

optimus

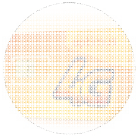
First Learning's from LTE Rollout & Optimisation Preparing LTE-Advanced

Luís Santo, Optimus, 5th June 2013

A large, stylized '4G' logo in orange and yellow with a black outline, set against a glowing yellow circular background. The background features a network diagram with white nodes and lines connecting them, all on an orange gradient background.



LTE WORLD EVOLUTION



4G @ OPTIMUS

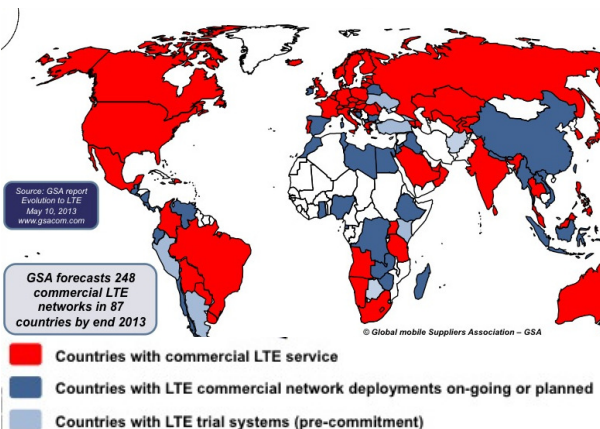


ROLLOUT & OPTIMISATION

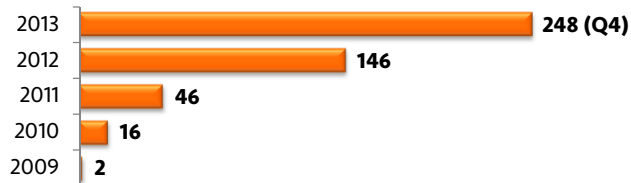


LTE-ADVANCED

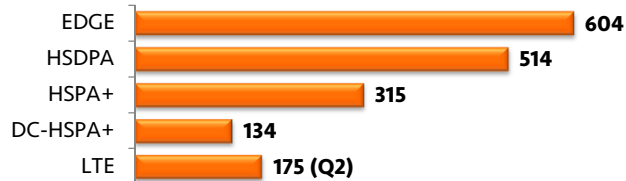
Source: <http://www.gsacom.com>



LTE Commercial Networks



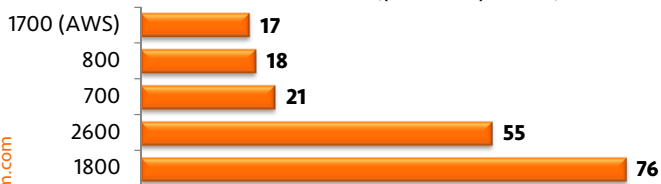
Commercial Networks (per Technology)



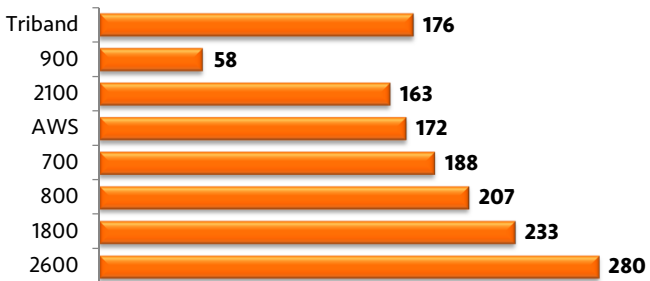
175 LTE commercial networks by May 2013. 100 Operators launching per year

FREQUENCY BANDS & DEVICES

LTE Commercial Networks (per Freq band)



UE Devices (per Freq band)

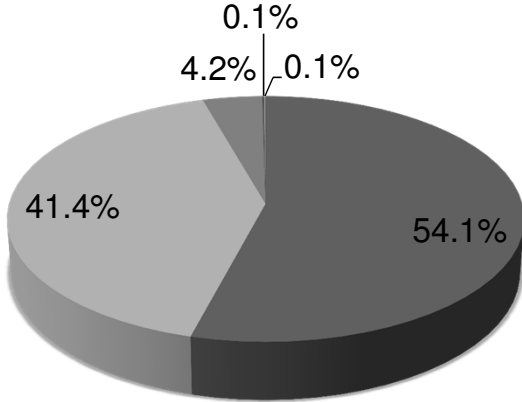


Source: <http://www.gsacom.com>

- 1800 MHz: **76 Commercial operators** in 43 countries
- 149** (/175) live LTE networks use **800 or 1800 or 2600 MHz**
- 821 LTE devices**, 562 are +3G. 2013: >400 new devices/year.
- 176** are **800/1800/2600 MHz**. 307 LTE 1800/2600 MHz devices.

LTE WORLD EVOLUTION
SUBSCRIBER EVOLUTION

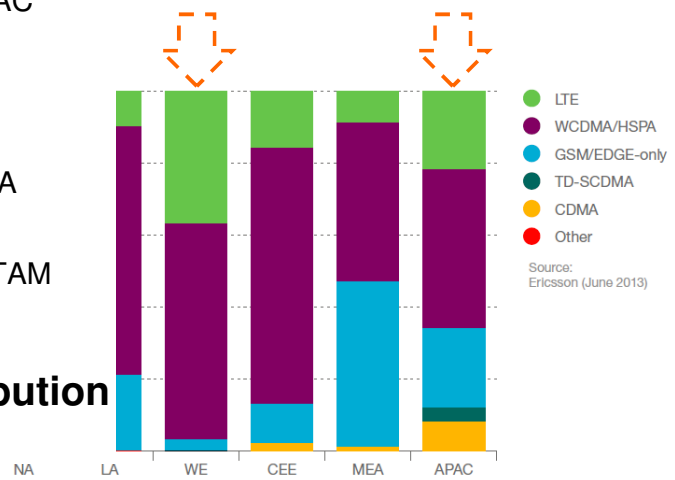
Source: <http://www.gsacom.com> Source: Ericsson Mobility Report, June 2013



LTE Subs World Distribution

- NA
- APAC
- EU
- MEA
- LATAM

LTE 20 million new subscriptions added in Q1-13
 2G: +30M, 3G: +60 M



Source: Ericsson (June 2013)

SUBSCRIBER EVOLUTION (PORTUGAL Q1 2013)



92.1% of resident Population has a mobile subscription (Marktest)



Mobile penetration: 158%, with 124% of SIMs with effective usage (ANACOM)

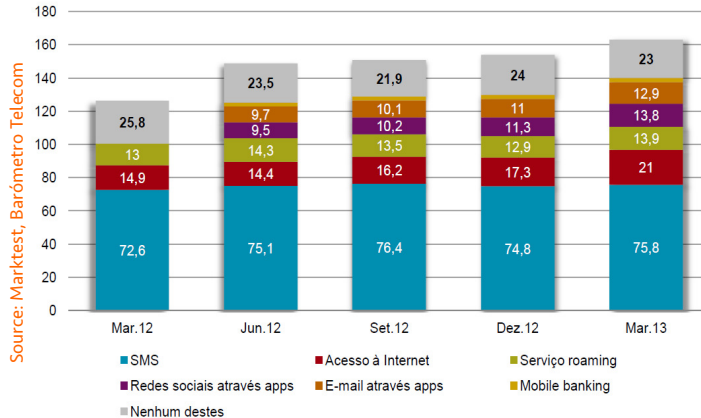


MBB 4.3M (-2.3% Q412, +7.5% YoY)

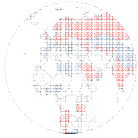


Total sales to final subscribers: 530M€ (-7.3% YoY)

Source: <http://www.anacom.pt>



Effective usage showing the lower penetration rate registered since 2010



LTE WORLD EVOLUTION



4G @ OPTIMUS

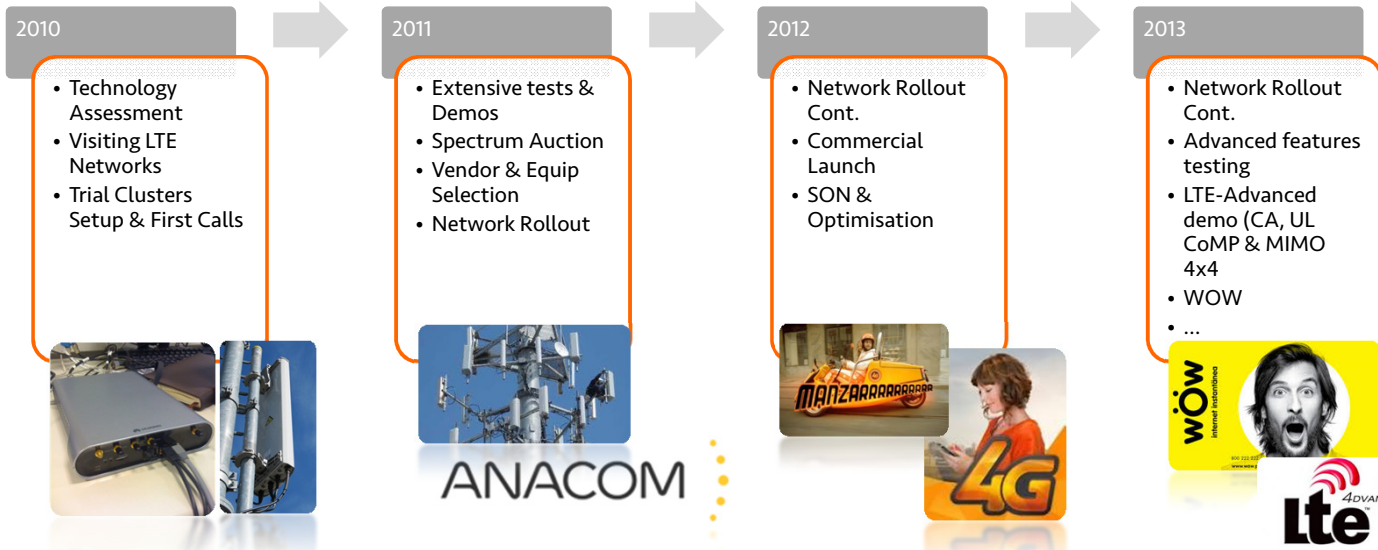


ROLLOUT & OPTIMISATION




LTE-ADVANCED

4G @ OPTIMUS LTE MILESTONES



4G Launched in 15th March 2012. Required more than 2 years preparation, and a whole company to drive it...

REVENUE OPPORTUNITIES & NEW SERVICES



Improved QoE & Capacity

- through improvement in user experience and increased capacity – higher ARPU




New Services

- by exploring services previously restricted to wireline and fostering service innovation



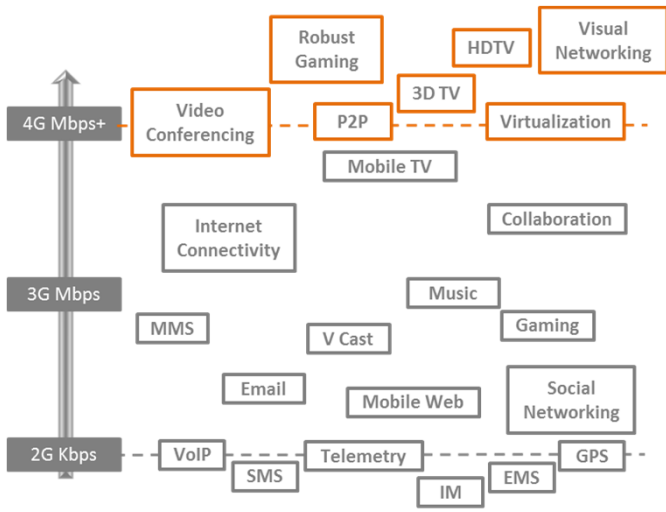
Fixed Mobile Substitution

- by providing 2P services for underserved areas
- 2P less data demanding segments




Downside Pressures


- Better latency, increase of VoIP
- Higher adoption on OTT (Netflix, etc.)




LTE enables or accelerate the adoption of a significant number of new services

 Smartphones


- CSFB (2G & 3G)
- Up to 50 Mbps

 Kanguru, Hotspots & Pads

- Up to 150 Mbps
- Unlimited volume offers available

 WÖW

- 20/40/100 Mbps unlimited offers
- 2P Fixed Substitution

 Cobertura

- 80% national coverage
- 800/1800/2600 MHz bands used



WÖW – INTERNET INSTANTÂNEA

optimus

instantânea

basta ligar à tomada para começar a usar, sem cabos, sem furos e sem esperas.

simples

fácil de ligar os seus equipamentos wi-fi.

transportável

fácil de transportar, leve-o consigo para a sua casa de férias.

net fixa 100Mbps

tráfego ilimitado
downloads até 100Mbps
uploads até 10Mbps

€36,99
/mês

net fixa 40Mbps

tráfego ilimitado
downloads até 40Mbps
uploads até 4Mbps

€30,99
/mês

net fixa 20Mbps

tráfego ilimitado
downloads até 20Mbps
uploads até 2Mbps

€24,99
/mês

The WÖW product challenges the 4G technology to a “fixed like” usage profile


TRAFFIC CHARACTERISATION



4G vs. 3G Global Vol: **5x**
 4G vs. 3G Smartphone Vol: **10x**



4G traffic growing exponentially (>60%/quarter, Q1 13)

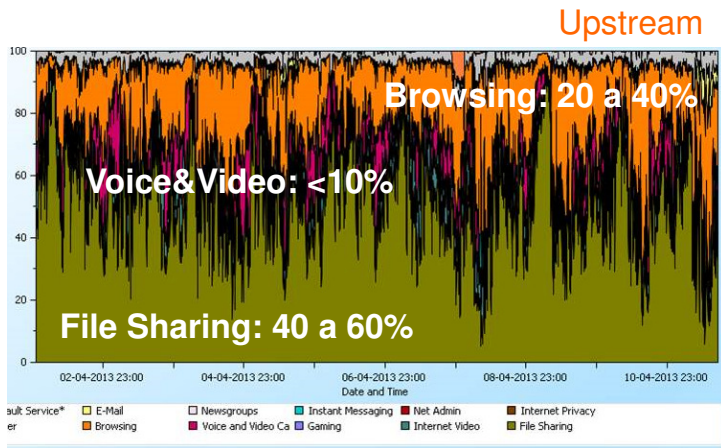


4G is a smartphone dominated network from day one



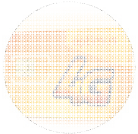
Video/Flash Video is the dominant application in DL. P2P dominates UL

4G dominated by smartphone devices. Different profiles per device. Video dominates DL





LTE WORLD EVOLUTION



4G @ OPTIMUS

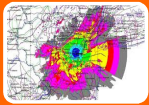


ROLLOUT & OPTIMISATION



LTE-ADVANCED

WHY REFORMING GSM1800 TO LTE



Better Coverage & Capacity

- 1800 coverage area nearly 2x 2600 MHz
- 1800 refarmed allows for same 20 MHz



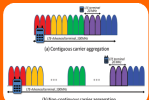
GSM1800 Asset Reuse

- Antennas, radio units (SDR), feeders, passive components (e.g. diplexers, DAS, etc.)



Device Ecosystem Building

- 233 1800 MHz LTE devices available
- Growing fast – roaming band candidate



Allows for LTE-A C.A. Expansion

- Up to 300 Mbps when C.A with LTE2600
- Up to 225 Mbps when C.A with LTE800



Reinforce 2G Capacity

- TRX & Abis upgrade



Improve 900MHz Freq Reuse plans

- Mitigate interference and optimise MA frequencies


codec	Encoding Rate (kbps)	Decoding Rate (kbps)	Relative Error Rate	Relative Throughput
AMR-NB	6.5	6.5	1.0	1.0
AMR-WB	12.7	12.7	1.0	1.0
AMR-WB	18.25	18.25	1.0	1.0
AMR-WB	23.85	23.85	1.0	1.0
AMR-WB	29.4	29.4	1.0	1.0
AMR-WB	35.0	35.0	1.0	1.0
AMR-WB	40.6	40.6	1.0	1.0
AMR-WB	46.2	46.2	1.0	1.0
AMR-WB	51.8	51.8	1.0	1.0
AMR-WB	57.4	57.4	1.0	1.0
AMR-WB	63.0	63.0	1.0	1.0
AMR-WB	68.6	68.6	1.0	1.0
AMR-WB	74.2	74.2	1.0	1.0
AMR-WB	79.8	79.8	1.0	1.0
AMR-WB	85.4	85.4	1.0	1.0
AMR-WB	91.0	91.0	1.0	1.0
AMR-WB	96.6	96.6	1.0	1.0
AMR-WB	102.2	102.2	1.0	1.0
AMR-WB	107.8	107.8	1.0	1.0
AMR-WB	113.4	113.4	1.0	1.0
AMR-WB	119.0	119.0	1.0	1.0
AMR-WB	124.6	124.6	1.0	1.0
AMR-WB	130.2	130.2	1.0	1.0
AMR-WB	135.8	135.8	1.0	1.0
AMR-WB	141.4	141.4	1.0	1.0
AMR-WB	147.0	147.0	1.0	1.0
AMR-WB	152.6	152.6	1.0	1.0
AMR-WB	158.2	158.2	1.0	1.0
AMR-WB	163.8	163.8	1.0	1.0
AMR-WB	169.4	169.4	1.0	1.0
AMR-WB	175.0	175.0	1.0	1.0
AMR-WB	180.6	180.6	1.0	1.0
AMR-WB	186.2	186.2	1.0	1.0
AMR-WB	191.8	191.8	1.0	1.0
AMR-WB	197.4	197.4	1.0	1.0
AMR-WB	203.0	203.0	1.0	1.0
AMR-WB	208.6	208.6	1.0	1.0
AMR-WB	214.2	214.2	1.0	1.0
AMR-WB	219.8	219.8	1.0	1.0
AMR-WB	225.4	225.4	1.0	1.0
AMR-WB	231.0	231.0	1.0	1.0
AMR-WB	236.6	236.6	1.0	1.0
AMR-WB	242.2	242.2	1.0	1.0
AMR-WB	247.8	247.8	1.0	1.0
AMR-WB	253.4	253.4	1.0	1.0
AMR-WB	259.0	259.0	1.0	1.0
AMR-WB	264.6	264.6	1.0	1.0
AMR-WB	270.2	270.2	1.0	1.0
AMR-WB	275.8	275.8	1.0	1.0
AMR-WB	281.4	281.4	1.0	1.0
AMR-WB	287.0	287.0	1.0	1.0
AMR-WB	292.6	292.6	1.0	1.0
AMR-WB	298.2	298.2	1.0	1.0
AMR-WB	303.8	303.8	1.0	1.0
AMR-WB	309.4	309.4	1.0	1.0
AMR-WB	315.0	315.0	1.0	1.0
AMR-WB	320.6	320.6	1.0	1.0
AMR-WB	326.2	326.2	1.0	1.0
AMR-WB	331.8	331.8	1.0	1.0
AMR-WB	337.4	337.4	1.0	1.0
AMR-WB	343.0	343.0	1.0	1.0
AMR-WB	348.6	348.6	1.0	1.0
AMR-WB	354.2	354.2	1.0	1.0
AMR-WB	359.8	359.8	1.0	1.0
AMR-WB	365.4	365.4	1.0	1.0
AMR-WB	371.0	371.0	1.0	1.0
AMR-WB	376.6	376.6	1.0	1.0
AMR-WB	382.2	382.2	1.0	1.0
AMR-WB	387.8	387.8	1.0	1.0
AMR-WB	393.4	393.4	1.0	1.0
AMR-WB	399.0	399.0	1.0	1.0
AMR-WB	404.6	404.6	1.0	1.0
AMR-WB	410.2	410.2	1.0	1.0
AMR-WB	415.8	415.8	1.0	1.0
AMR-WB	421.4	421.4	1.0	1.0
AMR-WB	427.0	427.0	1.0	1.0
AMR-WB	432.6	432.6	1.0	1.0
AMR-WB	438.2	438.2	1.0	1.0
AMR-WB	443.8	443.8	1.0	1.0
AMR-WB	449.4	449.4	1.0	1.0
AMR-WB	455.0	455.0	1.0	1.0
AMR-WB	460.6	460.6	1.0	1.0
AMR-WB	466.2	466.2	1.0	1.0
AMR-WB	471.8	471.8	1.0	1.0
AMR-WB	477.4	477.4	1.0	1.0
AMR-WB	483.0	483.0	1.0	1.0
AMR-WB	488.6	488.6	1.0	1.0
AMR-WB	494.2	494.2	1.0	1.0
AMR-WB	499.8	499.8	1.0	1.0
AMR-WB	505.4	505.4	1.0	1.0
AMR-WB	511.0	511.0	1.0	1.0
AMR-WB	516.6	516.6	1.0	1.0
AMR-WB	522.2	522.2	1.0	1.0
AMR-WB	527.8	527.8	1.0	1.0
AMR-WB	533.4	533.4	1.0	1.0
AMR-WB	539.0	539.0	1.0	1.0
AMR-WB	544.6	544.6	1.0	1.0
AMR-WB	550.2	550.2	1.0	1.0
AMR-WB	555.8	555.8	1.0	1.0
AMR-WB	561.4	561.4	1.0	1.0
AMR-WB	567.0	567.0	1.0	1.0
AMR-WB	572.6	572.6	1.0	1.0
AMR-WB	578.2	578.2	1.0	1.0
AMR-WB	583.8	583.8	1.0	1.0
AMR-WB	589.4	589.4	1.0	1.0
AMR-WB	595.0	595.0	1.0	1.0
AMR-WB	600.6	600.6	1.0	1.0
AMR-WB	606.2	606.2	1.0	1.0
AMR-WB	611.8	611.8	1.0	1.0
AMR-WB	617.4	617.4	1.0	1.0
AMR-WB	623.0	623.0	1.0	1.0
AMR-WB	628.6	628.6	1.0	1.0
AMR-WB	634.2	634.2	1.0	1.0
AMR-WB	639.8	639.8	1.0	1.0
AMR-WB	645.4	645.4	1.0	1.0
AMR-WB	651.0	651.0	1.0	1.0
AMR-WB	656.6	656.6	1.0	1.0
AMR-WB	662.2	662.2	1.0	1.0
AMR-WB	667.8	667.8	1.0	1.0
AMR-WB	673.4	673.4	1.0	1.0
AMR-WB	679.0	679.0	1.0	1.0
AMR-WB	684.6	684.6	1.0	1.0
AMR-WB	690.2	690.2	1.0	1.0
AMR-WB	695.8	695.8	1.0	1.0
AMR-WB	701.4	701.4	1.0	1.0
AMR-WB	707.0	707.0	1.0	1.0
AMR-WB	712.6	712.6	1.0	1.0
AMR-WB	718.2	718.2	1.0	1.0
AMR-WB	723.8	723.8	1.0	1.0
AMR-WB	729.4	729.4	1.0	1.0
AMR-WB	735.0	735.0	1.0	1.0
AMR-WB	740.6	740.6	1.0	1.0
AMR-WB	746.2	746.2	1.0	1.0
AMR-WB	751.8	751.8	1.0	1.0
AMR-WB	757.4	757.4	1.0	1.0
AMR-WB	763.0	763.0	1.0	1.0
AMR-WB	768.6	768.6	1.0	1.0
AMR-WB	774.2	774.2	1.0	1.0
AMR-WB	779.8	779.8	1.0	1.0
AMR-WB	785.4	785.4	1.0	1.0
AMR-WB	791.0	791.0	1.0	1.0
AMR-WB	796.6	796.6	1.0	1.0
AMR-WB	802.2	802.2	1.0	1.0
AMR-WB	807.8	807.8	1.0	1.0
AMR-WB	813.4	813.4	1.0	1.0
AMR-WB	819.0	819.0	1.0	1.0
AMR-WB	824.6	824.6	1.0	1.0
AMR-WB	830.2	830.2	1.0	1.0
AMR-WB	835.8	835.8	1.0	1.0
AMR-WB	841.4	841.4	1.0	1.0
AMR-WB	847.0	847.0	1.0	1.0
AMR-WB	852.6	852.6	1.0	1.0
AMR-WB	858.2	858.2	1.0	1.0
AMR-WB	863.8	863.8	1.0	1.0
AMR-WB	869.4	869.4	1.0	1.0
AMR-WB	875.0	875.0	1.0	1.0
AMR-WB	880.6	880.6	1.0	1.0
AMR-WB	886.2	886.2	1.0	1.0
AMR-WB	891.8	891.8	1.0	1.0
AMR-WB	897.4	897.4	1.0	1.0
AMR-WB	903.0	903.0	1.0	1.0
AMR-WB	908.6	908.6	1.0	1.0
AMR-WB	914.2	914.2	1.0	1.0
AMR-WB	919.8	919.8	1.0	1.0
AMR-WB	925.4	925.4	1.0	1.0
AMR-WB	931.0	931.0	1.0	1.0
AMR-WB	936.6	936.6	1.0	1.0
AMR-WB	942.2	942.2	1.0	1.0
AMR-WB	947.8	947.8	1.0	1.0
AMR-WB	953.4	953.4	1.0	1.0
AMR-WB	959.0	959.0	1.0	1.0
AMR-WB	964.6	964.6	1.0	1.0
AMR-WB	970.2	970.2	1.0	1.0
AMR-WB	975.8	975.8	1.0	1.0
AMR-WB	981.4	981.4	1.0	1.0
AMR-WB	987.0	987.0	1.0	1.0
AMR-WB	992.6	992.6	1.0	1.0
AMR-WB	998.2	998.2	1.0	1.0
AMR-WB	1003.8	1003.8	1.0	1.0
AMR-WB	1009.4	1009.4	1.0	1.0
AMR-WB	1015.0	1015.0	1.0	1.0
AMR-WB	1020.6	1020.6	1.0	1.0
AMR-WB	1026.2	1026.2	1.0	1.0
AMR-WB	1031.8	1031.8	1.0	1.0
AMR-WB	1037.4	1037.4	1.0	1.0
AMR-WB	1043.0	1043.0	1.0	1.0
AMR-WB	1048.6	1048.6	1.0	1.0
AMR-WB	1054.2	1054.2	1.0	1.0
AMR-WB	1059.8	1059.8	1.0	1.0
AMR-WB	1065.4	1065.4	1.0	1.0
AMR-WB	1071.0	1071.0	1.0	1.0
AMR-WB	1076.6	1076.6	1.0	1.0
AMR-WB	1082.2	1082.2	1.0	1.0
AMR-WB	1087.8	1087.8	1.0	1.0
AMR-WB	1093.4	1093.4	1.0	1.0
AMR-WB	1099.0	1099.0	1.0	1.0

OPTIMISING 4G CHALLENGES




OFDMA vs CDMA

- Limited ICIC
- Need to control cell overlap



Optimizing PCI and RACH Planning

- Define coverage and service areas
- Watch overshooting in LTE800



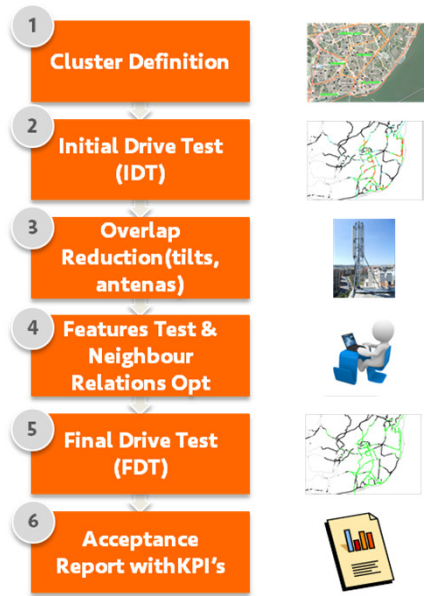
Mobility and iRAT

- Ensure X2 and HO performance
- Ensure adequate idle/dch mode reselection



Antenna Design & Optim

- Optimise tilts for different bands
- Evaluate antenna change impact to 2G/3G services




OPTIMISING 4G CHALLENGES




OFDMA vs CDMA

- Limited ICIC
- Need to control cell overlap



Optimizing PCI and RACH Planning

- Define coverage and service areas
- Watch overshooting in LTE800



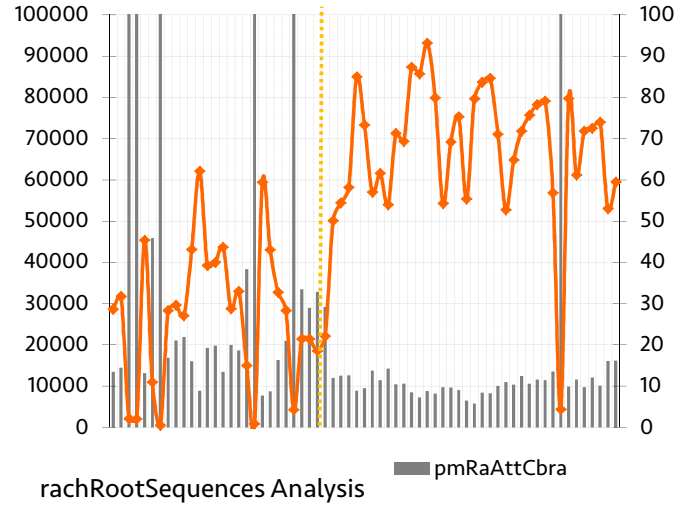
Mobility and iRAT

- Ensure X2 and HO performance
- Ensure adequate idle/dch mode reselection



Antenna Design & Optim

- Optimise tilts for different bands
- Evaluate antenna change impact to 2G/3G services



Limited cell overlap is critical for high performance. Complex iRAT mobility settings

LTE800 & TDT CO-EXISTENCE



TDT Interference from Spain

- TDT in Spain still using LTE800 spectrum
- High usage of CH 67 to 69



Illegal usage of CH69 in PT

- Self oscillating TV amplifiers still radiating in default CH69



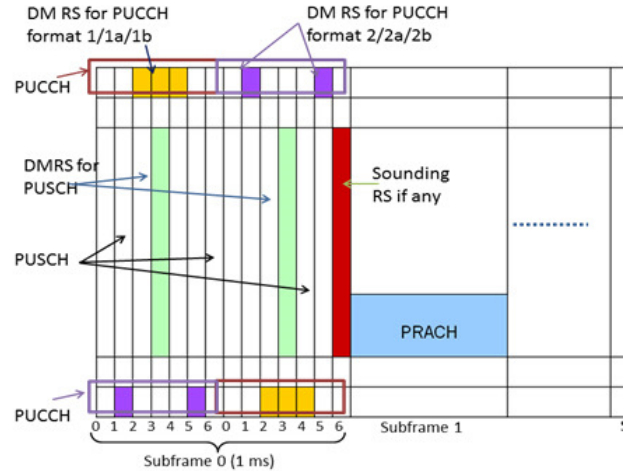
No relevant impact to CH56 TDT PT

- Insignificant incidence of LTE800 inducing problems to TDT reception (blocking)



Spain TDT Refarming in 2015

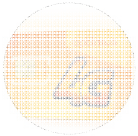
- Announced shutdown until end 2014
- Court troubles with TV operators – delay?



LTE800 interference mitigation: PUCCH optimised configuration



LTE WORLD EVOLUTION



4G @ OPTIMUS



ROLLOUT & OPTIMISATION



LTE-ADVANCED

LTE Advanced Objectives (3GPP R10)



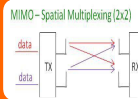
LTE R-10 is to provide higher bitrates in a cost efficient way, and at the same time fulfil the requirements set by ITU for IMT



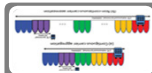
Increased peak data rate, DL 3 Gbps, UL 1.5 Gbps. increased number of simultaneously active subscribers



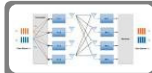
Higher spectral efficiency, from a maximum of 16bps/Hz in R8 to 30 bps/Hz in R10



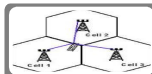
Improved performance at cell edges, e.g. for DL 2x2 MIMO at least 2.40 bps/Hz/cell.



Carrier Aggregation



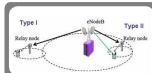
High order MIMO (up to 8x8)



UL CoMP



Heterogeneous Networks



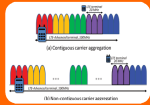
Relaying



SON Enhancements

Most relevant new Features: Carrier Aggregation, UL CoMP and MIMO 4x4

LTE-ADVANCED CARRIER AGGREGATION & MIMO 4x4



Frequency Bands

- C.A 1800 & 2600 MHz. MIMO 4x4 in 1800
- 2x 20 MHz , 300 Mbps peak



UE Device & LTE SW

- Lab unit provided by Huawei
- Consisting of 2 receivers (1 per band)



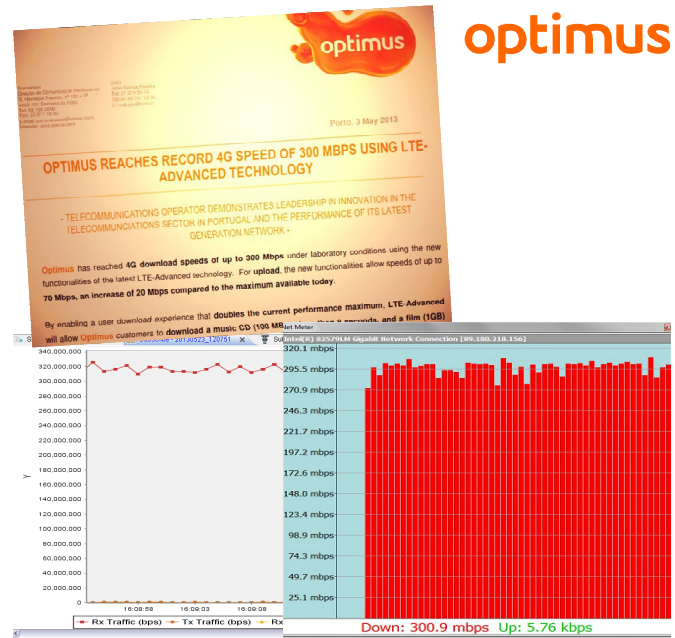
300 Mbps obtained in live

- Very good radio conditions, indoor
- Similar for CA and MIMO 4x4

Modulation	QAM	Rate	Power	Power	Power	Power
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100
64	QAM	100	100	100	100	100

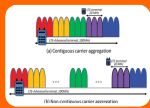
CAT 5 UE: 64 QAM UL tested

- Up to 68 Mbps (75M Theoretical Peak)
- Difference due to cell setup



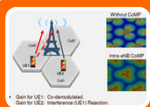
Optimus was the first operator to demo LTE-Advanced Carrier Aggregation, with Huawei Tech.

UPLINK COORDINATED MULTI-POINT (CoMP)



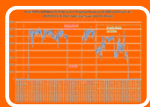
Mecanism to reduce ICI

- Intra node initially
- Minimizes inter cell interference



Support to legacy UEs

- Feature at eNodeB level
- No specific UE requirement (R8)



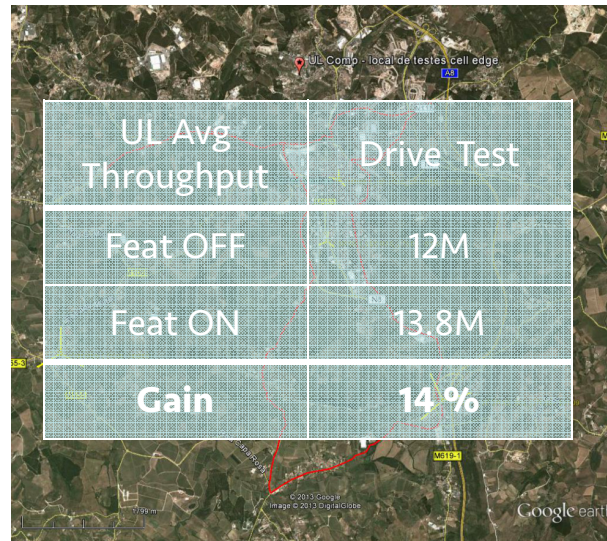
UL Throughput Gain

- > 5% at average capacity
- > 10% at peak throughput



Stringent requisites to IP transport

- X2 low latency for intra eNodeB
- Requires high eNodeB processing power



Source: <http://www.gsacom.com>

UL CoMP can improve 4G UL up to 14% at cell edge. Supported in legacy UEs

5G IS BUILDING UP (...ITS FIRST STEPS)



UK speeds up signals on 5G introduction (Ofcom consultation on new spectrum)



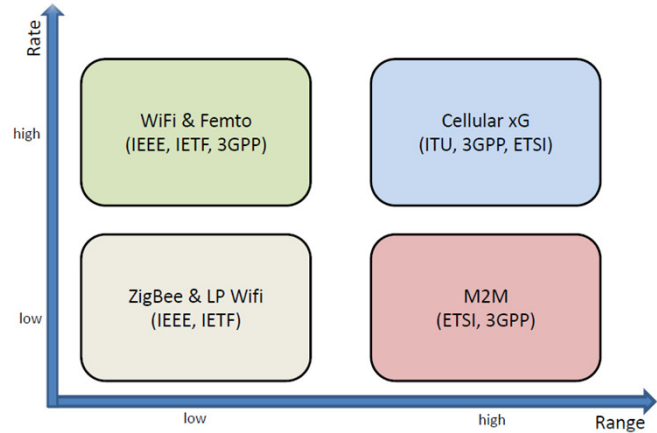
Fresh €50 million EU research grants in 2013 to develop '5G' technology



Samsung To Launch 5G By 2020, Hits Speeds Of 1Gbps In Tests



University of Surrey secured £35M for new 5G research centre, joint funded between UK Gov + Suppliers (2012)



5G is likely to have a more technology integration perspective than new radio technologies



175 LTE commercial networks by May 2013. 100 Operators launching per year
4G Smartphones to grow 3x. Video will account for 50% of volume (2018)



LTE enables or accelerate the adoption of a significant number of new services
4G dominated by smartphones. Different profiles/device. Video dominates DL



1800M strategy allows superior QoE. Need to control interference increase in GSM900
Limited cell overlap is critical for high performance. Complex iRAT mobility settings



Most relevant new Features: Carrier Aggregation, UL CoMP and MIMO 4x4
UL CoMP can improve 4G UL up to 14% at cell edge. Supported in legacy UEs

TELECOM, AS OTHER BUSINESSES, IS CHANGING FASTER



It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change (Darwin)

optimus

luis.santo@optimus.pt

www.optimus.pt

<https://www.facebook.com/optimus>

[http://www.linkedin.com/
company/optimus](http://www.linkedin.com/company/optimus)

4G