# WCDMA and LTE Synchronization Aspects

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# Presentation outline

- Overview on WCDMA and LTE
- WCDMA and LTE Synchronization Requirements
- Alternative solutions for timing distribution

# WCDMA and LTE Overview

# Useful 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 future LTE wireless communication standard.
- **LTE** (Long Term Evolution) is the next major step in mobile radio communications, and will be introduced in 3GPP Release 8 improving latency, capacity and throughput.

# Mobile Broadband happens now

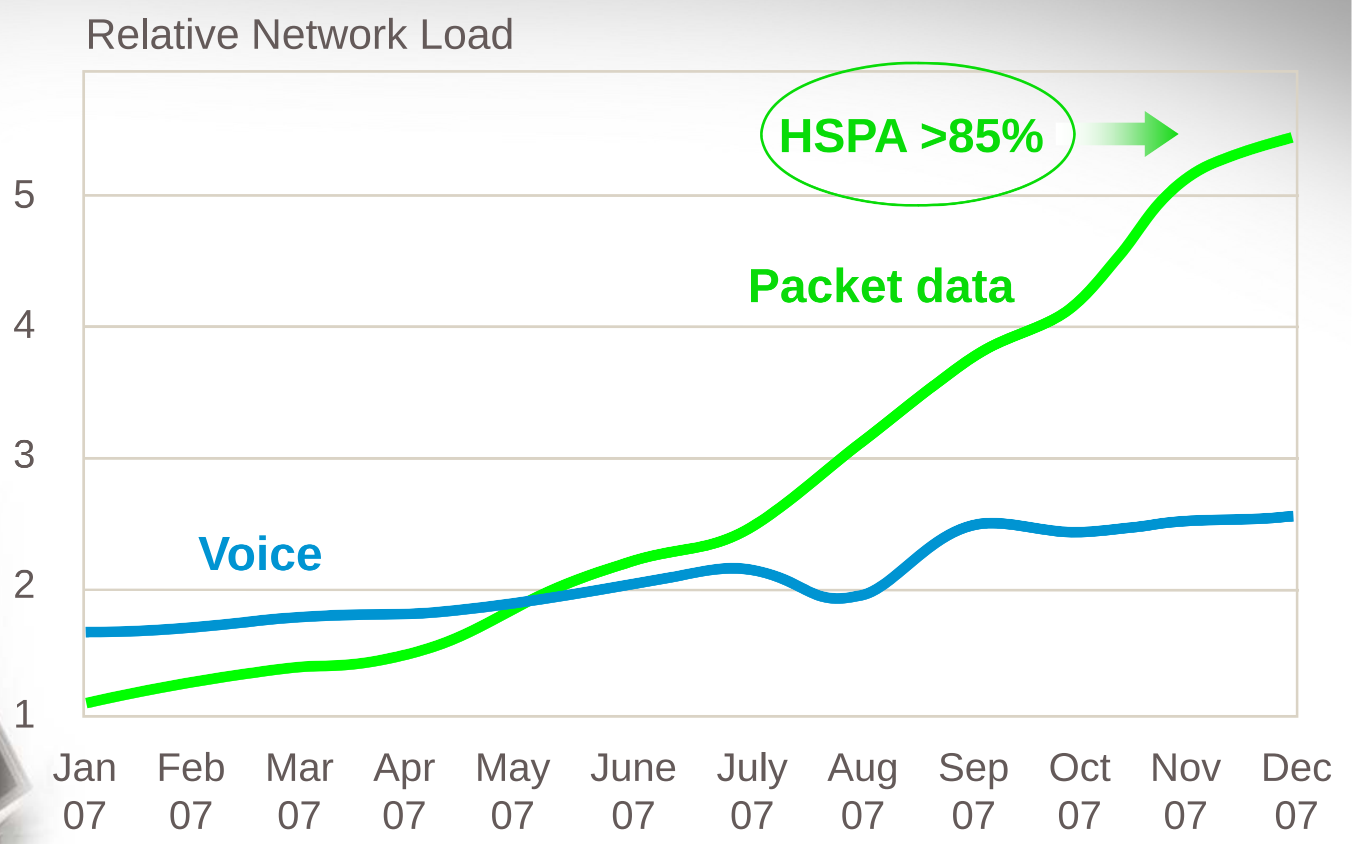
## > 1.8 billion subscriptions 2012


*Source: OVUM, Strategy Analytics & Internal Ericsson*

**The majority of these will be served by WCDMA/HSPA and LTE**

# Strong growth in data traffic

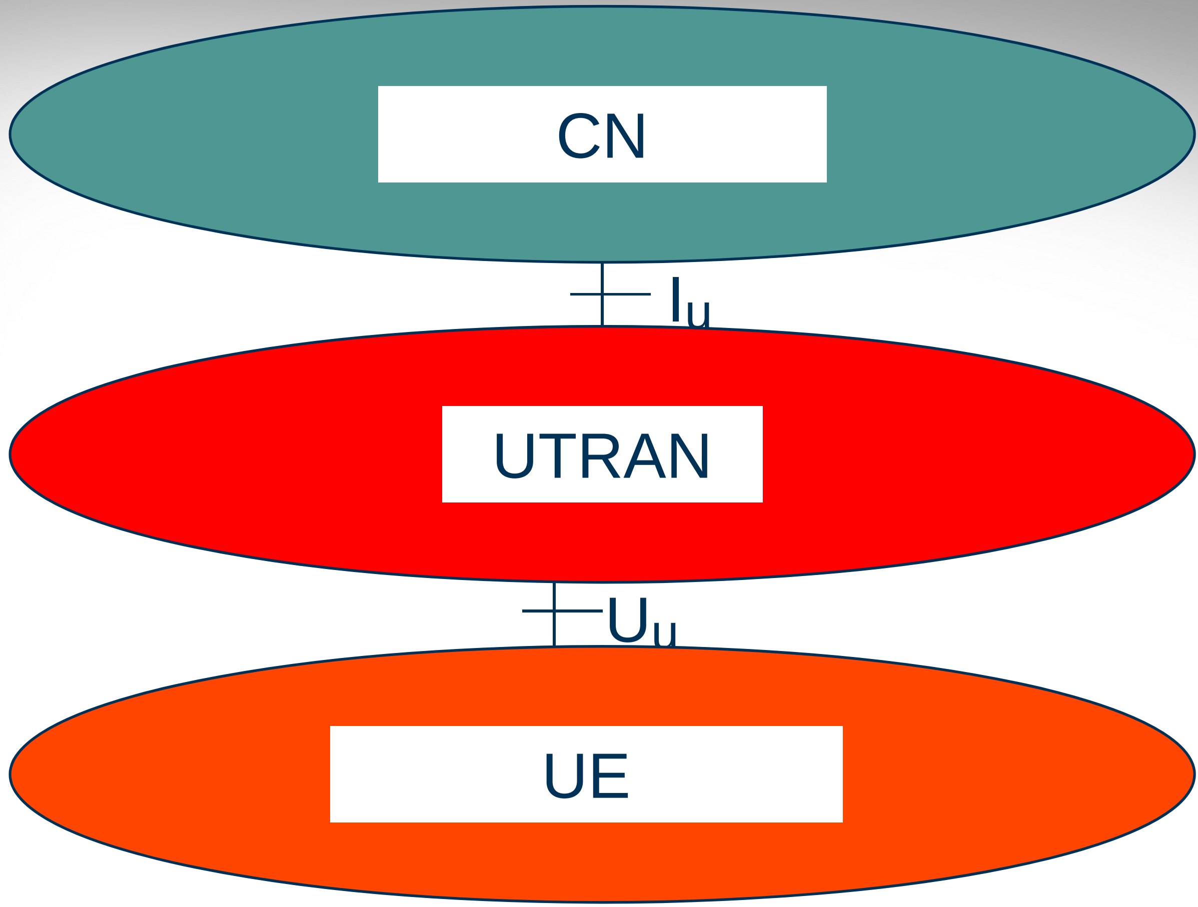
## WCDMA & HSPA world average




*Source: Ericsson*

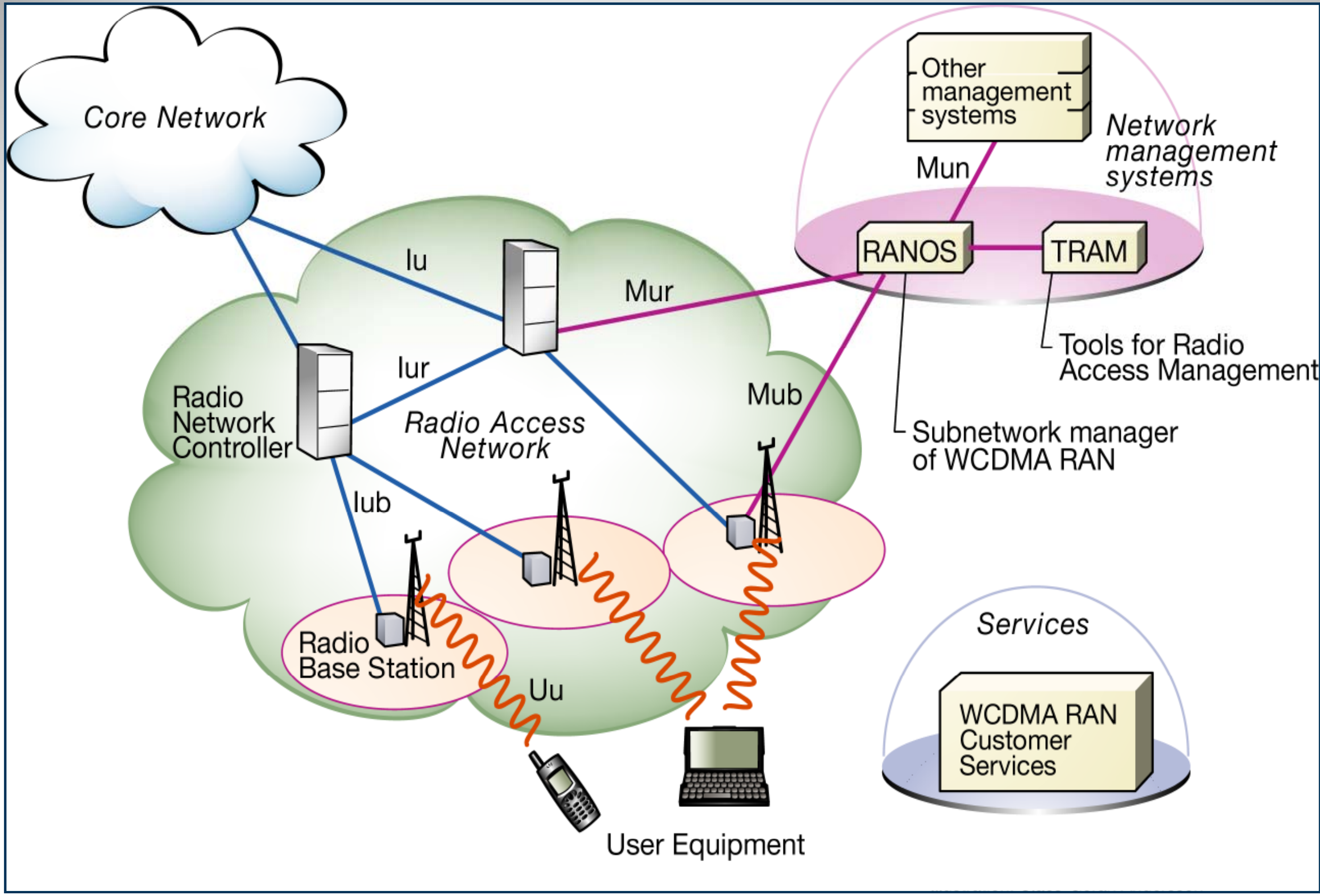
**Traffic growths leading to an IP RAN**

# UMTS Architecture




**CN: Core Network**
**UE: User Equipment**
**UTRAN: Universal Terrestrial Radio Access Network**

# UMTS Terrestrial Radio Access Network (UTRAN) Model



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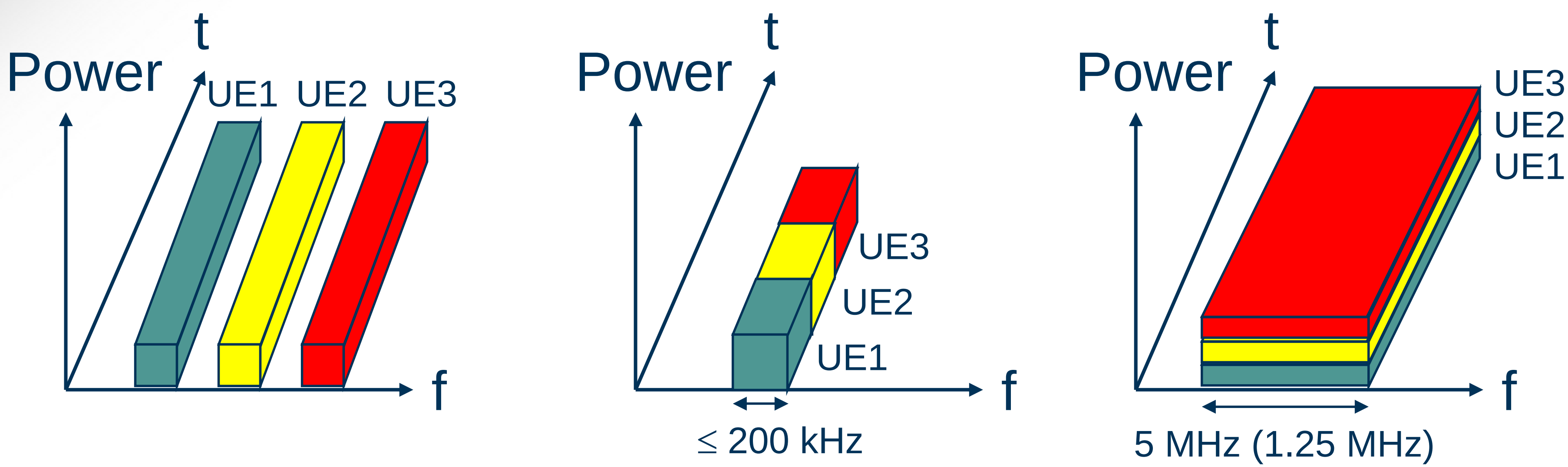
# From 1G to 3G: Modulation Techniques

| FDMA | TDMA | CDMA |
|---|---|---|
| NMT | GSM | IS-95 |
| AMPS | PDC | CDMA2000 |
| TACS | D-AMPS | WCDMA |

1G: NMT, AMPS, TACS

2G: GSM, PDC, D-AMPS, IS-95

3G: CDMA2000, WCDMA

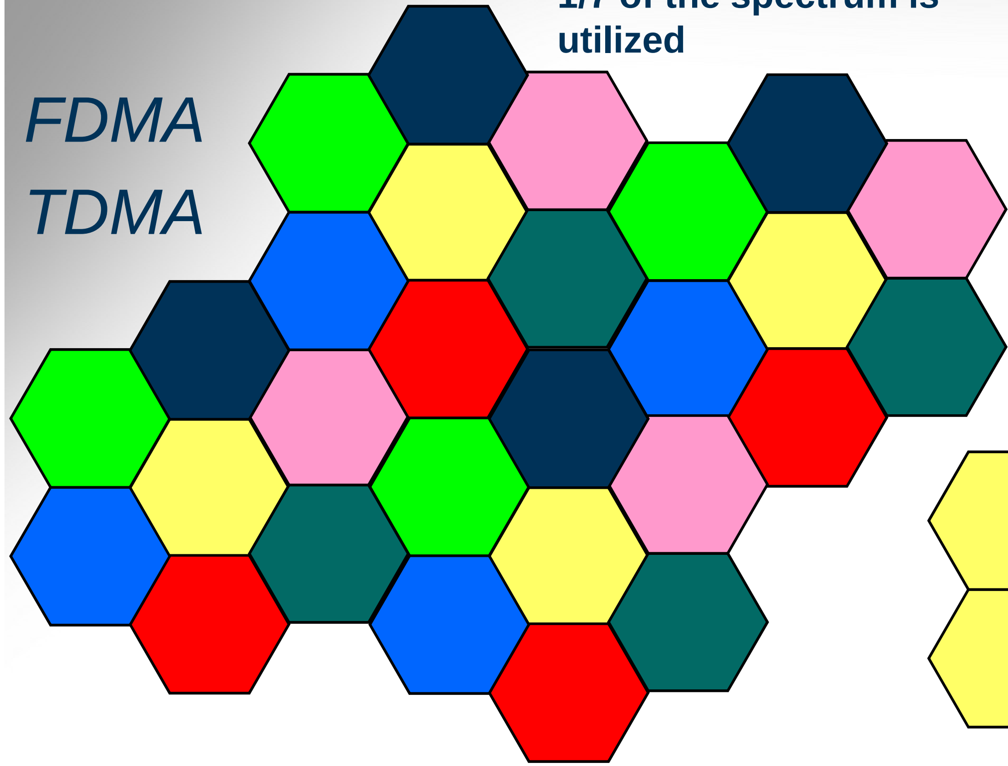


# Frequency Spectrum Utilization (Frequency Re-Use)

*FDMA*

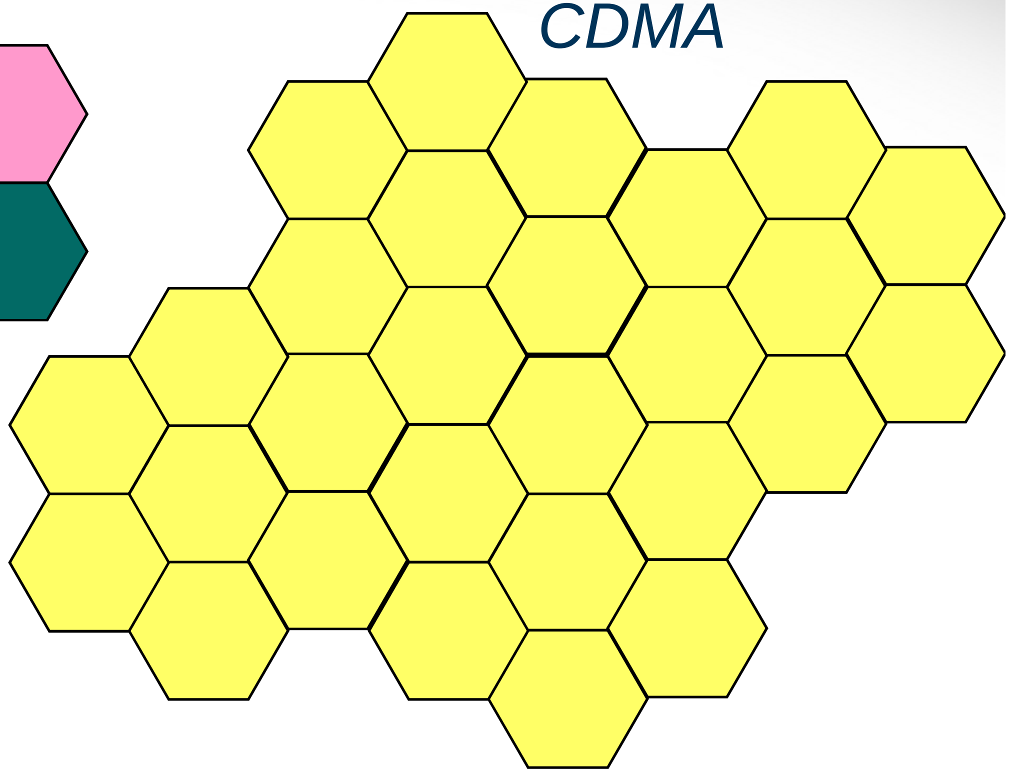
*TDMA*

**1/7 of the spectrum is utilized**

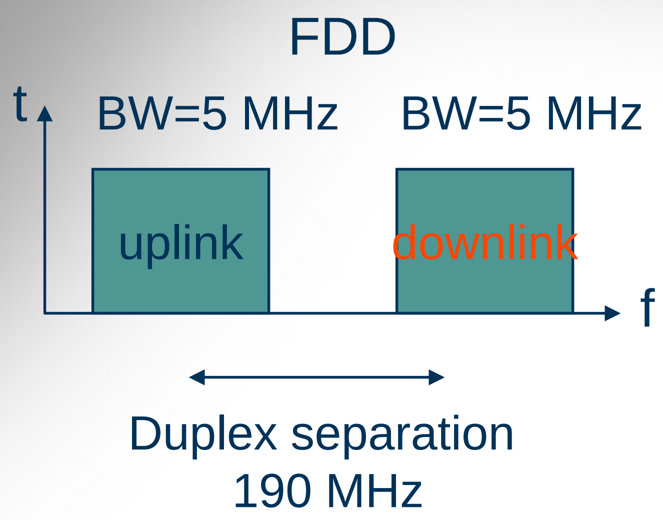


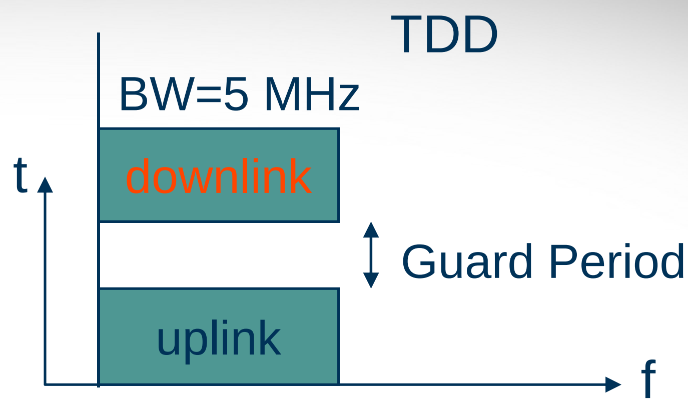
**Frequency Spectrum is fully utilized**

*CDMA*

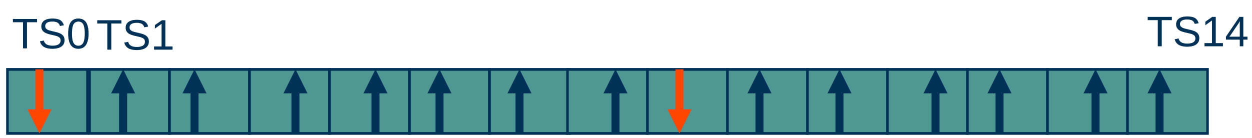


# WCDMA Radio Network: FDD and TDD Modes




Example of TDD uplink/downlink transmission

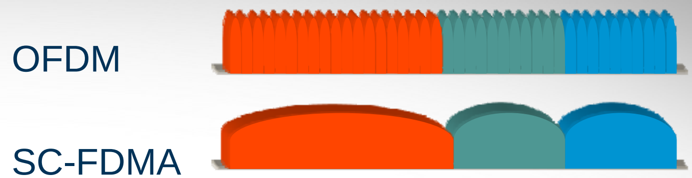


# 3GPP LTE, Long Term Evolution

- **LTE is the next major step in mobile radio communications**
- **High data rates**
  - Downlink: >100 Mbps
  - Uplink: >50 Mbps
- **Low delay/latency**
  - Round Trip Delay: <10 ms
- **High spectral efficiency**
  - Targeting 3 X HSPA Rel. 6
- **High Performance Broadcast services (e.g. gaming, IPTV)**
- **Cost-effective network design**

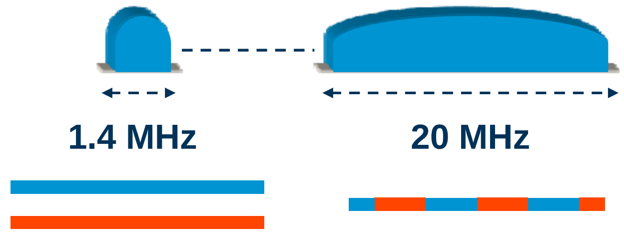
# Key LTE radio access features

- **LTE radio access**
  - Downlink: OFDM
  - Uplink: SC-FDMA




- **Advanced antenna solutions**
  - Diversity
  - Multi-layer transmission (MIMO)
  - Beam-forming

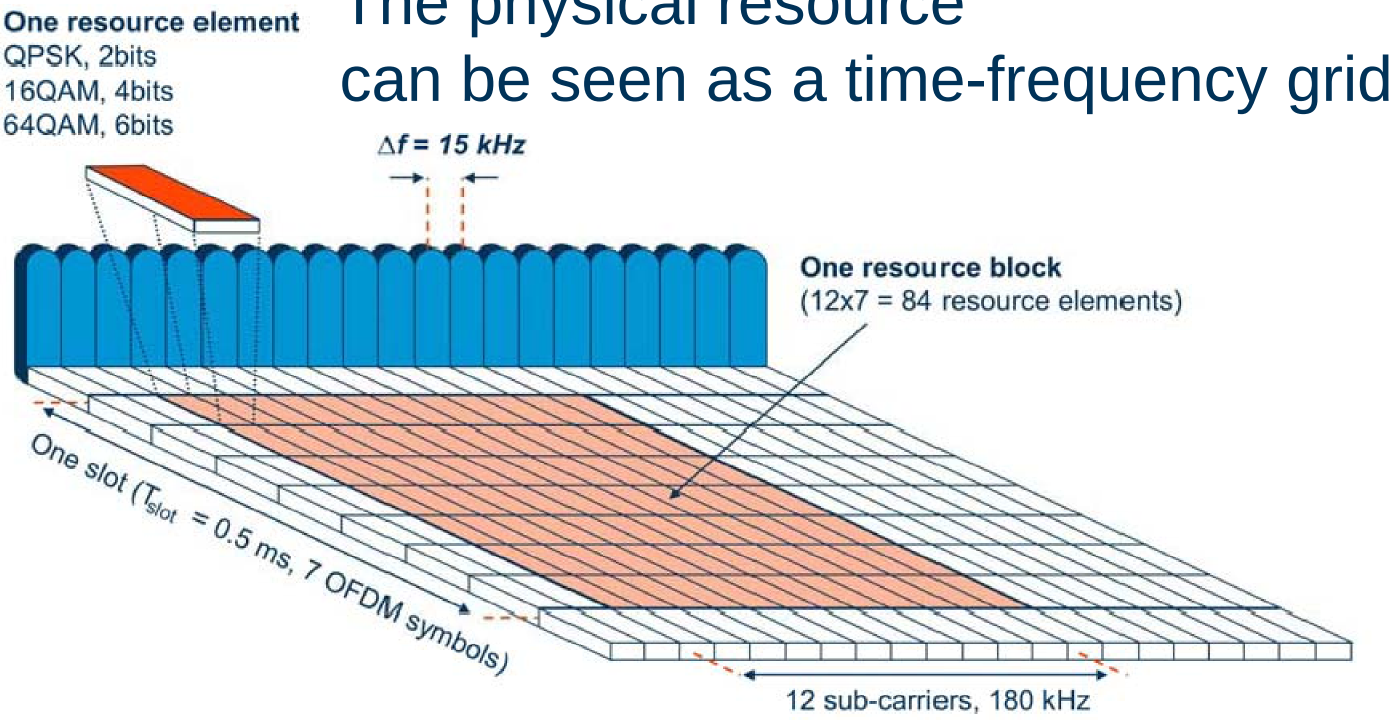

- **Spectrum flexibility**
  - Flexible bandwidth
  - New and existing bands
  - Duplex flexibility: FDD and TDD



# LTE physical resource

LTE uses Orthogonal Frequency Division Multiplexing (OFDM) as its radio technology in downlink

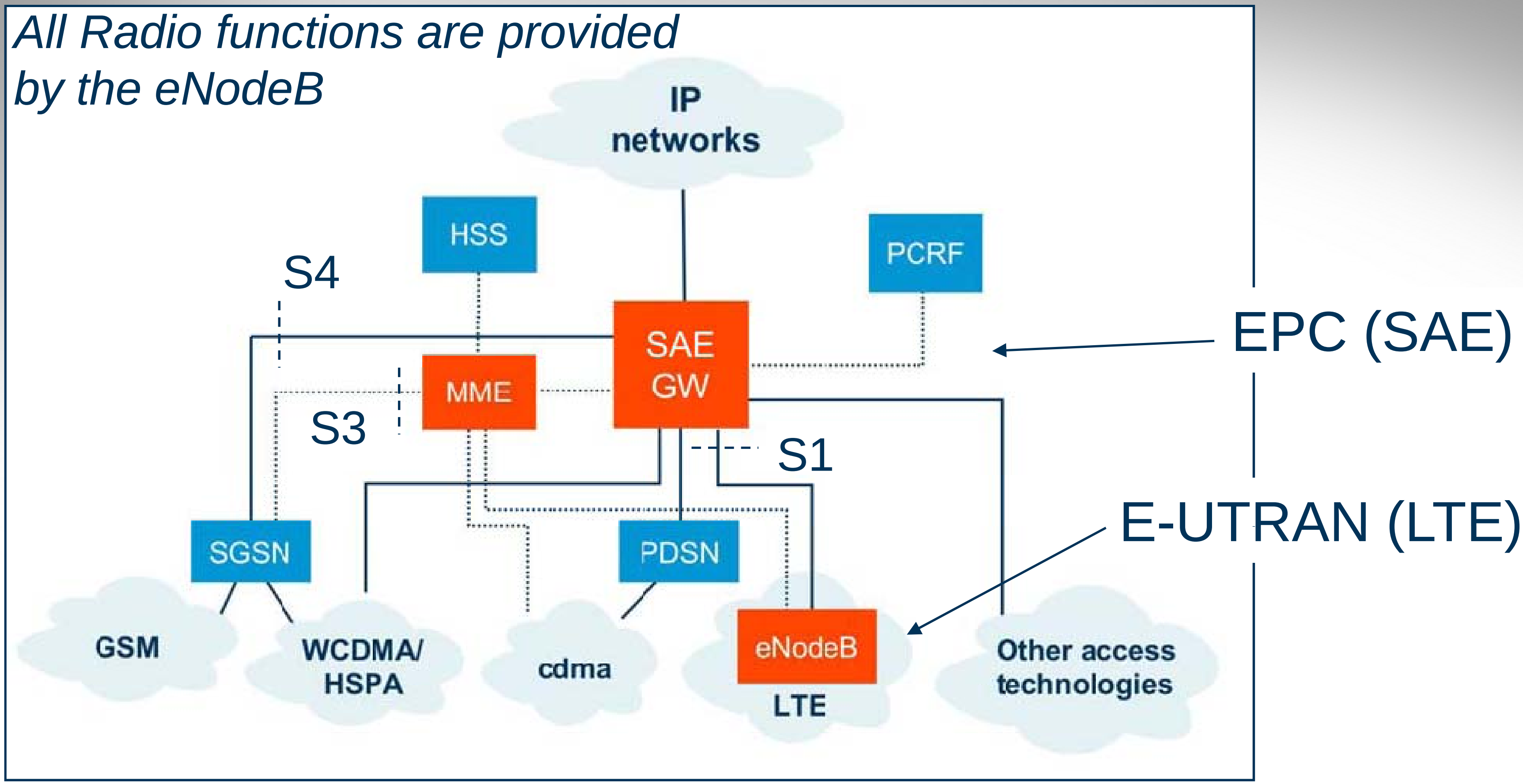
The physical resource can be seen as a time-frequency grid




In the uplink LTE uses a pre-coded version of OFDM, SC-FDMA (Single Carrier Frequency Division Multiple Access) to reduce power consumption

# LTE-SAE (EPS) Architecture

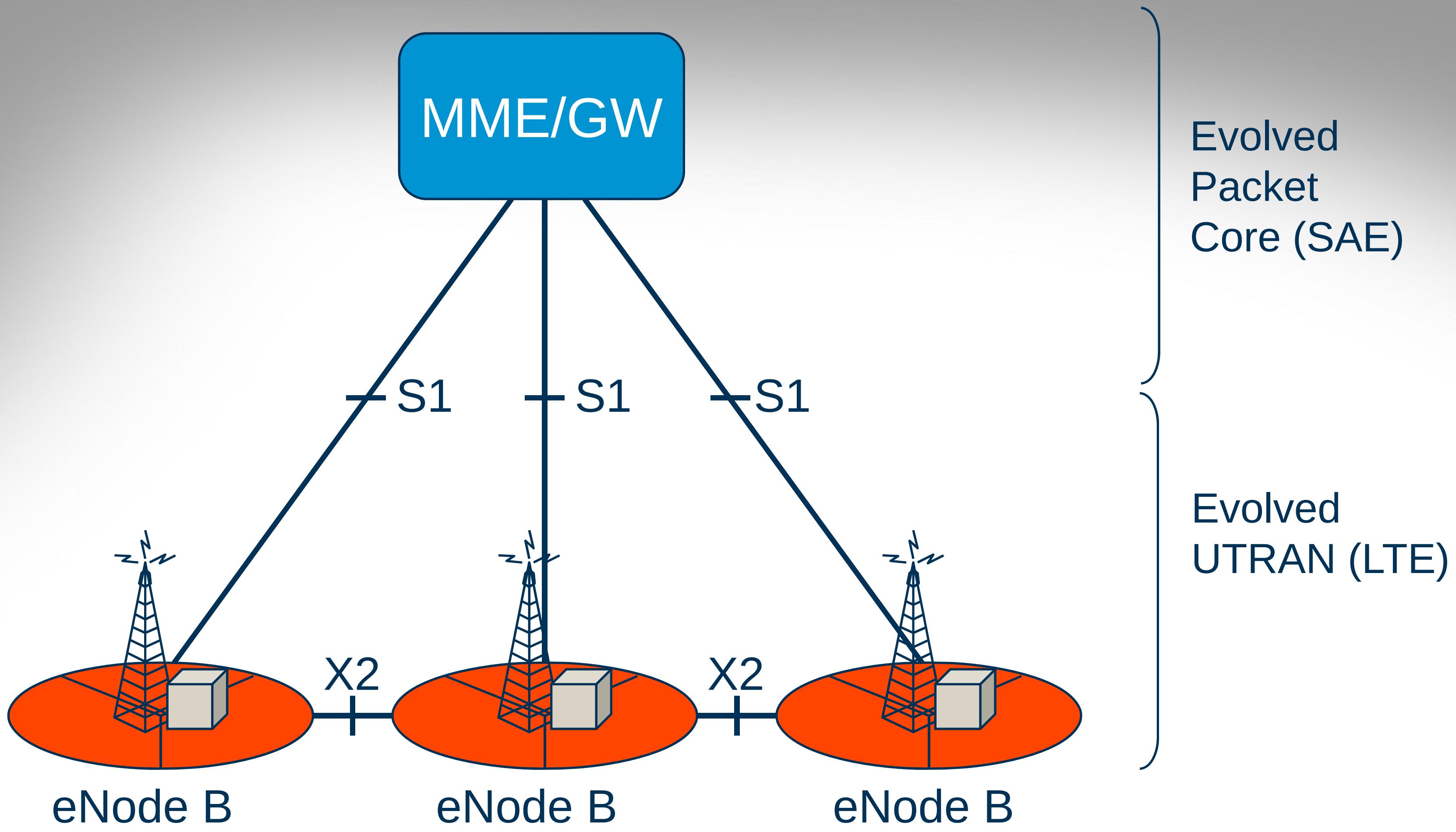
LTE-SAE (System Architecture Evolution): IP-based, flat architecture




EPC: Evolved Packet Core
EPS: Evolved Packet System
HSS Home Subscriber Server
MME: Mobility Management Entity (Control Signaling)

PCRF: Policing and Charging Rules Function
PDSN Packet Data Serving Node
SAE GW: SAE Gateway
SGSN: Serving GPRS Serving Node

# eUTRAN (LTE) interfaces




Direct connections between adjacent base stations for transfer of data at HO

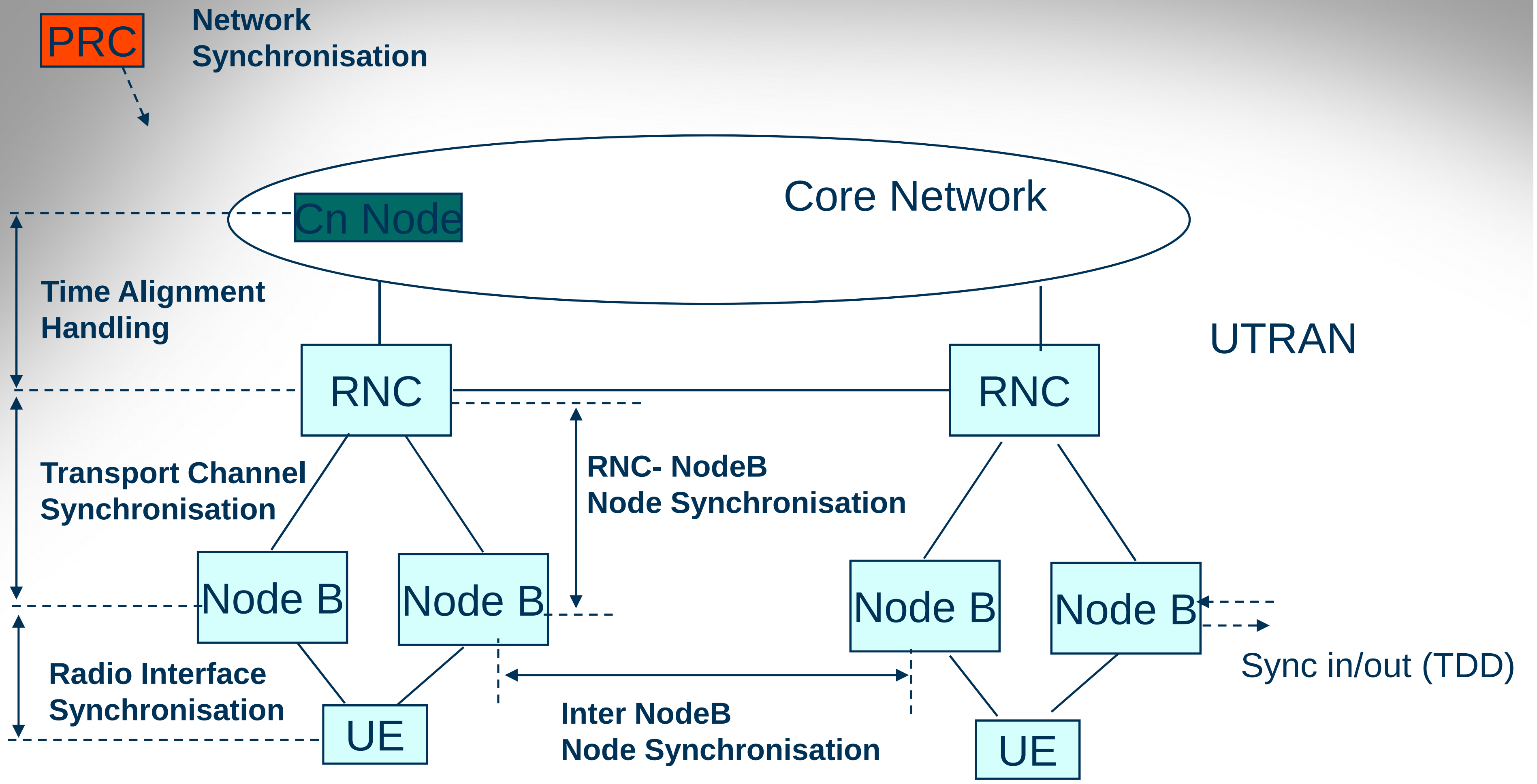
# WCDMA and LTE Synchronization Requirements

# Synchronization Requirements Relevant Standards/Specifications

| | WCDMA | LTE |
|---|---|---|
| **General and Network Interfaces** | TS 25.402, TS 25.411 | TS 36.300 , TS 36.401<br>TS 36.211 |
| **RF Characteristics** | TS 25.104 ,TS 25.105 | TS 36.104 |
| **Others (e.g. Node Synchronization, Transport Channel Synchronisation)** | TS 25.427, TS 25.435<br>TS 25.415 | |

| | Frequency Sync | Time-Phase Sync |
|---|---|---|
| **SDH/PDH Sync** | G.803, G.811, G.812, G.813, G.823, G.824,G.825 | - |
| **Packet Network Sync (SyncE)** | G.8261, G.8262, G.8264 (completed in 2008) | - |
| **Packet Network Sync (Packet Based, e.g IEEE1588, NTP)** | G.8261, G.8263, G.8264<br>(under study) | G.pactiming-bis, G.8265<br>(under study) |

# Synchronization in the UTRAN (TS 25.402)

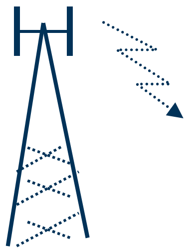


# NodeB TX Frequency Error

- 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

**<u>Frequency error minimum requirement</u>**

| BS class | Accuracy |
|---|---|
| Wide Area BS | ±0.05 ppm |
| Local Area BS | ±0.1 ppm |



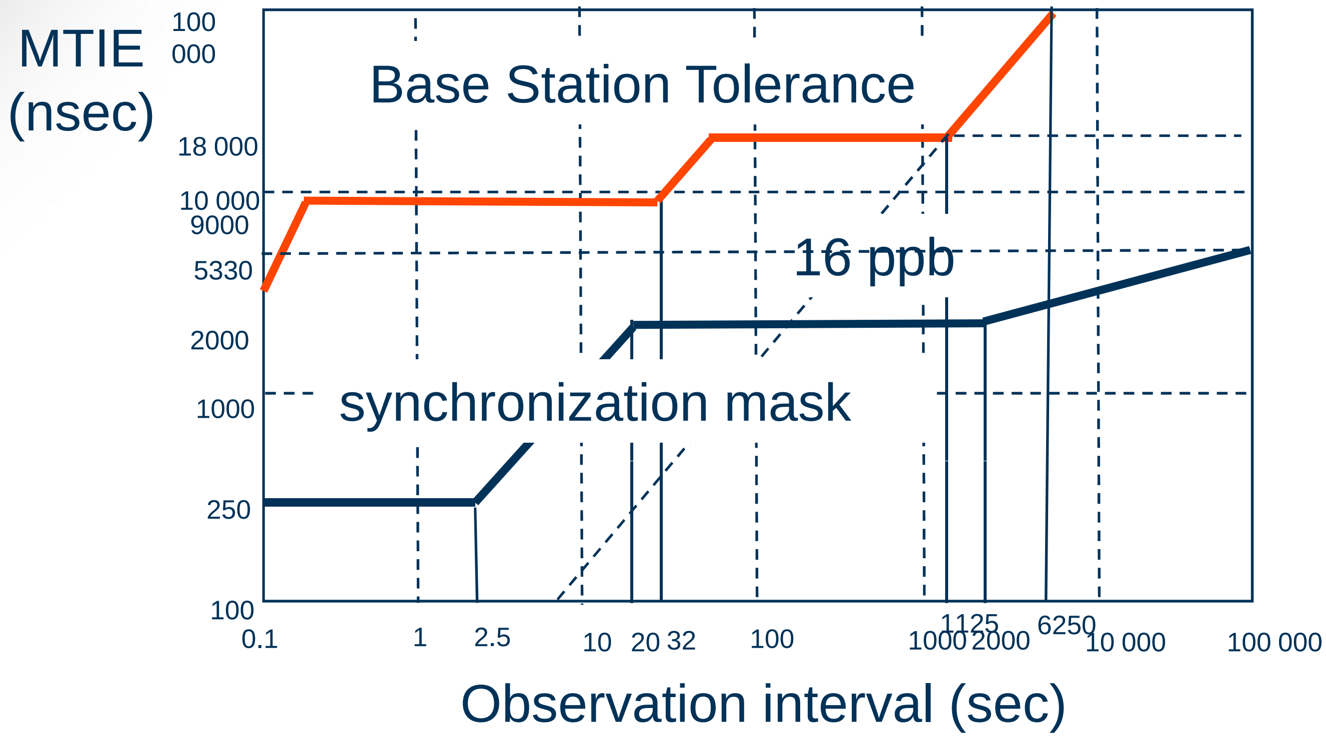
Y < 0.05-0.1 ppm

NodeB

The requirement applies on the radio interface

# NodeB Input Requirements

- Requirements at the input of the NodeB depends on the implementation
- Additional information is provided in case frequency synchronization is distributed over the TDM links (TS 25.411): sync requirement can be defined at the input of the NodeB in terms of network limits (e.g. ITU-T G.823 traffic masks)
- 16 ppb is often considered as a suitable long-term requirement at the input of NodeB to achieve 50 ppb on the radio interface



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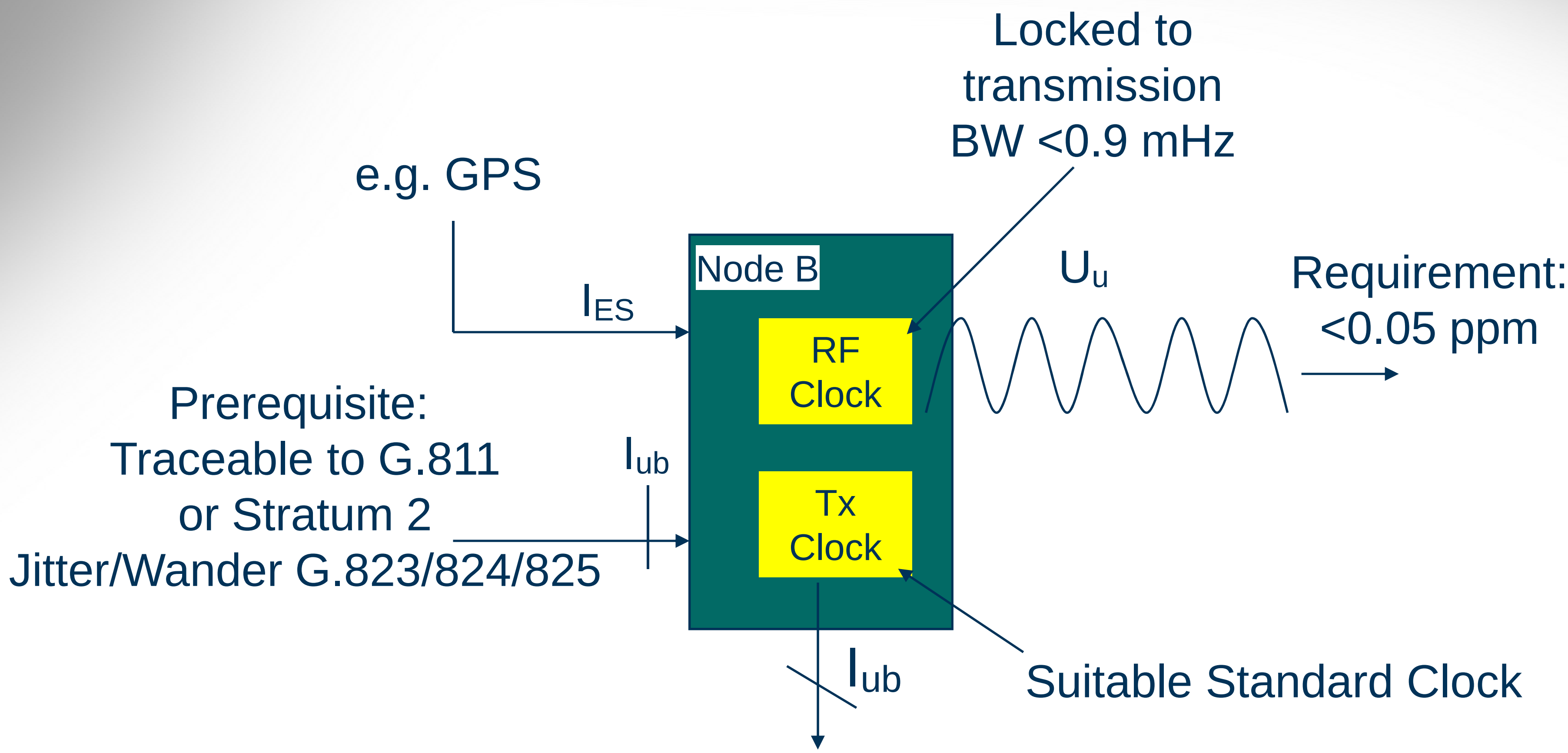
# Node B traditional (TDM based) Sync implementation



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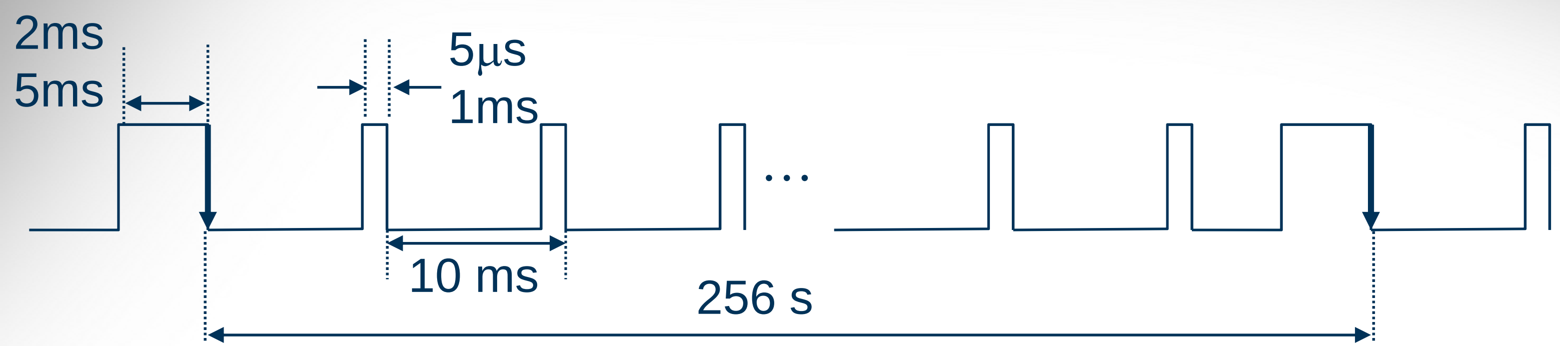
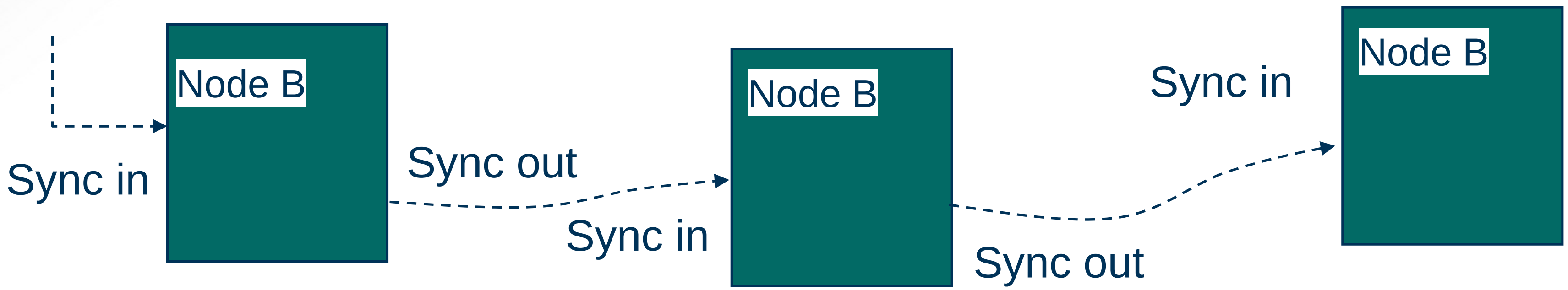
# Node B Sync additional requirement for TDD mode

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)*

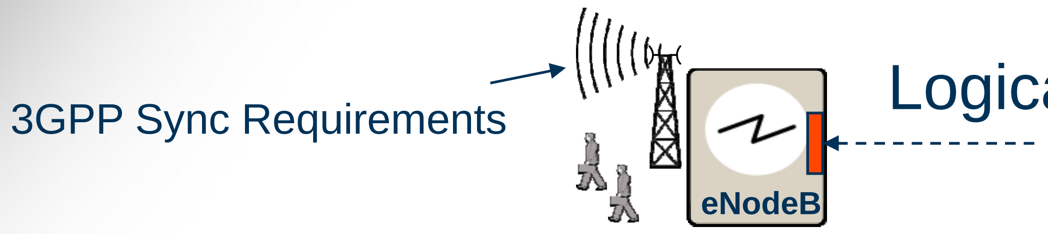
External sync Source (e.g. GPS)




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

# LTE General Network Synchronization aspects

- The eNB shall support a logical synchronization port for phase, time and frequency synchronization as required (TS 36.300, TS 36.401).

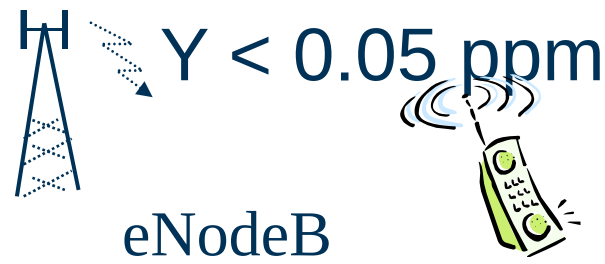



- This port shall provide:
  - accuracy that allows to meet eNB phase requirements TDD and MBSFN;
  - continuous time without leap seconds traceable to common time reference;
- Common SFN (System Frame Number) initialisation time shall be provided for all eNBs.

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

# eNodeB TX Frequency Error

- Frequency Synchronization (Radio Interface) requirements are specified in 3GPP TR 36.104
- The same source shall be used for RF frequency and data clock generation.
- The modulated carrier frequency of the BS shall be accurate to within ±0.05 ppm observed over a period of one subframe (1ms)
- Local Area and Home application are under definition (e.g. 100 ppb-250 ppb)




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

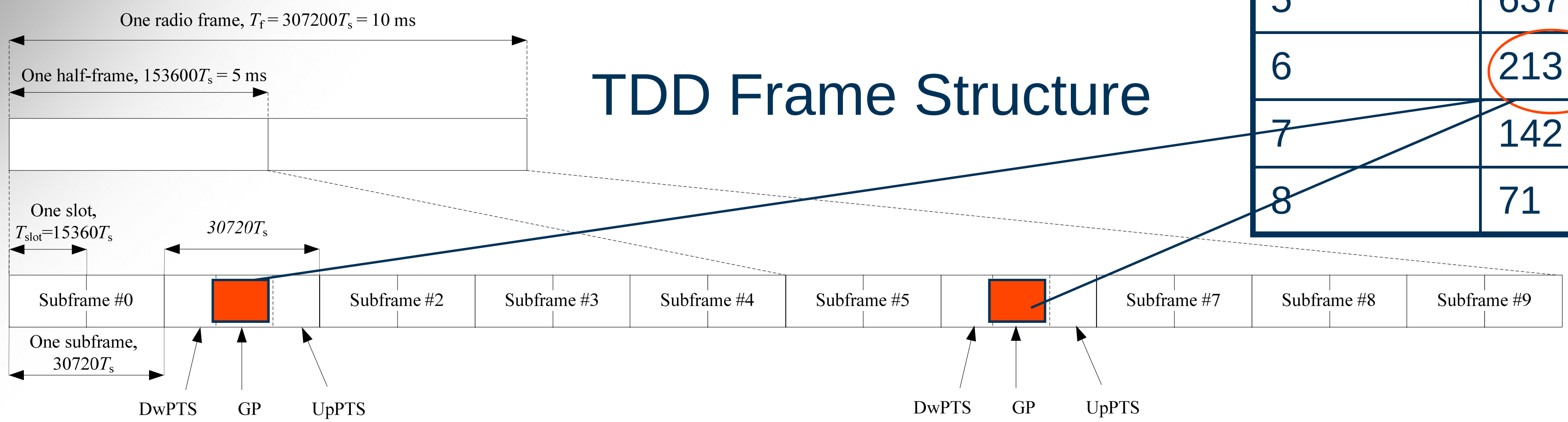
**The requirement applies on the radio interface**

# Phase Synchronization Requirements

- Phase Synchronization (Radio Interface) concerns the TDD mode.
- The requirements are related to 3GPP TS 36.211

| Special sub-frame configuration | Guard Period (μs) |
|---|---|
| 0 | 710 |
| 1 | 283 |
| 2 | 213 |
| 3 | 142 |
| 4 | 71 |
| 5 | 637 |
| 6 | 213 |
| 7 | 142 |
| 8 | 71 |

TDD Frame Structure




- Depending on cell size different GP are suitable (due to different propagation delays)
- LTE TDD systems may be defined to operate with tens of μs phase accuracy
- Initial Requirement for the case of Small cells is being defined (3 μs has been proposed for a *safe* first release of LTE; the requirement may be relaxed in the future)



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# Additional sync requirements in case of special services: MBSFN

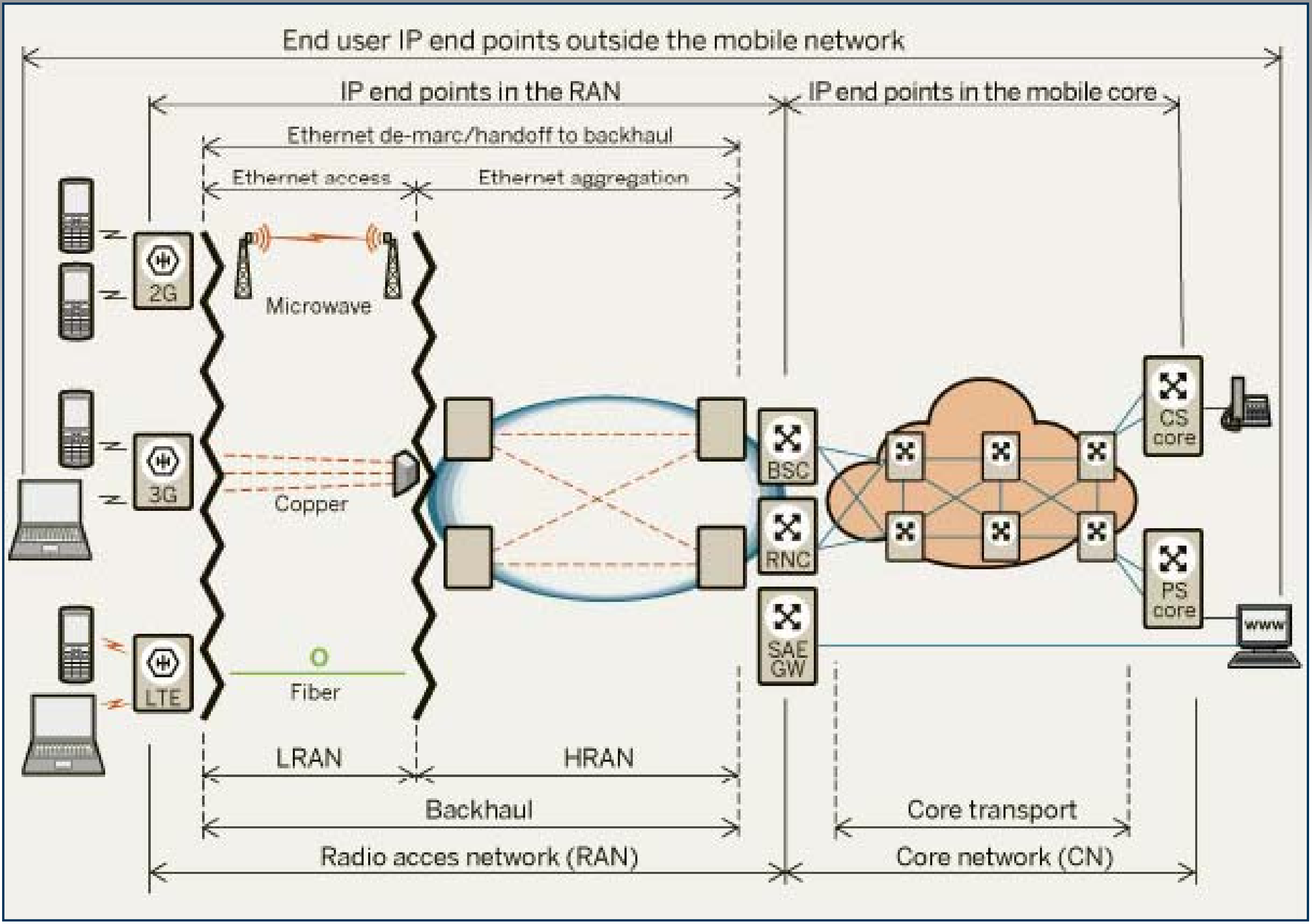
- MBMS (Multimedia Broadcast Multicast Service) is part of the WCDMA evolution standardized by 3GPP
- It is a technology for broadcast of content over cellular networks to small terminals (handsets) e.g. for mobile TV.
- Ordinary MBMS requires ± 20 ms time accuracy
- When MBMS is based on SFN (single-frequency 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: the requirement is driven by the length of the OFDM symbol
- Base Station budget should be a portion of this (e.g. +/- 1 microsecond)

# Synchronization Solutions

# Solutions for timing distribution

- Over the Physical Layer (frequency only): TDM, SyncE
- Packet Based method without support from the network (mainly frequency): PDV aspects to be considered.
  *The oscillator  in the Base Station is a key aspect.*
- Packet Based with support from the network nodes (accurate time-phase): Transport network requirements
- GNSS (Global Navigation Satellite System): Most accurate time and frequency sync; installation aspects
- CES (Circuit Emulation) (frequency only): PDV aspects to be considered; applicable in the migration scenarios

# Mobile Backhauling




Complex environment for synchronization distribution



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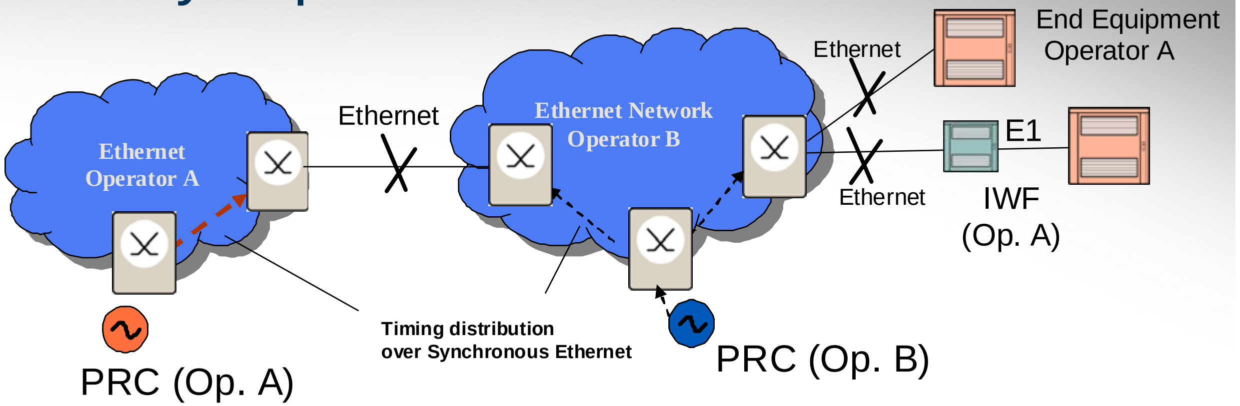
# Issues and facts

- The sync solution may be required to work over several technologies in the access (xDSL, Ethernet, microwave)
- Network Ownership is a key aspect

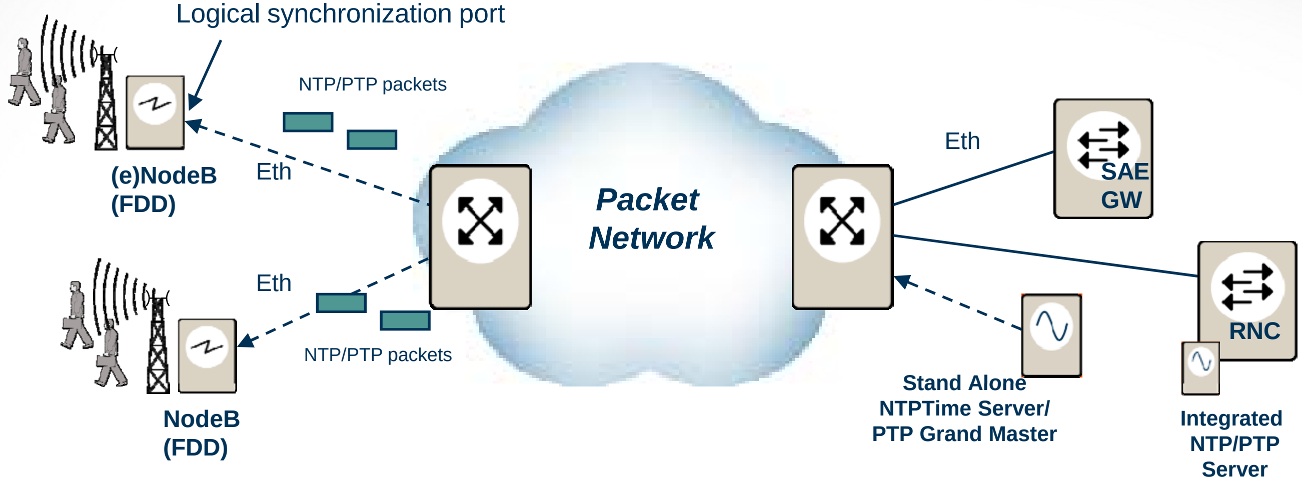
Ex.: SyncE is limited within the network operator boundaries




- Network migration aspects shall be considered (legacy equipment widely deployed)
- Different synchronization requirements:
  - 90 % of the world's mobile frequencies available are in paired bands (i.e. FDD) -> Currently only long term frequency as reference is sufficient in most of the cases
  - emerging services (e.g.  MBSFN) as well as spreading of TDD-based technologies will increase the need for stricter synchronization requirements in the future

# Sync Solutions: a timeline perspective

- Flexible timing distribution architecture is desired (different sync requirements, different transport technologies, network ownership, cost)
- Synchronous Ethernet may not always be feasible
- WCDMA FDD, LTE FDD (and GSM), are suited to a packet-based "end-to-end" solution (using NTP or PTP packets)




- For applications requiring accurate time and phase synchronization, e.g. LTE TDD, MBSFN, the use of GNSS is currently the only available and practical solution.
- Looking ahead, packet based solutions which incorporate support from the network nodes (e.g. IEEE1588/PTP) may provide in the future an alternative to GNSS

# Conclusions

- Mobile Broadband is happening now.
- HSPA today and LTE in the future are the prime technology for Mobile Broadband.
- Different levels of Synchronization Requirements apply
- Increased complexity of networks in the mobile backhauling.
- Flexible sync solutions are required: independent from the network in the near future (i.e. GNSS and Packet-based methods using PTP or NTP)
- Packet-based solutions with support from the network (e.g. based on IEEE1588) in the long term could provide valid alternative to GNSS to support TDD networks and MBSFN


THANK YOU
QUESTIONS ?