

Contents

<i>Preface</i>	<i>page xi</i>
<i>Acknowledgments</i>	<i>xiv</i>
1 Genesis of wireless broadband technology (from 2G to 4.5G)	1
1.1 Genesis of wireless technology	1
1.2 Key drivers for 4G/4.5G wireless broadband	4
1.3 Radio spectrum for wireless broadband	8
References	9
Additional reading	9
2 LTE overview	10
2.1 Introduction	10
2.2 System architecture	12
2.2.1 E-UTRAN	14
2.2.2 Evolved packet core	16
2.2.3 User equipment	18
2.3 Transmission scheme	20
2.3.1 OFDMA	20
2.3.2 SC-FDMA	25
References	30
3 Downlink transmission and system performance	33
3.1 Introduction	33
3.2 Mapping between transport and physical channels	34
3.3 LTE downlink frame structure	35
3.4 Data transmission	42
3.4.1 Shared data channel	42
3.4.2 Multimedia broadcast multicast service	48
3.5 Control signaling	50

viii CONTENTS

3.5.1	Physical Downlink Control Channel	50
3.5.2	Physical Control Format Indicator Channel	55
3.5.3	Physical HARQ Indicator Channel	56
3.5.4	Physical Broadcast Channel	59
3.5.5	Paging Control Channel	62
3.6	Downlink reference signal	63
3.7	Synchronization signals	67
3.7.1	Cell search and synchronization sequences	68
3.8	Performance results	69
3.8.1	Link-level performance	69
3.8.2	System-level performance	70
3.9	Rel-8 interference coordination schemes	72
3.10	LTE FDD vs. TDD comparison	74
	References	74
4	Uplink transmission and system performance	77
4.1	Introduction	77
4.2	Transmission scheme and frame structure	77
4.3	Data channel	80
4.3.1	Dynamic uplink scheduling assignment	82
4.3.2	Semi-persistent uplink scheduling assignment	85
4.3.3	Subframe bundling	87
4.3.4	HARQ processes	87
4.4	Control information	90
4.4.1	ACK/NACK and scheduling request	92
4.4.2	Channel measurement report – CQI/PMI/RI	97
4.5	Reference signals	108
4.5.1	Demodulation reference signal	110
4.5.2	Sounding reference signal	110
4.6	Random access	114
4.6.1	Random-access procedure	118
4.7	Timing advance	119

4.8	Power control	122
4.8.1	Data channel	122
4.8.2	Control channels	125
4.8.3	Random-access channel	126
4.8.4	Sounding reference signal	126
4.9	Interference coordination schemes	126
4.10	Performance results	128
4.10.1	Link-level performance	128
4.10.2	System-level performance	132
	References	137
5	MIMO	139
5.1	Introduction	139
5.2	Downlink multi-antenna techniques	139
5.2.1	Transmission mode 2: transmit diversity	142
5.2.2	Transmission mode 3: precoder-based open-loop spatial multiplexing	142
5.2.3	Transmission modes 4 and 6: closed-loop spatial multiplexing (single-user MIMO)	143
5.2.4	Transmission mode 5: multi-user MIMO	144
5.2.5	Transmission mode 7: UE-specific reference-symbol-based beamforming	145
5.2.6	System performance of LTE Rel-8 multiple-antenna schemes	147
5.3	Uplink multi-antenna techniques	152
	References	157
6	LTE-Advanced	160
6.1	Introduction	160
6.2	Carrier aggregation	161
6.2.1	Data transmission	167
6.2.2	Control signaling	169
6.3	Downlink multi-antenna transmission	176
6.3.1	LTE Rel-9 downlink spatial multiplexing	177
6.3.2	LTE Rel-10 downlink spatial multiplexing	180
6.3.3	Coordinated multi-point transmission	183

X CONTENTS

6.4	Uplink multi-antenna transmission	184
6.4.1	Control channels	186
6.4.2	Random-access channel	189
6.4.3	Data channel	190
6.4.4	Coordinated multi-point reception	195
6.5	Heterogeneous network	200
6.5.1	Heterogeneous network overview	201
6.5.2	Indoor distributed-antenna system	202
6.5.3	In-band relays	205
6.5.4	Pico- and femto-cell underlay	210
6.5.5	Interference-management techniques for heterogeneous network	212
6.6	Miscellaneous	216
6.6.1	Non-contiguous uplink transmission	216
6.6.2	Aperiodic SRS	218
	References	218
	Additional reading	220
7	Comparison of broadband technologies	222
7.1	Introduction	222
7.2	Feature comparison of wireless broadband technologies	222
7.3	Performance comparison of LTE/LTE-A and WiMAX/802.16m	227
7.4	Migration and co-existence scenarios	232
	Additional reading	236
	<i>Appendix</i>	238
	<i>A.1 System analysis and performance metrics</i>	238
	<i>A.2 Abbreviations</i>	241
	<i>Index</i>	247