



Sistemas de 4ta Generación - LTE

Sistemas de 4ta Generación

Long Term Evolution (LTE /4G LTE)

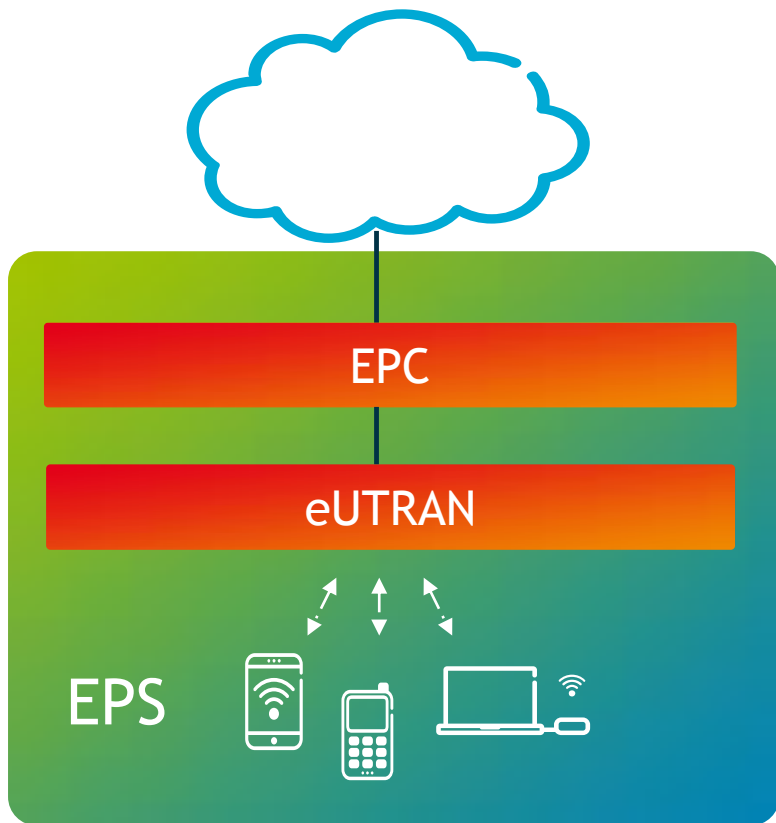
4ta. Generación Móvil Celular 2009



TeliaSonera (Oslo y Stockholm).
Diciembre 14 del 2009.
Primera red comercial LTE en el mundo.

LTE

Terminología



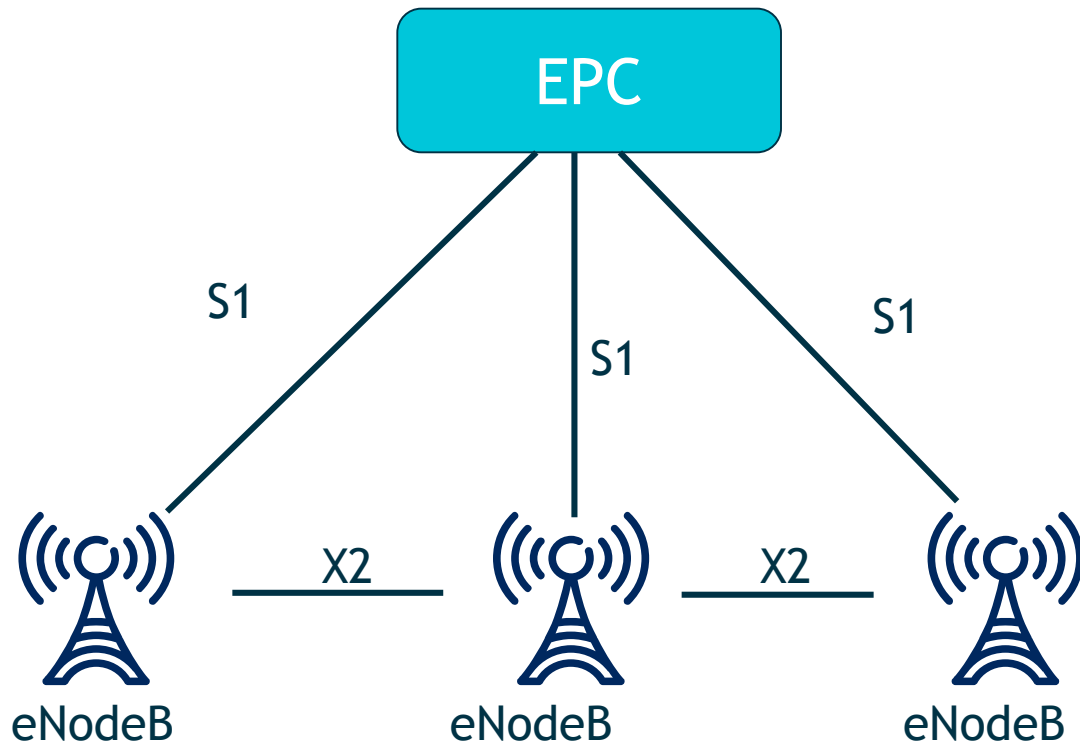
EPC - Evolved Packet Core
SAE - System Architecture Evolution

eUTRAN - Evolved UTRAN
LTE - Long Term Evolution

EPS - Evolved Packet System

LTE

LTE/EPC Architecture Interfaces



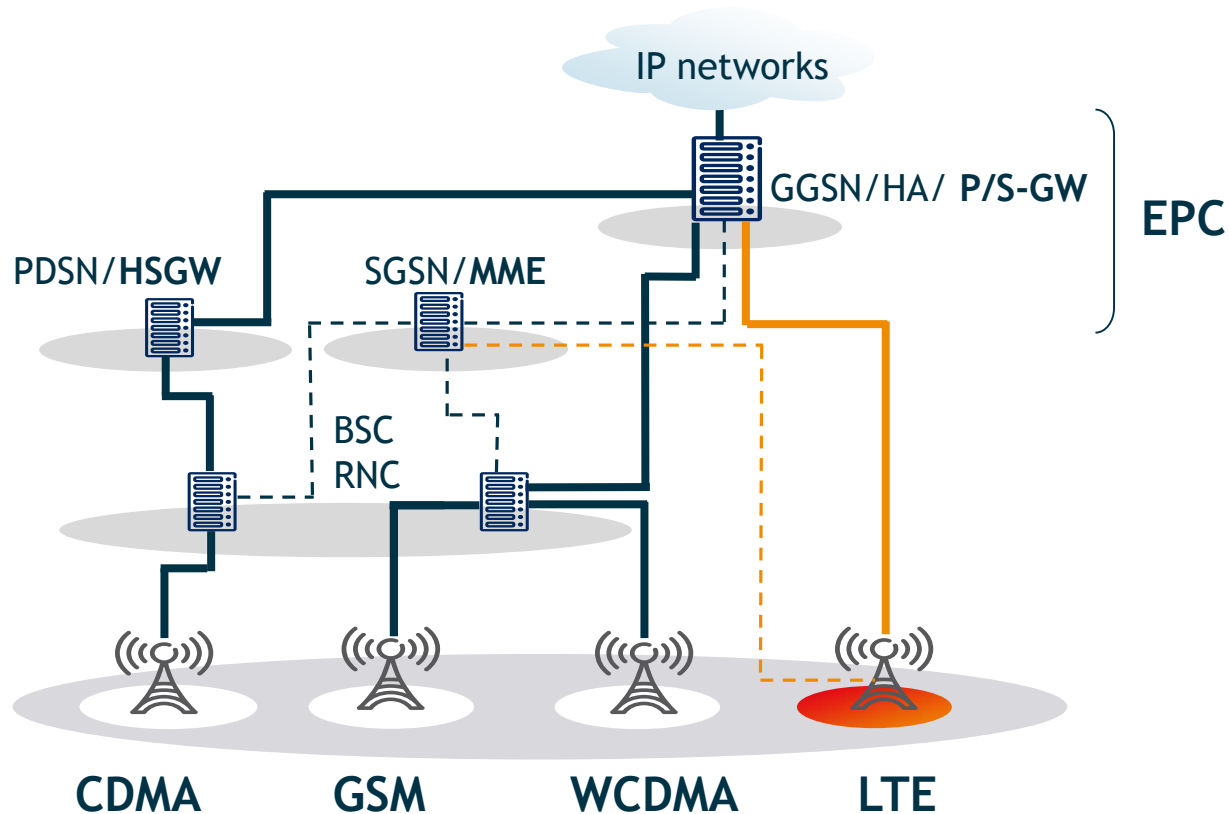
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LTE/EPC Network Architecture

GGSN => PS-GW

SGSN => MME

PDSN => HSGW



MME = Mobility Management Entity

P/S-GW = PDN/Serving gateway

PDSN = Packet Data Serving Node

HRPD = High Rate Packet data

HSGW = HRPD Serving gateway

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Key LTE radio access features

LTE radio access

Downlink: OFDM

Uplink: SC-FDMA

Advanced antenna solutions

Diversity

Beam-forming

Multi-layer transmission (MIMO)

Spectrum flexibility

Flexible bandwidth

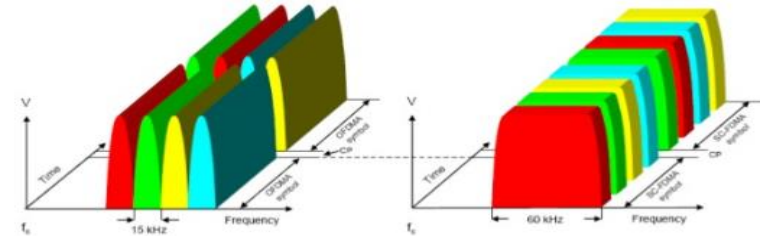
New and existing bands

Duplex flexibility: FDD and TDD

- QPSK example using N=4 subcarriers

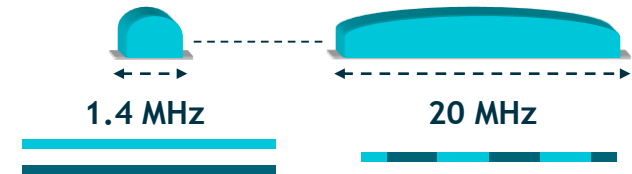
- How OFDM and SC-FDMA would be used to transmit a sequence of 8 QPSK symbols

The following graphs show how this sequence of QPSK symbols is represented in frequency and time



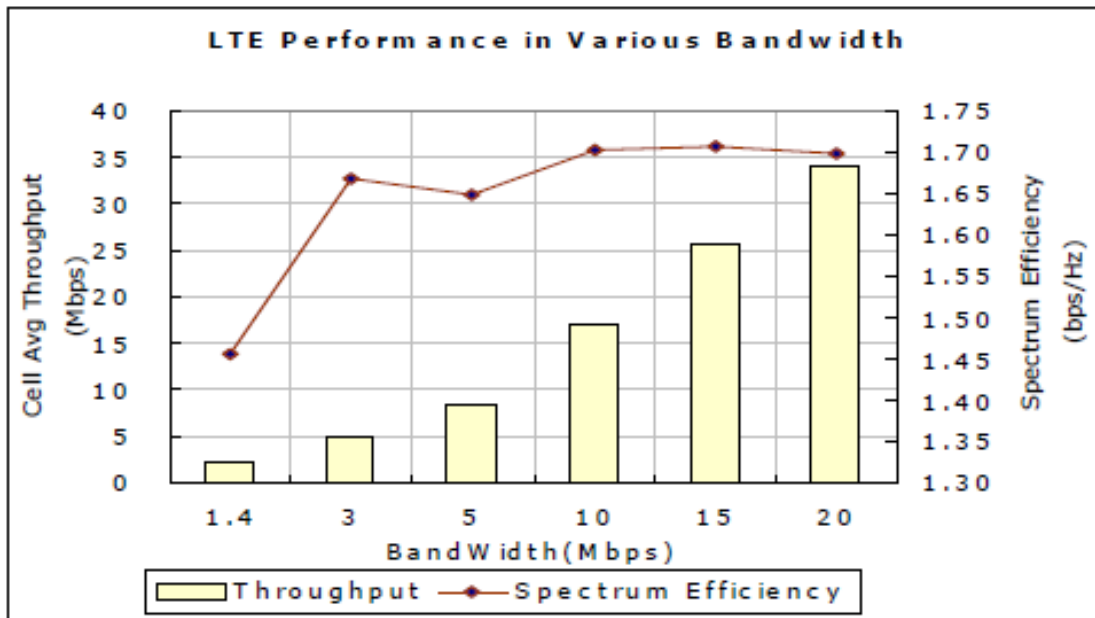
OFDMA
Data symbols occupy 15 kHz for one OFDMA symbol period

SC-FDMA
Data symbols occupy N*15 kHz for 1/N SC-FDMA symbol periods



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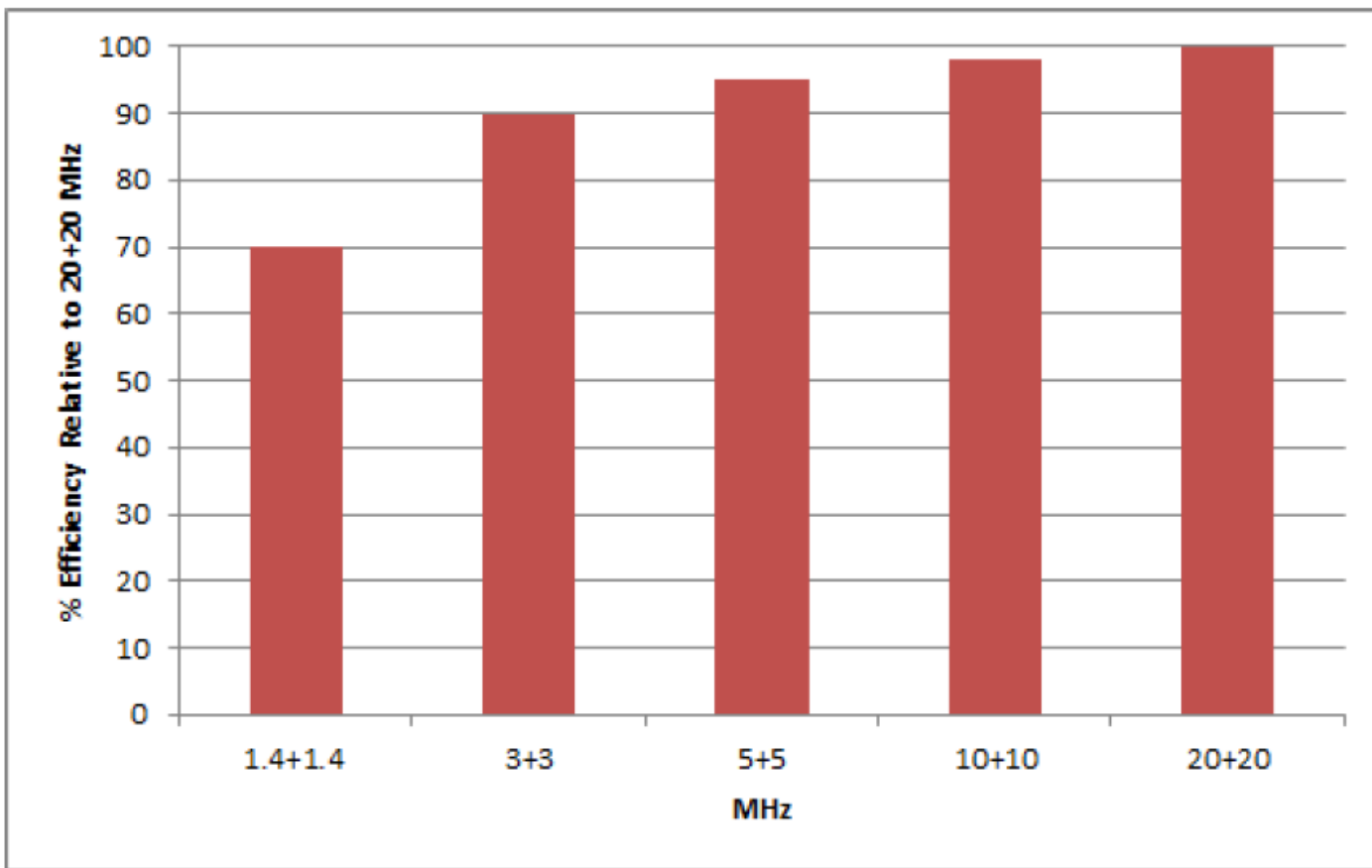
Spectrum efficiency vs LTE Carrier Bandwidth



Notes: Simulate in SCM-C channel and using 2x2 CL-MIMO

LTE

Spectrum efficiency vs LTE Carrier Bandwidth



LTE

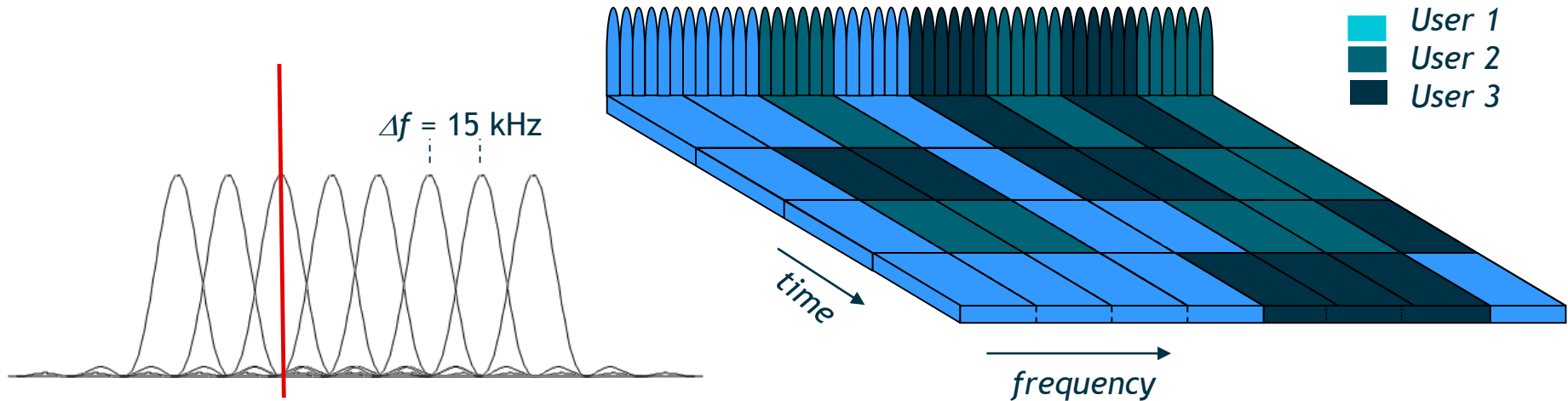
Drive Test of commercial European LTE Network 10+10 MHz



LTE Radio Access - Downlink

OFDM - Orthogonal Frequency Division Multiplexing

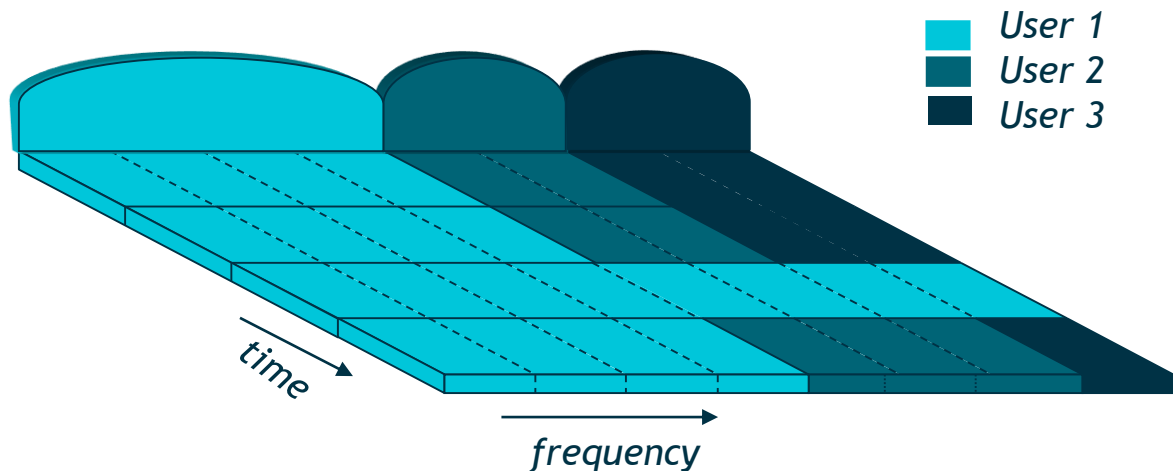
- > Large number of 15 kHz sub carriers
- > Orthogonal: Other carriers zero at sampling point



LTE Radio Access - Uplink

SC-FDMA - Single Carrier FDMA (DFTS-OFDM)

- > Low Peak-to-Average Power Ratio
- > Similar to OFDM
 - 15 kHz tones BUT consecutive
 - Same time-domain structure



LTE

Scheduling

> Time domain

- Round-robin
- Max C/I
- Proportional fair

> Frequency domain

- Consecutive
- Random
- Measurement based

Round-robin



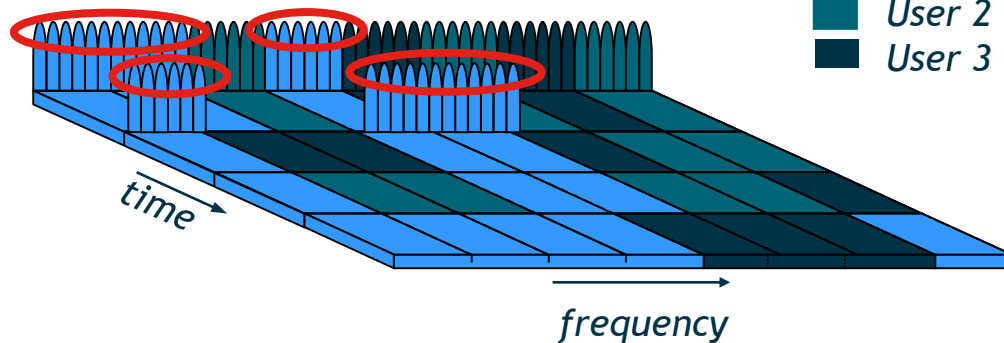
Max C/I



Proportional fair



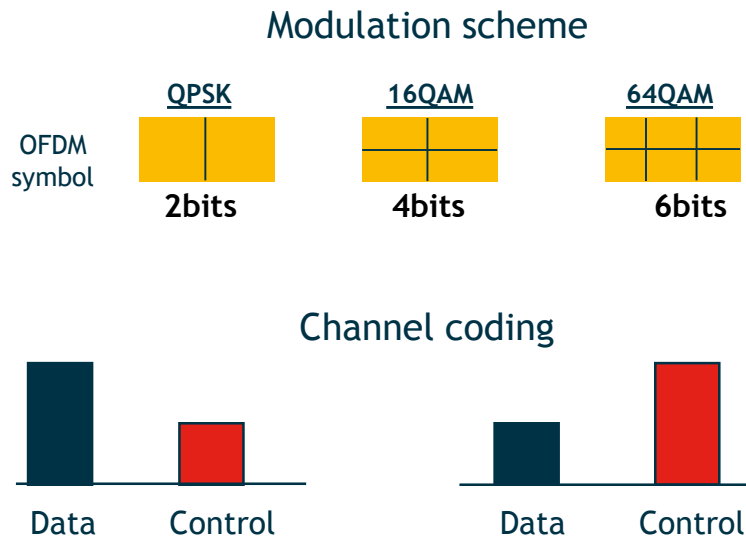
Downlink



LTE

Link Adaptation

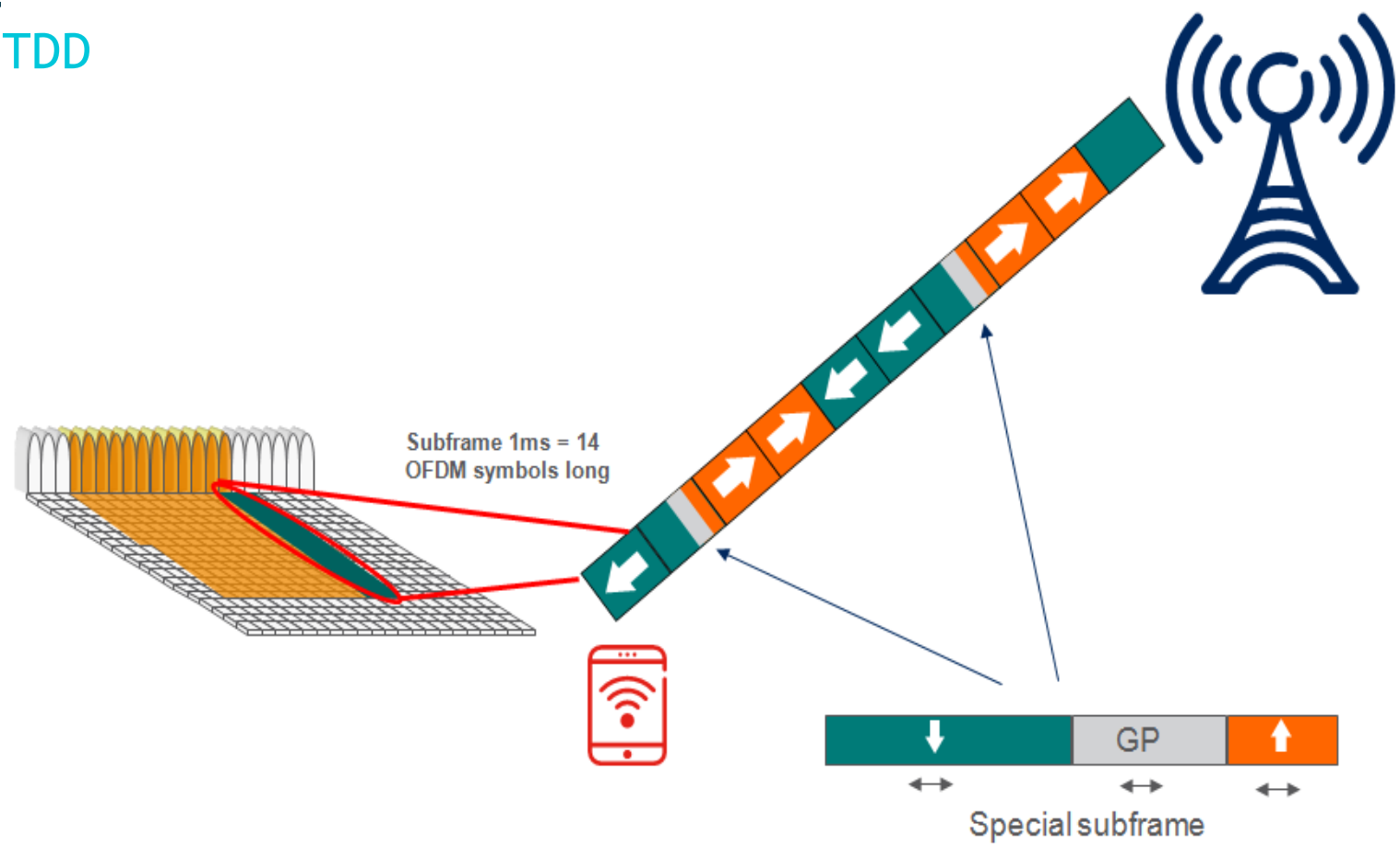
- > Time Domain (/user)
 - Modulation scheme
 - Channel coding



- > Frequency Domain (/SB)
 - *Not that common*

LTE

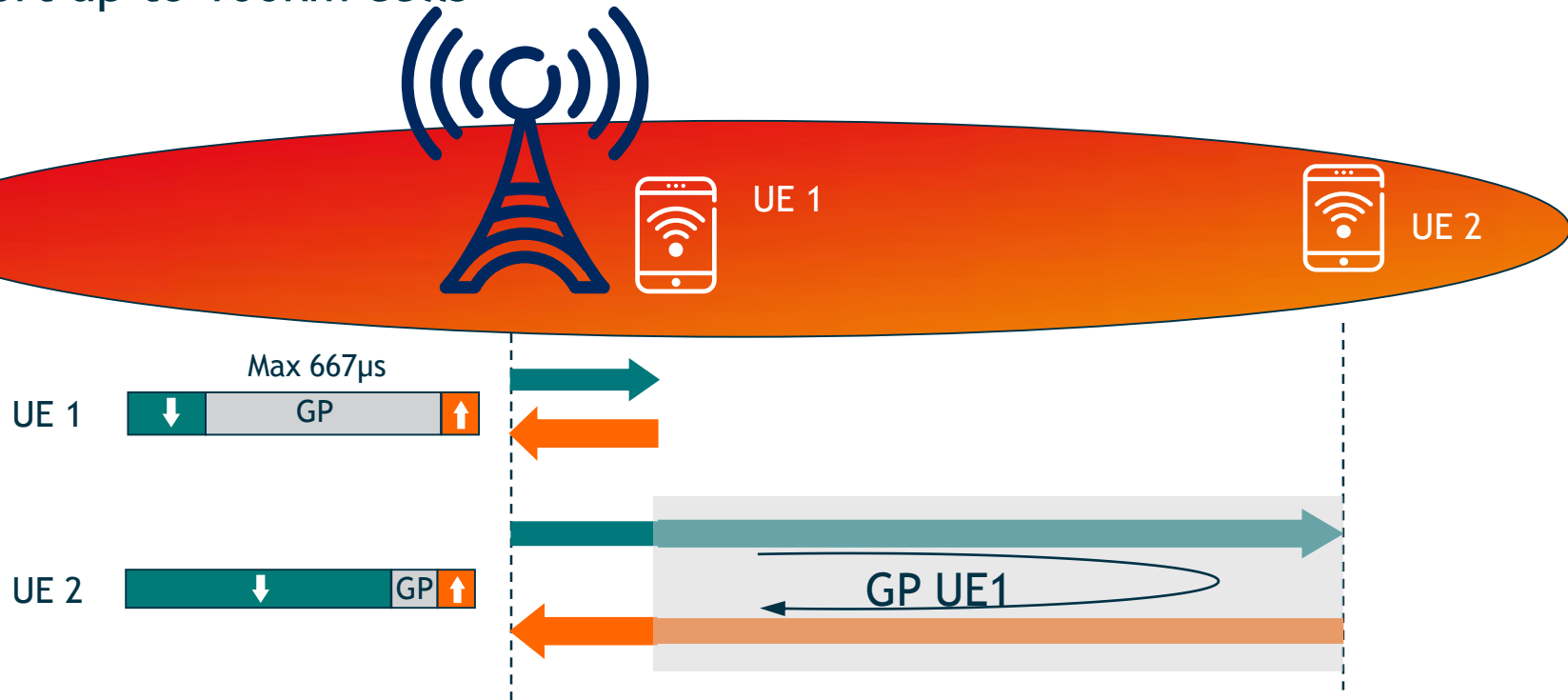
LTE TDD



LTE

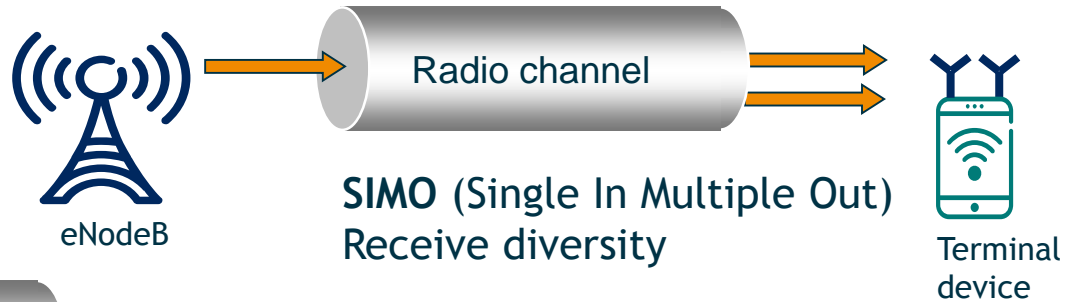
TDD Guard Period

Support up to 100km cells



LTE

Multi-antenna Transmission



LTE

Throughput performance

	Downlink		Uplink	
	Peak Network Speed	Peak and/or Typical User Rate	Peak Network Speed	Peak and/or Typical User Rate
LTE (2X2 MIMO, 10+10 MHz)	70 Mbps	6.5 to 26.3 Mbps ⁶⁸	35 Mbps ⁶⁹	6.0 to 13.0 Mbps
LTE (4X4 MIMO, 20+20 MHz)	300 Mbps		71 Mbps ⁷⁰	
LTE Advanced (8X8 MIMO, 20+20 MHz, DL 64 QAM, UL 64 QAM)	1.2 Gbps		568 Mbps	

LTE

User Equipments Categories

*Referencias comerciales disponibles actualmente
Dongles & Smartphones*



Category		1	2	3	4	5
Peak rate Mbps	DL	10	50	100	150	300
	UL	5	25	50	50	75
Capability for physical functionalities						
RF bandwidth		20MHz				
Modulation	DL	QPSK, 16QAM, 64QAM				
	UL	QPSK, 16QAM				QPSK, 16QAM, 64QAM
Multi-antenna						
2 Rx diversity		Assumed in performance requirements.				
2x2 MIMO		Not supported	Mandatory			
4x4 MIMO		Not supported				Mandatory

LTE DL Peak Rate

64 QAM and 20 MHz and 4x4 MIMO

14 OFDM symbols per 1.0 ms subframe
64QAM = 6 bits per symbol
 $6 \times 14 = 84$ bits per 1.0 ms subframe

$84\text{bits}/1.0\text{ms} = 84\text{kbps}$ per subcarrier
 $12 \times 84\text{kbps} = 1.008\text{Mbps}$ per Scheduling Block
100 Scheduling Blocks in 20MHz
 $100 \times 1.008\text{Mbps} = 100.8\text{Mbps}$ per antenna

4 x 4 MIMO: 403.2Mbps !

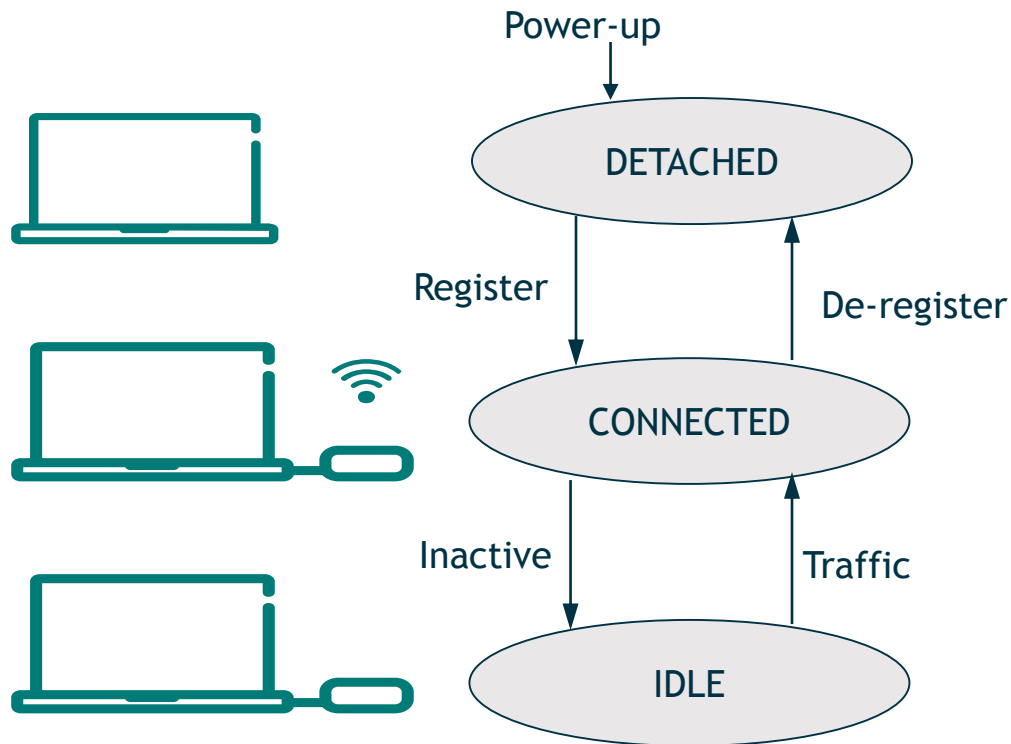
BUT in reality approx. 300Mbps

...and UL
no MIMO
75Mbps

LTE

LTE UE States

- > 3 UE states (5 in WCDMA)
 - Detached
 - Idle
 - Connected





Sistemas de 4ta Generación - LTE Advance

LTE Release 10

- > LTE Advanced => LTE 3GPP Rel 10
- > Major enhancements
 - Higher peak rates
 - Relaying solutions



LTE Rel. 10

Higher peak rates

Carrier aggregation



Spectrum aggregation



DL/UL Multi-Antenna transmission

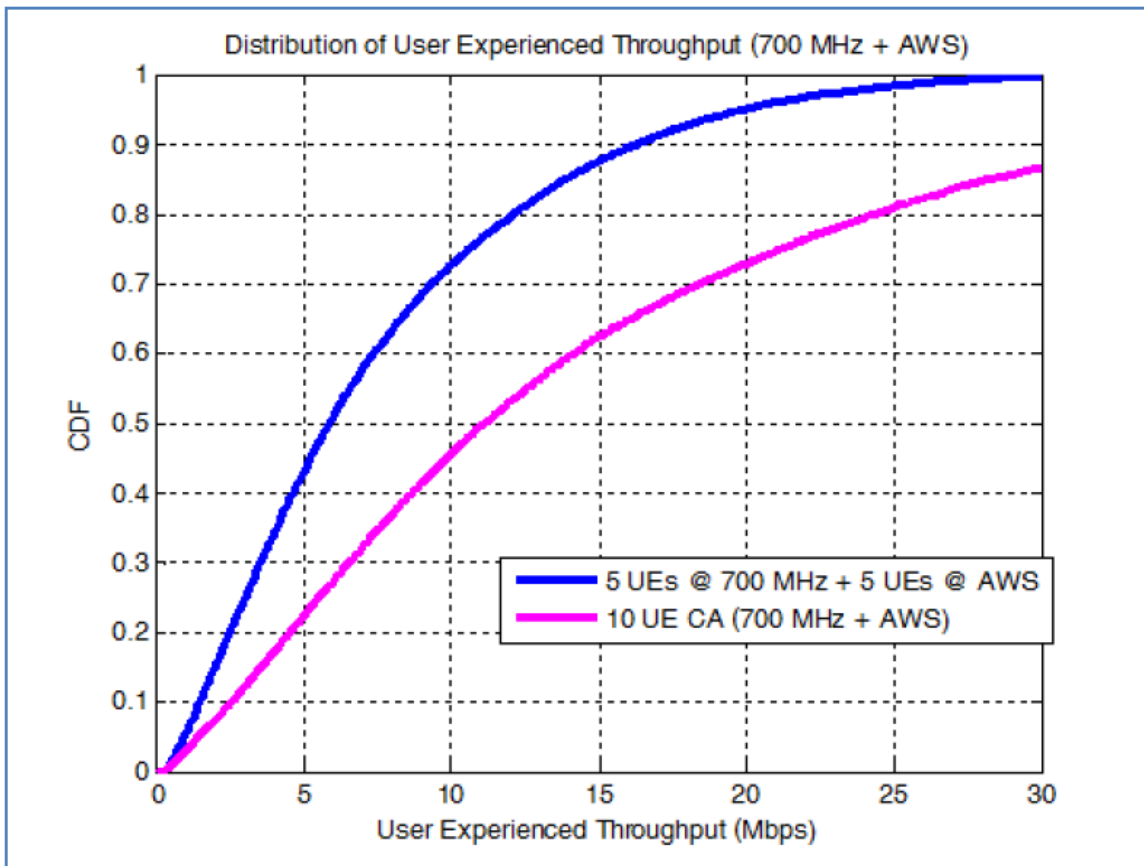


[Peak rates: 3Gbps/1.5Gbps !]

LTE Rel. 10

Higher peak rates

The result of one simulation study that compares download throughput rates between the blue line that shows five user devices in 700 MHz and five user devices in AWS not using CA and the pink line that shows ten user devices that have access to both bands. Assuming a lightly loaded network with CA, 50% or more users (the median) experience 91% greater throughput and 95% or more users experience 50% greater throughput. These trunking gains are less pronounced in heavily-loaded networks.



LTE Rel. 10

LTE-A Users Equipments Categories

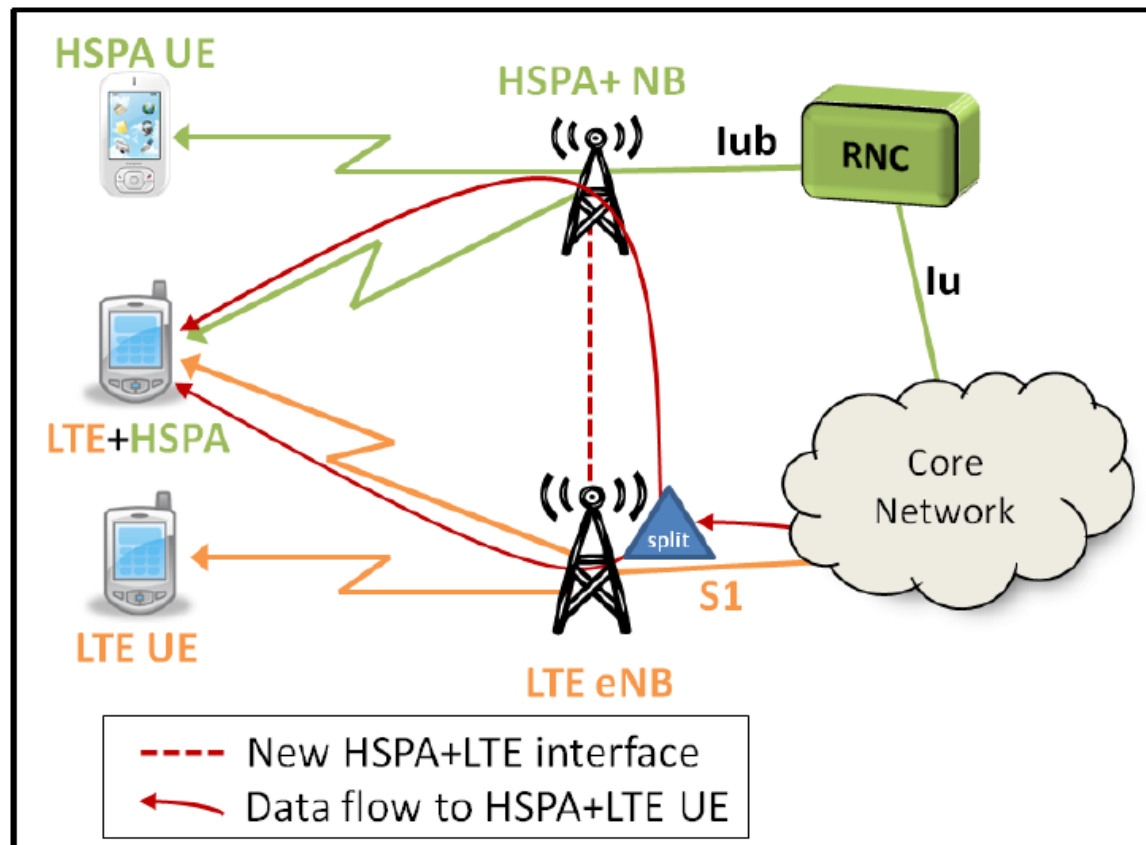
3GPP Release	UE Category	Max DL Throughput	Maximum DL MIMO Layers	Maximum UL Throughput	Support for UL 64 QAM
8	1	10.3 Mbps	1	5.2 Mbps	No
8	2	51.0 Mbps	2	25.5 Mbps	No
8	3	102.0 Mbps	2	51.0 Mbps	No
8	4	150.8 Mbps	2	51.0 Mbps	No
8	5	299.6 Mbps	4	75.4 Mbps	Yes
10	6	301.5 Mbps	2 or 4	51.0 Mbps	No
10	7	301.5 Mbps	2 or 4	102.0 Mbps	No
10	8	2998.6 Mbps	8	1497.8 Mbps	Yes

LTE Rel. 12

Inter-Technology Carrier Aggregation

Inter-technology (for example, LTE on one channel, HSPA+ on another). This is currently under consideration for Release 12.

While theoretically promising, a considerable number of technical issues will have to be addressed.



Curso Comunicaciones Móviles - 2017