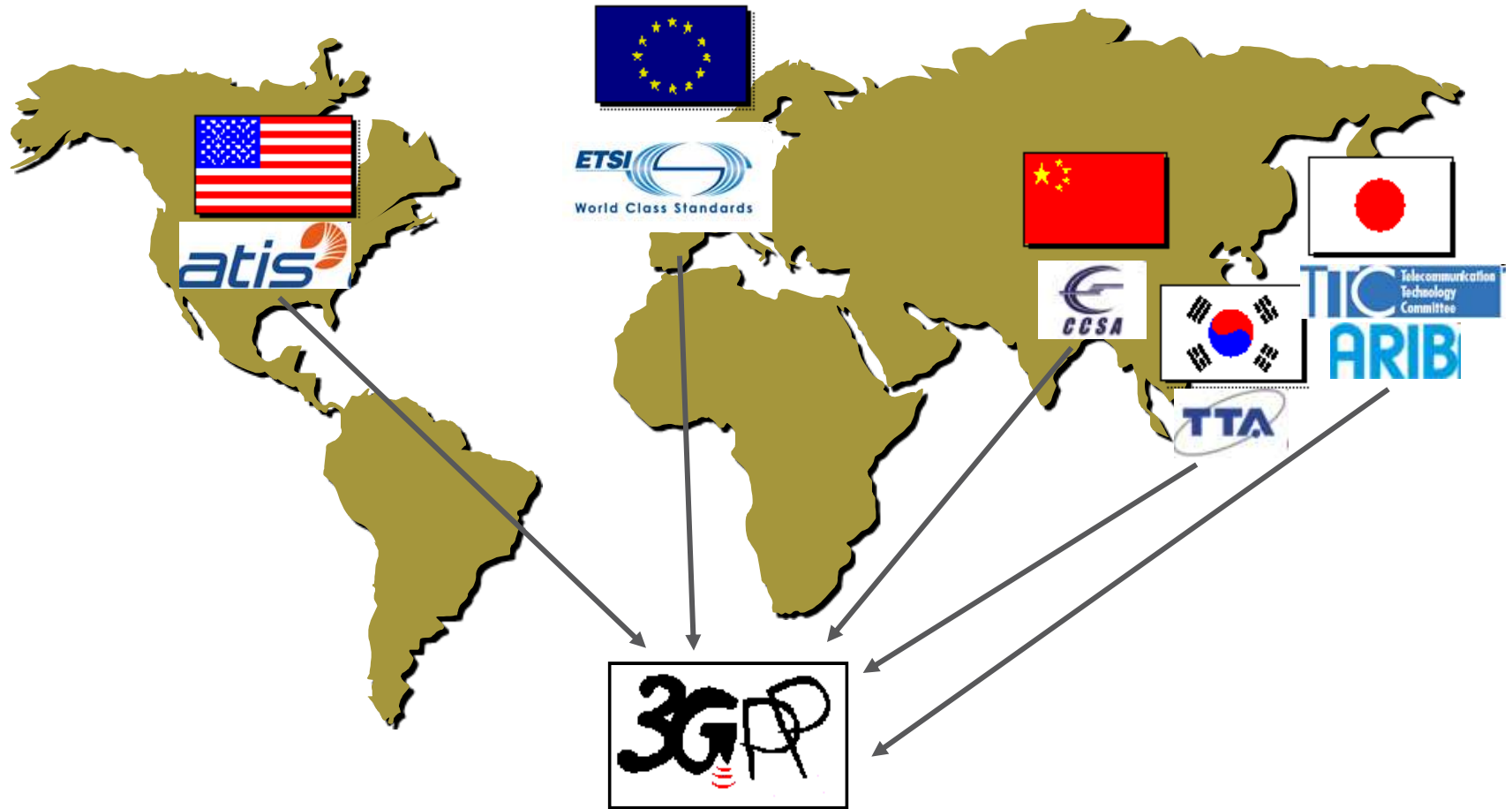  – Use of  different terminologies

  – Different focus

# ETSI and GSM

› ETSI (European Telecommunication Standards Institute), created in 1988, is officially responsible for standardization of ICT within Europe.

  – Developed GSM

  – Inspired the creation and is one of the members of 3GPP

› Sync Requirements mainly related to the frequency accuracy on the air interface (ETSI TS 145 010, **Radio subsystem synchronization**):

  – *The BTS shall use a single frequency source of absolute accuracy better than **0.05 ppm** for both RF frequency generation and clocking the timebase. The same source shall be used for all carriers of the BTS.*

  – *For the pico BTS class the absolute accuracy requirement is relaxed to **0.1ppm**.*

› Discussions on GSM synchronization became soon relevant in the ITU-T and ETSI sync related standardization developments:

  – increased wander when PDH carried over SDH (due to pointer adjustments)

  – issues for Base Station manufacturers; implementations updated according to a revised ITU-T G.823
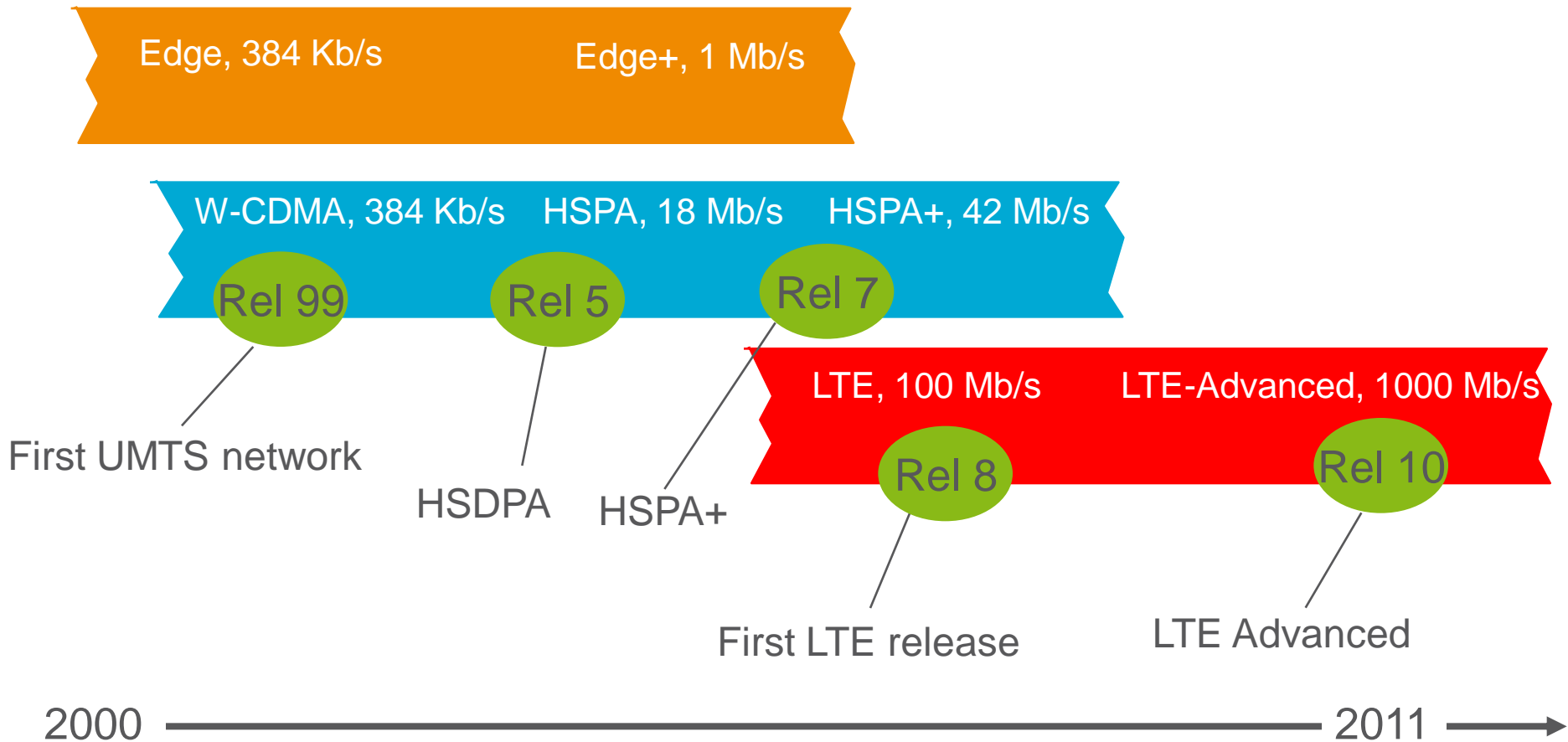
# 3GPP: 3rd Generation Partnership Project

› 3GPP was created in December 1998. Currently 6 Partners.

› "The purpose of 3GPP is to prepare, approve and maintain globally applicable Technical Specifications and Technical Reports for:

– an evolved 3rd Generation and beyond Mobile System based on the evolved 3GPP core networks, and the radio access technologies supported by the Partners (i.e., UTRA both FDD and TDD modes), to be transposed by the Organizational Partners into appropriate deliverables (e.g., standards).

– the Global System for Mobile communication (GSM) including GSM evolved radio access technologies (e.g. General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE)).

– an evolved IMS developed in an access independent manner."

(From "**3GPP Scope and Objectives Approved by 3GPP Organizational Partners by correspondence 31 August 2007**")

# 3GPP Organizational Partners

# Standard Availability



Edge, 384 Kb/s          Edge+, 1 Mb/s

W-CDMA, 384 Kb/s    HSPA, 18 Mb/s    HSPA+, 42 Mb/s

**Rel 99**          **Rel 5**          **Rel 7**

LTE, 100 Mb/s          LTE-Advanced, 1000 Mb/s

**Rel 8**          **Rel 10**

First UMTS network

HSDPA          HSPA+

First LTE release          LTE Advanced

2000                                                      2011

# Internal structure of 3GPP



**Project Co-ordination Group**

**TSG GERAN**
GSM EDGE
Radio Access Network

**GERAN WG1**
Radio Aspects

**GERAN WG2**
Protocol Aspects

**GERAN WG3**
Terminal Testing

**TSG RAN**
Radio Access Network

**RAN WG1**
Radio Layer 1 spec

**RAN WG2**
Radio Layer 2 spec
Radio Layer 3 RR spec

**RAN WG3**
Iub spec, Iur spec, Iu spec
UTRAN O&M requirements

**RAN WG4**
Radio Performance
Protocol aspects

**RAN WG5**
Mobile Terminal
Conformance Testing

**TSG SA**
Service & Systems Aspects

**SA WG1**
Services

**SA WG2**
Architecture

**SA WG3**
Security

**SA WG4**
Codec

**SA WG5**
Telecom Management

**TSG CT**
Core Network & Terminals

**CT WG1**
MM/CC/SM (Iu)

**CT WG3**
Interworking with external networks

**CT WG4**
MAP/GTP/BCH/SS

**CT WG6**
Smart Card Application Aspects

Developing Technical Specifications and Reports with sync related contents

Source: www.3gpp.org

# 3GPP2

› The Third Generation Partnership Project 2 (3GPP2) is another third generation (3G) telecommunications specifications-setting project
  – Mainly North American and Asian interests
  – Standardization group for CDMA2000.
› 3GPP2 was born out of the International Telecommunication Union's (ITU) International Mobile Telecommunications "IMT-2000" initiative
› IMT-2000 is intended to bring high-quality mobile multimedia telecommunications to a worldwide mass market
  – increasing the speed and ease of wireless communications,
  – addressing the increased demand of capacity,
  – "anytime, anywhere" services.

# Synchronization Requirements
# Relevant Standards/Specifications

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

# Synchronization in the UTRAN

PRC — **Network Synchronisation**

**TS 25.402:** *"Synchronisation in UTRAN Stage 2"*

Core Network

CN Node

UTRAN

**Time Alignment Handling**

RNC — RNC

**Transport Channel Synchronisation**

**RNC- NodeB Node Synchronisation**

Node B — Node B

Node B — Node B

**Radio Interface Synchronisation**

UE

**Inter NodeB Node Synchronisation**

UE

Sync in/out (TDD)
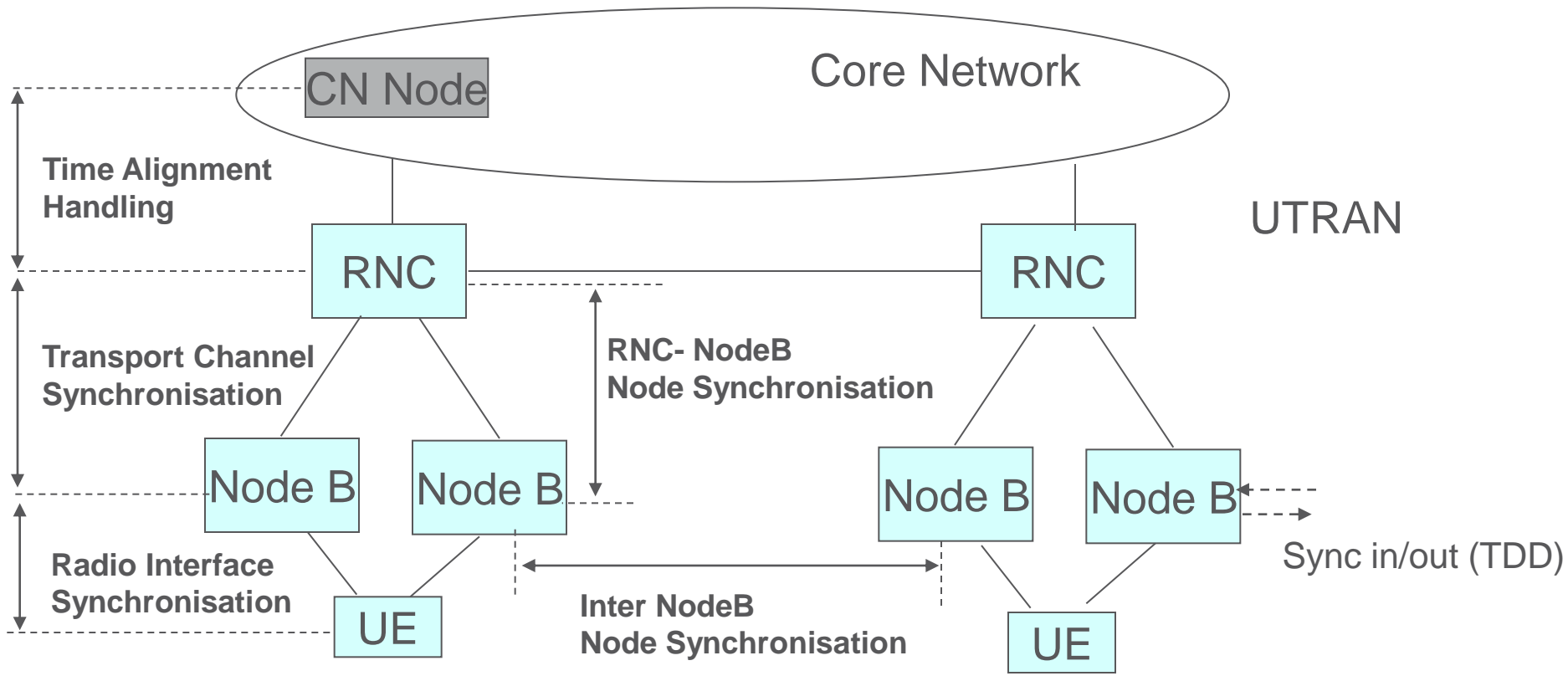
# Additional sync requirements for TDD mode

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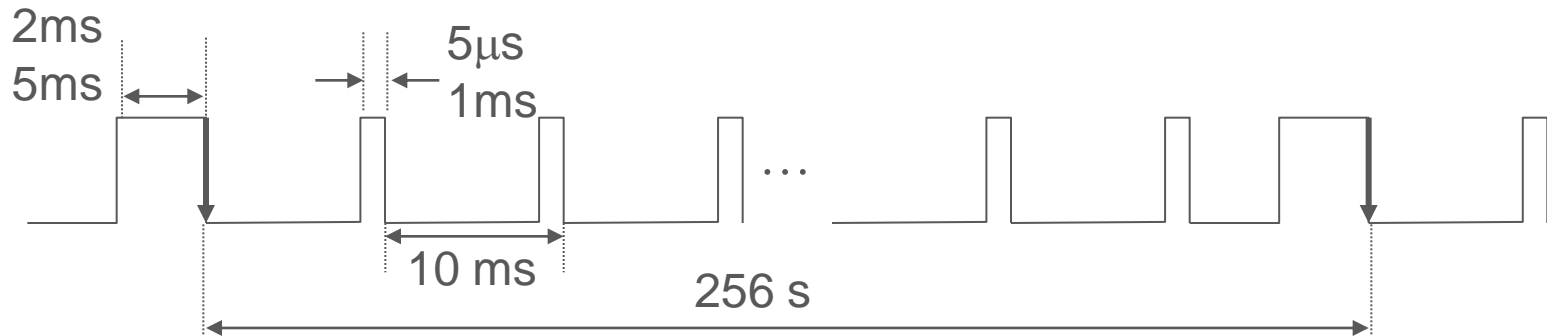


*The relative phase difference of the synchronization*
*Signal shall not exceed 2.5 μs (3 μs is mentioned for TD-SCDMA)*

External sync Source (e.g. GPS)
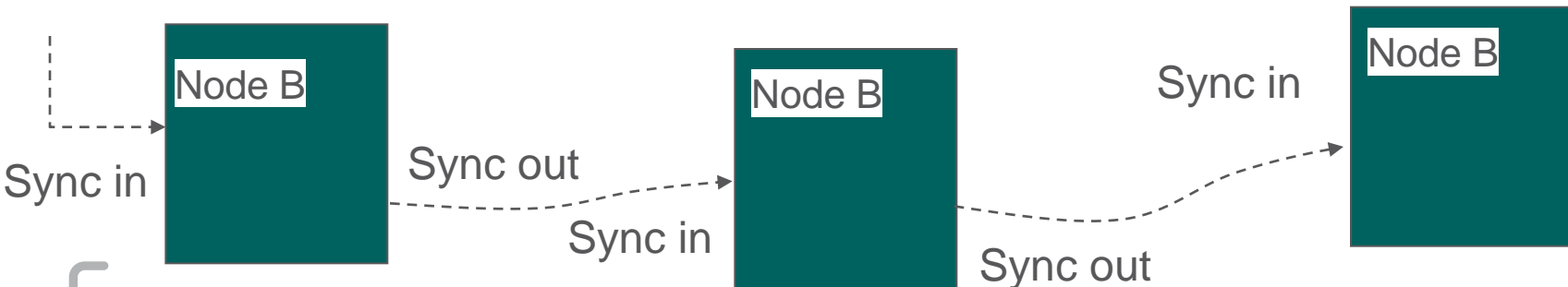


The Requirements is +/-1.25 μs for independent inputs to the NodeBs

# WCDMA Base Station TX Frequency Error

*TS 25.104/5:*

*"Base Station (BS) radio transmission and reception (FDD/TDD)"*

- Frequency Synchronization requirements (on the Radio Interface)

- are specified in 3GPP TS 25.104 (FDD), and TS 25.105 (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

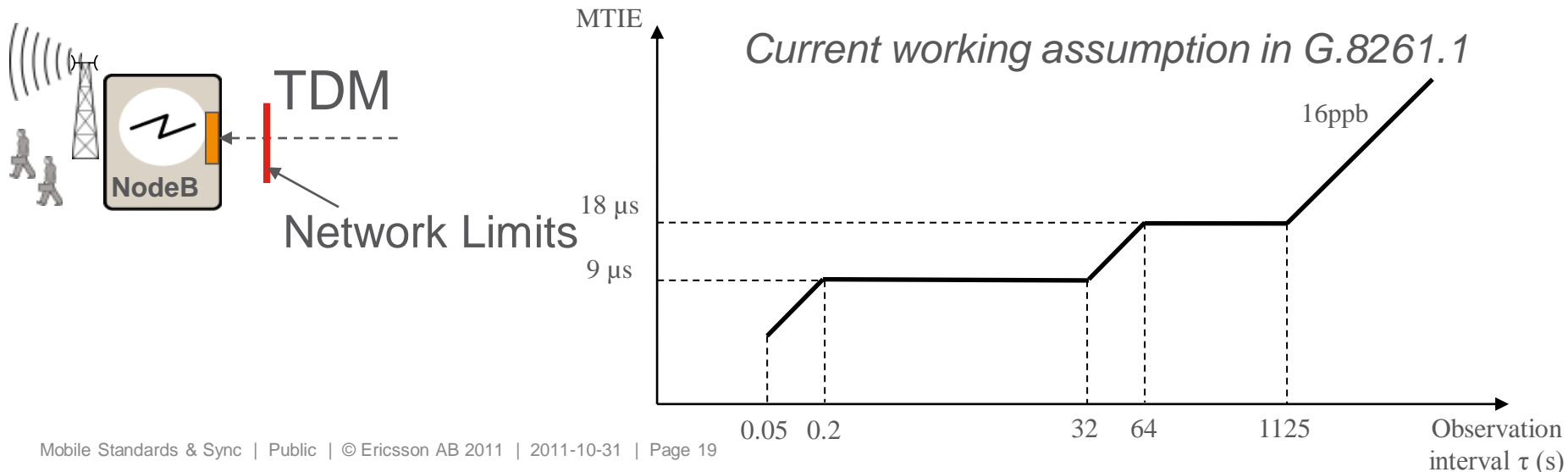| BS class | Accuracy |
|---|---|
| Wide Area BS | ±0.05 ppm |
| Medium Range BS | ±0.1 ppm |
| Local Area BS | ±0.1 ppm |
| Home BS | ±0.25 ppm |

Y < 0.05-0.1 ppm

NodeB
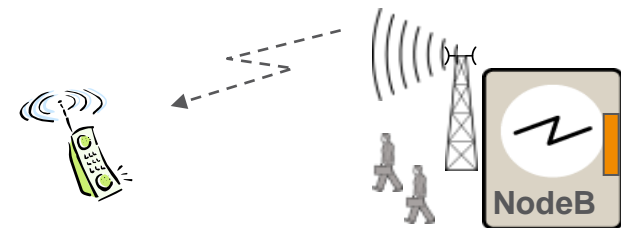
The requirement applies on the radio interface

# 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 <u>traffic</u> 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)

TDM

**NodeB**

Network Limits

MTIE

*Current working assumption in G.8261.1*

16ppb

18 μs

9 μs

0.05  0.2          32   64          1125

Observation interval τ (s)

# 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

3GPP Sync Requirements

Logical Sync Port

eNodeB
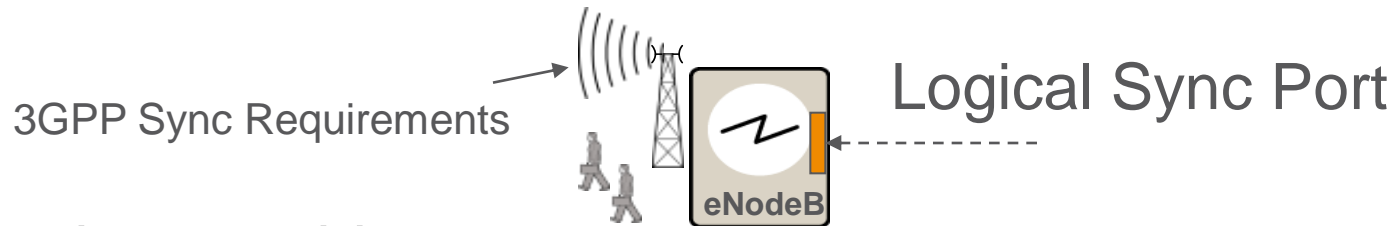
› This port shall provide:
  – accuracy that allows to meet eNB phase requirements TDD and MBSFN;
  – continuous time without leap seconds traceable to common time reference;

› 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 | ±0.05 ppm |
| Local Area BS | ±0.1 ppm |
| Home BS | ±0.25 ppm |

Y < 0.05-0.25 ppm
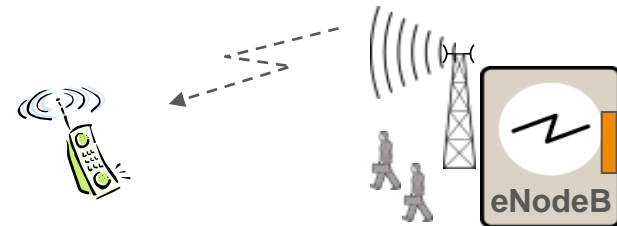
eNodeB

Requirements at the input of the eNodeB depends on the actual implementation (for instance network limits are defined in case the frequency reference is distributed over the physical layer, TDM or Synchronous Ethernet)

The requirement applies on 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"*

| | Maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas |
|---|---|
| **LTE-TDD** (Wide-Area Base station | - **3usec** for small cell (< 3km radius), <br> - **10usec** for large cell ( > 3km radius) |
| **LTE-TDD** (Home-Area Base station) | - **3 usec** for small cell (< 500m radius). <br><br> - **1.33 +** *Tpropagation* μ**s**, for large cell (> 500m radius), *Tpropagation:* propagation delay between the Home BS and the cell selected as the network listening synchronization source |
| **LTE-TDD to CDMA handovers** (Synchronized E-UTRAN) | - eNodeB shall be synchronized to GPS time. <br><br> - With external source of CDMA system time disconnected, the eNodeB shall maintain the timing accuracy within $\pm$ 10usec 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 "Hetnet" scenarios (e.g. "small cells", also studied by NGMN)

  › Possibly specific synchronization requirements

# Example of Hetnet options: RBS vs RRU



Low power RBSs

Low power RRUs
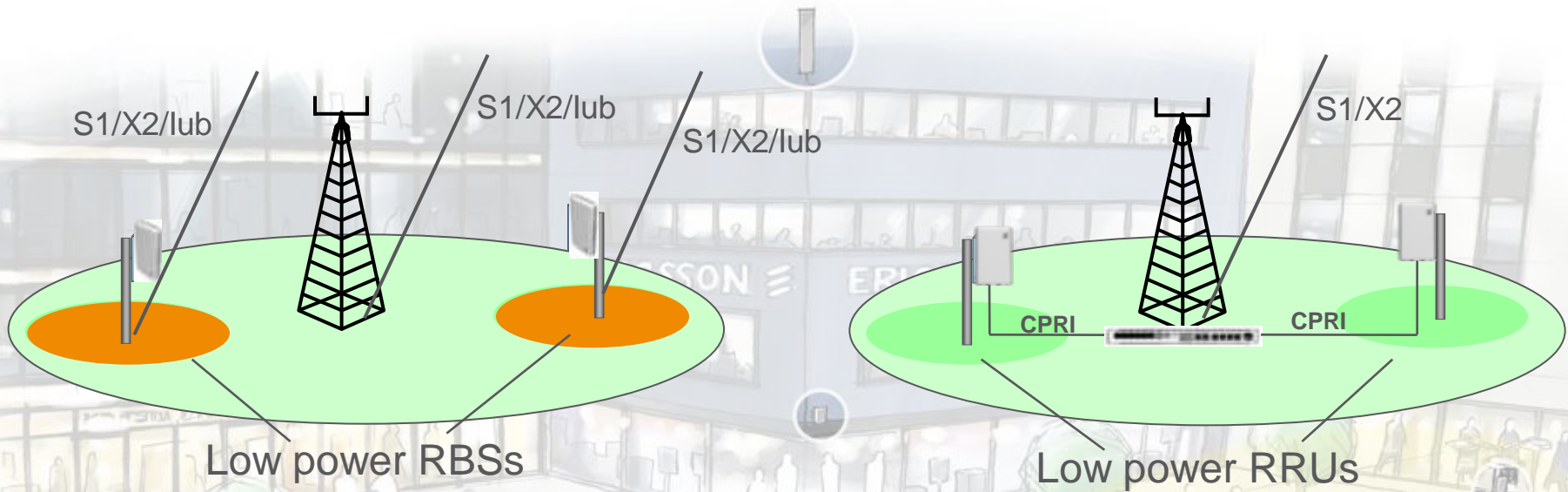
- › Backhaul: xDSL, uW, Eth etc.
- › Performance potential (e.g. In terms of UL interference): Good
- › Synchronization: Depends on desired level of coordination
- › Coordination: Loose

- › Backhaul: Dedicated Fibre for CPRI
- › Performance potential (e.g. In terms of UL interference): Best
- › Synchronization: via CPRI
- › Coordination: Tight

## Available transport dictates deployment strategy

# NGMN, Next Generation Mobile Networks

› The NGMN Alliance is a forum to share, assess, and drive aspects of mobile broadband technologies focusing on LTE & EPC (Evolved Packet Core) and its evolution.

› Among the targets of this alliance:
  – To establish clear performance targets, fundamental requirements including spectrum and deployment scenarios
  – To give guidance to equipment developers and standardisation bodies, leading to the implementation of a cost-effective network evolution

› The NGMN Alliance currently comprises 63 Partners from telecommunications industry and research:
  – 18 mobile network operators (Members),
  – 42 vendors/ manufacturers (Sponsors),
  – 3 universities or non-industrial research institutes (Advisors).

› Recently initiated a discussion with 3GPP and Q13/15 concerning sync in mobile backhaul

# MEF, Metro Ethernet Forum

› MEF is a global industry alliance formed in 2001

– to accelerate the worldwide adoption of Carrier-class Ethernet networks and services

– develops Carrier Ethernet technical specifications and implementation agreements to promote interoperability and deployment of Carrier Ethernet worldwide

› Main Deliverables:

– Implementation Agreements on existing standards

– Test Procedures

– Technical Specifications

– Marketing

– Certification Program

–  Practical examples of Implementation of Carrier Ethernet
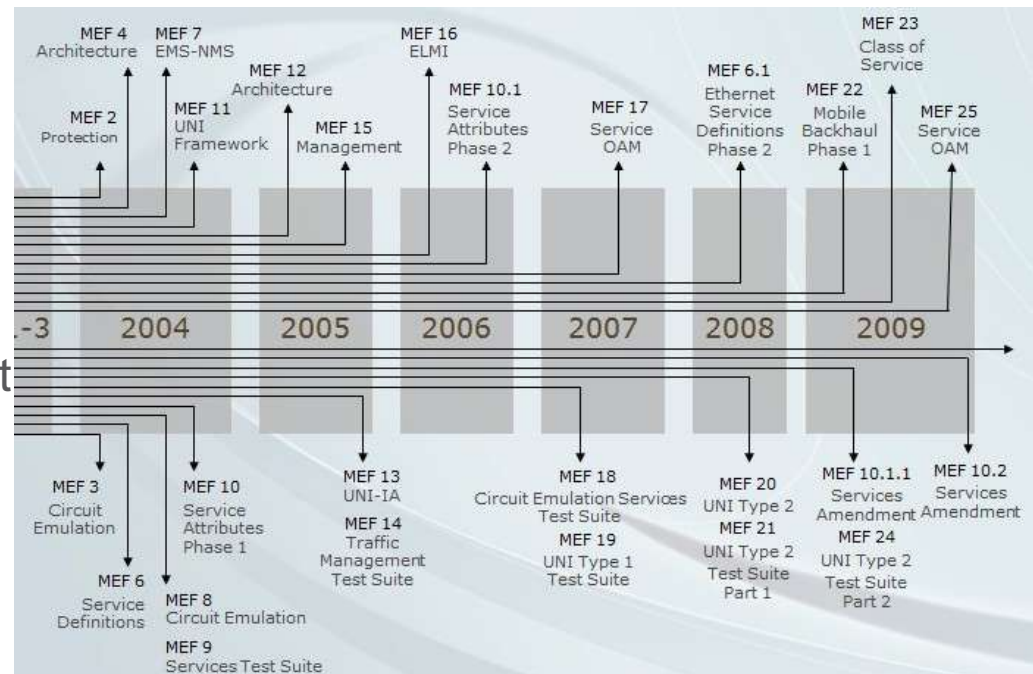
# Mobile Backhaul WG

› Application of Carrier Ethernet Networks to Mobile Backhaul applications is one of the main study point in MEF

› MEF 22 (Mobile Backhaul IA), Phase 1 & 2 to address all related aspects

› MEF 22 Phase 1 was approved as an official MEF Specification in January 2009.

  – Synchronization is one of the main items (frequency synchronization)

  – either delivered outside of the Ethernet transport network or using a packet based method that is transparent to the MEN

› MEF 22 Phase 2 under development (planned to be completed by end 2011):

  – Synchronous Ethernet is the main addition

# BBF, Broadband Forum

› Consortium of about 200 Telecom industry players
  – Established in 1994 originally as the ADSL Forum and later the DSL Forum, the Broadband Forum recently united with the IP/MPLS Forum

› Aiming at driving broadband wireline solutions and empowering converged packet networks worldwide

› Develop multi-service broadband packet networking specifications addressing interoperability, architecture and management.

› The work is structured into Technical and Marketing Working Groups; Mobile Backhaul and related synchronization aspects have a central role in some of the Working groups, e.g. :
  – WT 221, MPLS Based Mobile Backhaul
  – WT 178, Multi-service Broadband Network Architecture and Nodal Requirements
  – WD 145, Multi-service Broadband Network Functional Modules and Architecture

# Summary

› 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

› Definition of new services and architectures in 3GPP may lead to new sync related activities in the standards

   – CoMP

   – "Hetnet/Small Cells"

   – Etc.