
Contents

LIST OF FIGURES	xi
LIST OF TABLES	xix
INTRODUCTION	xxi
CHAPTER 1. LTE STANDARDS AND ARCHITECTURE	1
1.1. 3rd generation partnership project (3GPP)	1
1.1.1. 3GPP history	1
1.1.2. 3GPP, the current organization	3
1.1.3. 3GPP releases	8
1.2. LTE – numbering and addressing	10
1.2.1. The network IDs	11
1.2.2. The MME IDs	11
1.2.3. The tracking area IDs	11
1.2.4. The Cell IDs	12
1.2.5. The mobile equipment ID	12
1.3. LTE architecture overview	13
1.3.1. Overall high level description of LTE	14
1.3.2. LTE performance	22
1.3.3. LTE – QoS architecture.	23
1.3.4. FDD, TDD, LTE advanced.	23
1.3.5. Frequencies for LTE.	24
1.3.6. Basic parameters of LTE	25
1.4. Radio access subsystem: eUTRAN (also called eUTRA).	26

1.4.1. LTE visualization tool from Rohde and Schwartz	28
1.4.2. eUTRAN characteristics	28
1.4.3. eUTRAN interfaces	30
1.4.4. Signaling on the radio path	35
1.4.5. Physical layer	46
1.4.6. RLC and MAC layer	49
1.4.7. Dynamic radio resource management in LTE	51
1.4.8. MIMO	52
1.4.9. Macrocells, microcells and femtocells	53
1.5. Core network	54
1.5.1. LTE network elements	57
1.5.2. LTE interfaces [TS 23.401]	59
1.5.3. Functional split between the E-UTRAN and the EPC	69
1.5.4. S1 interface-based handover	70
1.6. LTE – roaming architecture	83
1.6.1. LTE network mobility management	87
1.7. SIM for communications privacy	89
1.7.1. SIM	89
1.7.2. USIM	95
1.7.3. ISIM	96
1.8. Glossary	96
1.9. Appendix 1: Complete submission of 3GPP LTE release 10 and beyond (LTE-advanced) under step 3 of the IMT-advanced process	98
1.9.1. Summary of the candidate submission	98
1.9.2. Classification of the candidate submission	100
1.9.3. Detailed checklist for the required elements for each candidate RIT within the composite SRIT and/or for the composite SRIT of the candidate submission (to fulfill section 3.1 of ITU-R Report M.2133)	100
1.9.4. Additional supporting information	102
1.9.5. Contact person	102
1.10. Appendix 2: GPRS Tunneling Protocol (GTP)	102
1.11. Appendix 3: The SGW implementation by CISCO	107
1.12. Appendix 4: AT&T has LTE small cells “in the lab”: Source Dan Janes, Site Editor, Light Reading mobile [JON 13].	110

CHAPTER 2. OFDMA	113
2.1. What is OFDM/OFDMA?	113
2.1.1. Claimed OFDMA advantages	115
2.1.2. Recognized disadvantages of OFDMA.	116
2.1.3. Characteristics and principles of operation	117
2.2. General principles	118
2.2.1. Cyclic prefixes	122
2.3. LTE channel: bandwidths and characteristics	124
2.3.1. LTE OFDM cyclic prefix, CP	125
2.3.2. LTE OFDMA in the downlink.	126
2.3.3. Downlink carriers and resource blocks.	127
2.3.4. LTE SC-FDMA in the uplink	128
2.3.5. Transmitter and receiver structure of LP-OFDMA/SC-FDMA	130
2.4. OFDM applied to LTE.	132
2.4.1. General facts	132
2.4.2. LTE downlink	133
2.4.3. Uplink	136
2.5. OFDMA in the LTE radio subsystem: OFDMA and SCFDMA in LTE	138
2.5.1. The downlink physical-layer processing of transport channels	138
2.5.2. Downlink multi-antenna transmission	139
2.5.3. Uplink basic transmission scheme	140
2.5.4. Physical-layer processing.	141
2.6. Appendix 1: the constraints of mobile radio	143
2.6.1. Doppler effect	144
2.6.2. Rayleigh/Rice fading	145
2.6.3. Area of service	151
2.6.4. Shadow effect	153
2.7. Appendix 2: Example of OFDM/OFDMA technological implementation Innovative DSP	153
2.8. Appendix 3: LTE error correction on the radio path [WIK 14d]	154
2.8.1. Hybrid ARQ with soft combining.	156
2.9. Appendix 4: The 700 MHz frequencies in the USA for LTE	157
2.9.1. Upper and lower 700 MHz.	158

CHAPTER 3. THE FULL IP CORE NETWORK	159
3.1. Fixed mobile convergence.	159
3.2. IP multimedia subsystem	160
3.2.1. General description of IMS.	160
3.2.2. Session Initiation Protocol	162
3.2.3. IMS components and interfaces	163
3.3. Evolved packet system in 3GPP standards	182
3.3.1. Policy and charging rules function	182
3.3.2. Release 8 system architecture evolution and evolved packet system.	184
3.4. Telephony processing	192
3.4.1. Enhanced voice quality	192
3.4.2. Circuit-switched fallback (CSFB).	192
3.4.3. Simultaneous voice and LTE (SVLTE)	192
3.4.4. Over-The-Top (OTT) applications	193
3.5. The requirements of VoLTE and V.VoIP applications	195
3.6. Voice and video over LTE are achieved using voice on IP channels (VoLTE).	196
3.7. Cut down version of IMS	201
3.8. Latency management.	202
3.9. Appendix 1: VoIP tests in UK	205
CHAPTER 4. LTE SECURITY. SIM/USIM SUBSYSTEM	207
4.1. LTE security.	207
4.1.1. Principles of LTE security	209
4.1.2. LTE EPC security	210
4.1.3. Interfaces protection.	214
4.1.4. Femtocells and relays	215
4.1.5. Specifications.	215
4.2. SIM card	216
4.2.1. SIM-lock	218
4.2.2. Electronic component of the UICC	219
4.2.3. Form factor	219
4.2.4. SIM card physical interface	221
4.2.5. UICC communication protocol	221
4.2.6. Operating system (OS) and virtual machines	223
4.2.7. (U)SIM authentication	224
4.2.8. LTE USIM	225
4.2.9. ISIM	226

4.2.10. Over the Air Activation (OTA)	228
4.2.11. Security services	228
4.2.12. USIM directories	228
4.2.13. The UICC/SIM/USIM/ISIM industry.	237
4.2.14. EAP-SIM and EAP.	237
APPENDIX	239
BIBLIOGRAPHY	253
INDEX	257