

Contents

List of Acronyms	xix
List of Figures	xxiii
List of Tables	xxxi
1 Introduction	1
2 Performance analysis of random access (RA) in cellular networks under massive machine-type communication (mMTC) scenarios	7
2.1 Introduction	7
2.2 Related work	11
2.3 Random access in LTE Advanced (LTE-A)	12
2.3.1 Capacity of the RA procedure (RAP)	17
2.4 Performance analysis of RA in cellular networks	22
2.4.1 Methodology	22
2.4.2 Results	26
2.5 Conclusions	39

- 3 Analytical modeling of RA in cellular networks 41**
 - 3.1 Introduction 41
 - 3.2 RA in cellular networks: possible outcomes and common assumptions 44
 - 3.3 Analytical model of the RA in cellular networks 47
 - 3.3.1 Modeling the user equipment (UE) arrivals 47
 - 3.3.2 Modeling the access class barring (ACB) scheme 50
 - 3.3.3 Modeling the RAP 54
 - 3.3.4 Obtaining the key performance indicators (KPIs) 65
 - 3.3.5 Assessing the accuracy of our model 67
 - 3.4 Results and discussion 68
 - 3.4.1 Disabled ACB scheme 69
 - 3.4.2 Enabled ACB scheme 73
 - 3.4.3 The evolved NodeB (eNB) decodes the preambles transmitted by multiple UEs 77
 - 3.5 Conclusions 79

- 4 Adaptive access control for efficient mMTC in cellular networks 83**
 - 4.1 Introduction 83
 - 4.2 Related work 87
 - 4.3 Adaptive access class barring configuration (ACBC) scheme 90
 - 4.3.1 Adaptive filter algorithm configurations 93
 - 4.4 Test scenarios, tools, and methodology 97
 - 4.4.1 Performance metrics and methodology 100
 - 4.5 Results and discussion 102
 - 4.5.1 Performance of ACBC schemes with the optimal configuration 104
 - 4.5.2 Robustness of the proposed ACBC scheme 108

4.5.3	Stability test	110
4.5.4	Impact of realistic assumptions on the performance of the idealized full state information (IFI) scheme	114
4.6	Conclusions	115
5	Performance analysis of RA event-reporting in wireless sensor networks (WSNs)	117
5.1	Introduction	117
5.2	Related work	121
5.3	Hybrid method for the quality of service (QoS) analysis of RA WSN protocols	123
5.3.1	Network model	123
5.3.2	Obtaining the distribution of detecting cluster members (CMs)	128
5.3.3	Defining the Markov reward process	131
5.3.4	Obtaining the QoS parameters	138
5.4	QoS analysis	141
5.4.1	Fixed backoff (FB) approach	143
5.4.2	Adaptive backoff (AB) approach	145
5.4.3	Multi-event environments	149
5.5	Conclusions	152
6	Network-coded cooperation (NCC) for efficient massive content delivery through cellular networks	155
6.1	Introduction	155
6.2	Related work	160
6.3	NCC protocol and basic assumptions	162
6.4	Analytical model	166

6.5	Results	174
6.6	Conclusions	181
7	Conclusions and future perspectives	183
	Appendices	191
A	Notations	191
B	Derivations	193
B.1	Lower bounds for the physical RACH (PRACH) capacity	193
B.2	Proof of Lemma 3.1.	194
C	Performance of the proposed ACBC scheme with the recursive least-squares (RLS) algorithm	197
D	Publications directly related to this thesis	203
E	Research projects	207
	Bibliography	209