"Techno-economic modeling and Long Term Evolution model, Evaluation of upgrade scenarios"

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Budapest University of Technology and Economics

3GPP LTE (Rel. 8) Techno-Economic Analysis

Department of Informatics and Telecommunications - University of Athens
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Introduction

Welcome to the New Era of Telecommunications

Higher Spectral Efficiency

More Capacity

Better Coverage

Less Cost per Bit

Less Latency

Better User Experience

Less Interference

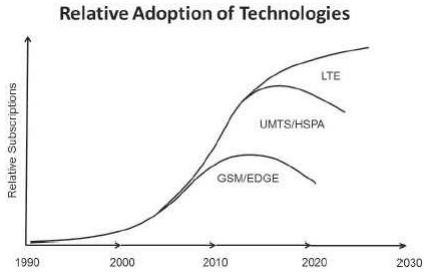
Create Economies of scale

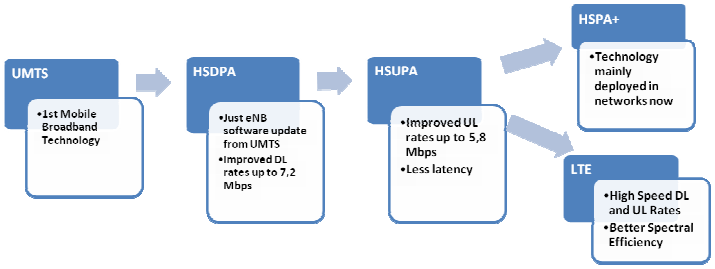
LTE Market Stats

- Worlds first commercial LTE Network launched by TeliaSonera in Oslo and Stockholm in December 2009.
- 174 LTE network commitments in 64 countries including 26 commercially launched networks worldwide as for September 2011.
- The fastest developing mobile telecommunications technology ever.

Mobile Evolution Path

The path from UMTS to LTE and technologies adoption rates

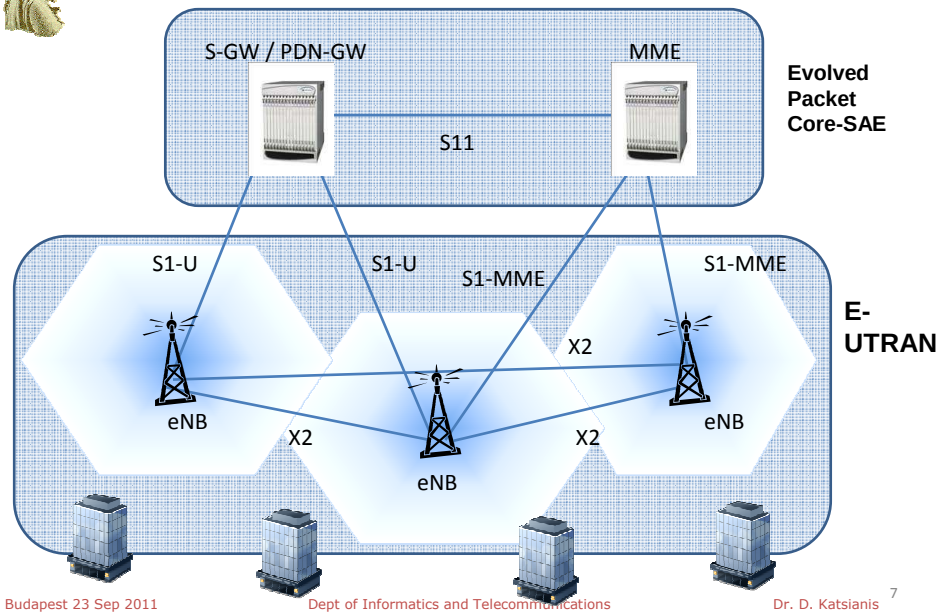




LTE Network Architecture

- Upgrades required in RAN (E-UTRAN) and Backhaul Network (EPC/SAE) from UMTS to LTE
- eNB with all radio interface related functions
- Serving-Gateway terminates interface towards E-UTRAN
- Mobile Management Entity-Gateway manages mobility, UE identity and security parameters
- All-IP Network Architecture

LTE Network Architecture



LTE Protocol Overview

- Downlink peak data rates up to 326 Mbps using 20 MHz bandwidth, 4x4 MIMO and 64QAM
- Uplink peak data rates up to 70 Mbps (16QAM)
- RAN latency less than 10 ms
- Scalable carrier bandwidth supported from 1,4 MHz to 20 MHz
- FDD and TDD support (paired/unpaired spectrum)
- OFDMA (DL) and SC-FDMA (UL) Multiplexing Schemes
- Backwards Compatibility with legacy networks except Voice and SMS services

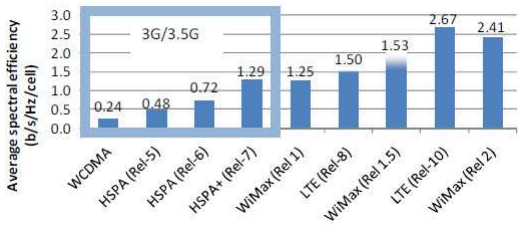
LTE Technology Overview

- Circuit Switching (CS) not supported, various technologies proposed for Voice and SMS.
- VoLTE (Voice over LTE), VoLGA (Voice over LTE Generic Access), CS FallBack to 2G/3G networks until full coverage of LTE networks

LTE – HSPA Comparison

	WCDMA (UMTS)	HSDPA/HSUPA	HSPA+	LTE (20 MHz)
Downlink	384 Kbps	14,4 Mbps	28 Mbps	300 Mbps
Uplink	128 Kbps	5,76 Mbps	11,5 Mbps	75 Mbps
Total Latency	150 ms	100 ms	50 ms	10 ms

Average Spectrum Efficiency HSPA to LTE



What's next? LTE-Advanced (Rel. 10)

- Up to 1Gbps low mobility DL peak data rate and 100 Mbps in high mobility DL scenario
- Protocol Highlights: Carrier Aggregation, Advanced Relay Nodes, MU-MIMO Transmission up to 8x8, Enhanced Interference Management using CoMP
- Heterogeneous Networks - Self Organizing Networks
- FemtoCell Integration – Machine2Machine (M2M) Communications

Mobile Broadband Demand Forecasts

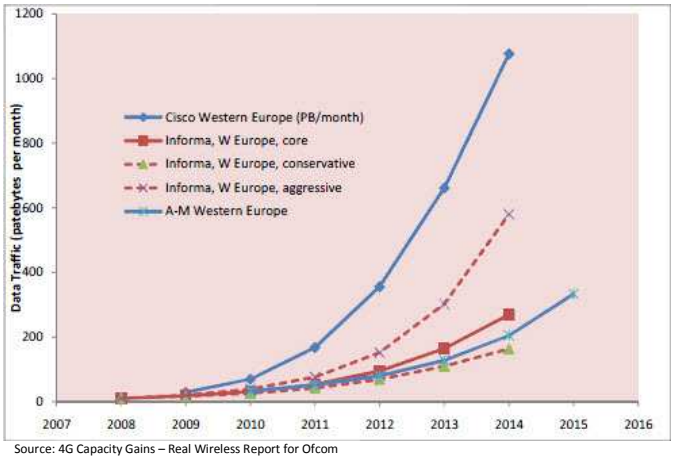
Mobile Data and Internet Traffic, 2010–2015

	2010	2011	2012	2013	2014	2015	CAGR 2010–2015
By Geography (PB per Month)							
North America	49	118	235	416	675	986	82%
Western Europe	64	146	326	635	1,073	1,632	91%
Asia Pacific	55	128	269	530	997	1,837	102%
Japan	40	86	172	289	425	578	70%
Latin America	12	26	60	127	257	488	111%
Central and Eastern Europe	10	25	56	110	201	346	102%
Middle East and Africa	6	17	44	90	179	387	129%
Total (PB per Month)							
Mobile data and Internet	237	546	1,163	2,198	3,806	6,254	92%

Source: Cisco VNI, 2011

- Compound Annual Growth Rate almost 100% each year worldwide
- Within 5 years 30x more data than voice delivered
- 1,5 billion mobile broadband subscribers worldwide

Mobile Broadband Demand Forecasts



Source: 4G Capacity Gains – Real Wireless Report for Ofcom

- Forecasts of exponential growth in mobile broadband demand in Western Europe

Spectrum for LTE

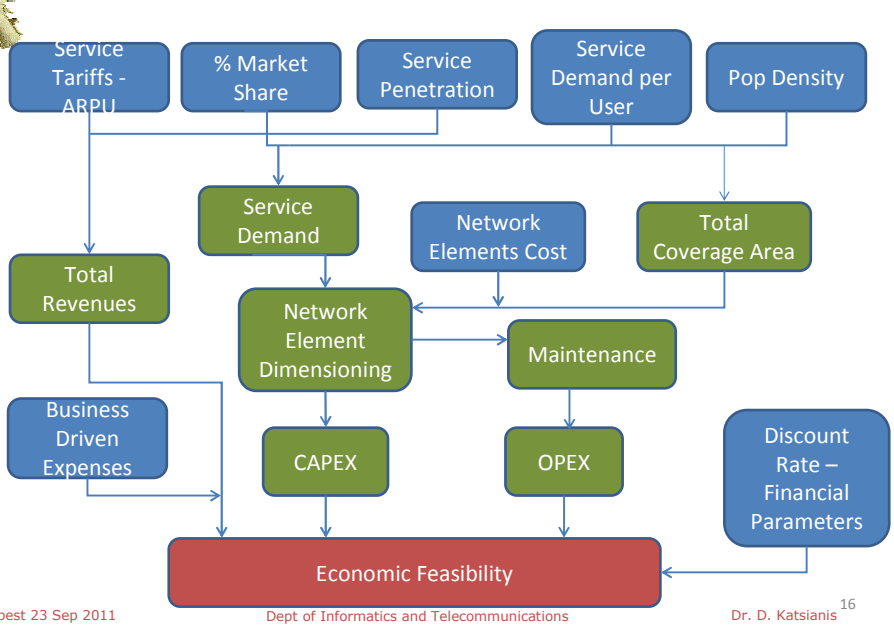
Available Frequencies

Digital Dividend (800/900 MHz) and 2,6 GHz band are very valuable for LTE deployments

LTE Deployment Case Study

1. Area Modeling
2. Service and Demand assumptions/penetration
3. Tariff assumptions and data plan marketing
4. Network Dimensioning – Capacity Driven and Coverage Driven results
5. Case Study Results
6. OPEX/CAPEX tables
7. Free Cash Flows tables
8. Cash Balance charts

Techno-Economic Model Used



LTE Deployment Case Study

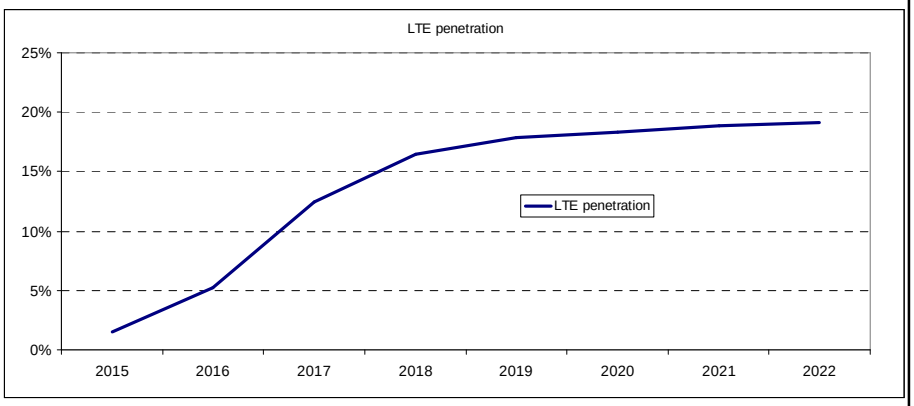
Study Area Modeling

	Population	Area (km²)	Pop Density (pop/km²)
Prefecture of Athens	2.931.253	361,719	8.104
Urban	2.931.253	361,719	8.104
Rural	0	0,000	0
Prefecture of Eastern Attica	444.309	1.512,993	294
Suburban	425.530	1.261,303	337
Rural	18.780	251,690	75
Prefecture of Western Attica	166.773	1.004,007	166
Suburban	162.395	844,725	192
Rural	4.378	159,282	27
Prefecture of Piraeus	595.654	929,382	641
Suburban	578.116	367,782	1.572
Rural	17.538	561,600	31
Totals	**4.137.989**	**3.808,101**	**1.087**

LTE Tariffs Europe

Providers	Data Rates (Mbps)	Tariff (€)/month
TeliaSonera (Sweden)	10-80 (data cap 30 Gb/month)	65
Telia (Finland)	10-80 (data cap 30 Gb/month)	46
NetCom/Telia (Norway)	10-80 (data cap 30 Gb/month)	63
Vodafone (Germany)	50	70
D-T Mobile (Germany)	Up to 100	75

LTE Service Market Penetration



Coverage driven network dimensioning

Methodology

- Define cell radius using propagation models depending on frequency used and environment (e.g. Okumura – Hata Propagation Models, Building density etc)
- 3 sector site: Site Area = 1,95 * 2,6 * CellRadius^2
- #Sites for Coverage : Case Study Area / Site Area

Capacity driven network dimensioning

Methodology

- Define Average Cell Throughput based on the predicted traffic – mapping of SINR distribution.
- Estimate Traffic Demand and Contention Ratio factor
- OverallDataRate = #Users*PeakDataRate*ContentionRatio
- #Sites for Capacity =
- OverallDataRate / SiteCapacity

LTE Techno-Economic Analysis

Technical Assumptions								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Spectrum Available	20MHz	20MHz	30MHz	30MHz	30Mhz	30MHz	40MHz	40MHz
Peak Spectral Efficiency (b/s/Hz)	5	5	10	10	10	12	12	14
Users Per Cell	300	300	400	400	420	420	500	500
Peak Data Rate Mbps (nominal)	60	60	120	140	140	200	240	280
QoS Average Data Rate (80% of cell users)	40	60	100	120	120	160	200	240
Mbps/eNB	18000	18000	48000	56000	58800	84000	120000	140000
Contention Ratio	20	20	30	30	30	30	30	30
Nominal Mbps/eNB	900	900	1600	1867	1960	2800	4000	4666,67
max users per eNB	6000	6000	12000	12000	12600	12600	15000	15000
International bandwidth cost (€/MB/year)	54,00 €	54,00 €	48,00 €	48,00 €	42,00 €	42,00 €	36,00 €	36,00 €
Price (ARPU)	47,50 €	45,00 €	45,00 €	40,00 €	40,00 €	35,00 €	35,00 €	30,00 €
Percentage Price Drop	0	5,56%	0,00%	12,50%	0,00%	14,29%	0,00%	16,67%
Sales (Users)	60.914	217.429	514.683	680.555	739.152	758.633	781.121	791.580
Sales Percentage Rise		71,98%	57,75%	24,37%	7,93%	2,57%	2,88%	1,32%

CAPEX Table

Annual CAPEX Breakdown

CAPEX									
Components	Initial Investment	2015	2016	2017	2018	2019	2020	2021	2022
Spectrum Fees	132.384.000 €								
LTE eNB	40.365.000 €								
LTE Antenna upgrade		0 €	0 €	7.452.000 €	0 €	0 €	0 €	9.315.000 €	0 €
Access Router	3.500.000 €								
Ethernet Switch	2.400.000 €								
Relay Nodes	22.032.000 €								
Mobile Management Entity		5.000.000 €	5.000.000 €	0 €	5.000.000 €	0 €	0 €	0 €	0 €
PDN Gateway		1.000.000 €	2.000.000 €	0 €	0 €	0 €	0 €	0 €	0 €
Serving Gateway		1.000.000 €	2.000.000 €	0 €	1.000.000 €	0 €	0 €	0 €	0 €
Equipment Cost	68.297.000 €	7.000.000 €	9.000.000 €	7.452.000 €	6.000.000 €	0 €	0 €	9.315.000 €	0 €
Total CAPEX	200.681.000 €	7.000.000 €	9.000.000 €	7.452.000 €	6.000.000 €	0 €	0 €	9.315.000 €	0 €

OPEX Table

Annual OPEX Breakdown

OPEX									
Components	Initial Investment	2015	2016	2017	2018	2019	2020	2021	2022
Maintenance (Defected Equipment)		2.018.250 €	2.018.250 €	2.018.250 €	2.018.250 €	2.018.250 €	2.018.250 €	2.018.250 €	2.018.250 €
International Bandwidth Rental		4.934.277 €	17.611.992 €	37.057.392 €	49.000.176 €	46.566.702 €	47.794.005 €	42.180.642 €	42.745.428 €
Service (Core Network)		70.000 €	160.000 €	160.000 €	220.000 €	220.000 €	220.000 €	220.000 €	220.000 €
Site Rent eNB (Year)	10.000 €	6.210.000 €	6.396.300 €	6.588.189 €	6.785.835 €	6.989.410 €	7.199.092 €	7.415.065 €	7.637.517 €
Site Rent RN (Year)	1.200 €	3.304.800 €	3.403.944 €	3.506.062 €	3.611.244 €	3.719.582 €	3.831.169 €	3.946.104 €	4.064.487 €
Leased Lines Rent (Transport Network)		142.776.000 €	135.637.200 €	128.855.340 €	122.412.573 €	116.291.944 €	110.477.347 €	104.953.480 €	99.705.806 €
Utilites	Watts (Average)								
BTS	900	269.866 €	296.852 €	326.537 €	359.191 €	395.110 €	434.621 €	478.083 €	525.892 €
RN	110	146.275 €	146.275 €	146.275 €	146.275 €	146.275 €	146.275 €	146.275 €	146.275 €
Mobile Server Switching Center	4000	1.931 €	6.373,64 €	7.011,00 €	10.282,80 €	11.311,08 €	12.442,19 €	12.815,45 €	14.097,00 €
Energy total OPEX		418.072 €	449.501 €	479.823 €	515.749 €	552.696 €	593.338 €	637.174 €	686.264 €
Total OPEX		159.731.399 €	165.677.187 €	178.665.057 €	184.563.827 €	176.358.584 €	172.133.201 €	161.370.714 €	157.077.751 €

NPV Cash Flows