

# Contents

1	INTRODUCTION	1
1.1	Design flow today	2
1.1.1	Basic concepts	2
1.1.2	The Y-model	4
1.1.3	The V-model	4
1.2	Increasing design efficiency through reuse and modularity	6
1.3	Motivation	8
1.4	Contributions	11
1.5	Overview	13
2	PERFORMANCE MODEL FOR EXPLORATION AND ROBUSTNESS OPTIMIZATION	15
2.1	Formal methods for performance verification	15
2.2	State-of-the-art system performance model	17
2.2.1	System parameters	18
2.2.2	System performance properties	19
2.2.3	Performance metrics and constraints	22
2.3	Example system	23
2.4	Design Space Exploration	23
2.4.1	Exploration methods	25
2.4.2	Requirements for design space exploration	28
2.4.3	Application scenario for iterative design space exploration	30
2.5	Design Robustness	32
2.5.1	Effects of system property variations	33
2.5.2	Evaluating design robustness	36

2.5.3	Use cases for design robustness	38
2.5.4	Design scenarios and assumption for robustness evaluation and optimization	39
3	ITERATIVE DESIGN SPACE EXPLORATION FRAMEWORK	43
3.1	Multi-objective evolutionary algorithms	44
3.2	Compositional search space encoding	46
3.3	Component interaction optimization	49
3.3.1	Traffic shaping with $d^-$ -EAFs	50
3.3.2	Example	52
3.4	Design space exploration loop	55
3.5	User-controlled design space exploration	57
3.6	Chromosomes for timing and performance exploration	60
3.6.1	Priority chromosome	61
3.6.2	TDMA chromosome	63
3.6.3	Traffic shaping chromosome	69
3.7	Optimization objectives for timing and performance exploration	71
3.7.1	Example metrics	71
3.7.2	Partitioning of the fitness landscape	73
3.8	Case study	74
3.8.1	Multi-processor platform example	74
3.8.2	Exploring the example system	76
3.9	Extension for automated search space modification	79
3.9.1	Integration into the exploration framework	80
3.9.2	Concept	81
3.10	Automated search space modification for priority chromosomes	82
3.10.1	Analyzer	82
3.10.2	Decision maker	84
3.10.3	Narrow curves	86
3.10.4	Evaluation	88
4	DESIGN ROBUSTNESS OPTIMIZATION	93
4.1	Preliminaries	95
4.1.1	Sensitivity analysis	95
4.1.2	Hypervolume	102
4.2	Robustness metrics	105

4.2.1	Independent system properties	108
4.2.2	Dependent system properties	110
4.2.3	Robustness gain through reconfigurability	114
4.3	Stochastic multi-dimensional sensitivity analysis	116
4.3.1	Analysis idea	116
4.3.2	Search space encoding	117
4.3.3	Initial population	118
4.3.4	Bounding the search space	119
4.3.5	Crossover operators	122
4.3.6	Mutation operators	125
4.3.7	Limiting the search resolution	133
4.3.8	Approximation quality and convergence behavior	134
4.4	Exploring robustness	144
4.4.1	Independent system properties	144
4.4.2	Dependent system properties	144
4.5	Case study	156
4.5.1	Two-dimensional robustness optimization	156
4.5.2	Three-dimensional robustness optimization	163
5	COMBINED PERFORMANCE ANALYSIS OF EMBEDDED SYSTEMS	171
5.1	Compositional performance analysis	172
5.1.1	Local component analysis	173
5.1.2	Compositional system level analysis loop	174
5.1.3	Starting point generation	175
5.2	Symbolic Timing Analysis for Systems SymTA/S	175
5.2.1	Composition using standard event models	176
5.2.2	Output event model calculation	176
5.3	Modular Performance Analysis MPA	177
5.3.1	Arrival curves	177
5.3.2	Service curves	178
5.3.3	System level performance analysis	178
5.3.4	Computational efficiency	180
5.4	Coupling SymTA/S and MPA	180
5.4.1	Event model conversion	181
5.4.2	Starting point generation	185
5.5	Experiments	186
5.5.1	Path latency analysis	187

6 CONCLUSIONS	191
List of Figures	195
List of Tables	200
Bibliography	201