

# Contents

<b>Acknowledgements</b>	<b>xi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	1
1.2 Parallel programming models . . . . .	4
1.3 Synchronization Architecture . . . . .	6
1.4 Problem statement and thesis . . . . .	9
1.5 Approach . . . . .	10
1.6 Outline . . . . .	11
<b>2 Conceptual approach</b>	<b>13</b>
2.1 Parallel models and definitions . . . . .	14
2.1.1 Parallelism and parallel computing . . . . .	14
2.1.2 Modeling . . . . .	15
2.1.3 PCMs and PMMs . . . . .	15
2.1.4 Detail levels . . . . .	18
2.1.5 Requirements of PPMs . . . . .	18
2.2 Synchronization architecture . . . . .	20
2.2.1 Types of synchronization: CS, ME . . . . .	20
2.2.2 Mutual exclusion, mapping and bounded resources . . . . .	21
2.2.3 Classification criteria for SAs . . . . .	24
2.2.4 Condition synchronization: CS classes . . . . .	26
2.2.5 Mutual exclusion: ME classes . . . . .	30
2.2.6 Mutual exclusion vs. condition synchronization . . . . .	32
2.2.7 Data-Dependency: DS, NDS classes . . . . .	33
2.3 Execution-level models . . . . .	35
2.3.1 SA class of machine models . . . . .	36
2.3.2 Conclusions about execution models . . . . .	39
2.4 Bridging models and cost models . . . . .	40
2.4.1 Class (SP,NME,NDS): PRAM . . . . .	40
2.4.2 Class (SP,ME,NDS): BSP . . . . .	46

2.4.3	Class (SP,ME,NDS): QSM . . . . .	53
2.4.4	Class (NSP,ME,DS): LogP . . . . .	55
2.4.5	Conclusions about PCMs SA . . . . .	59
2.5	Parallel programming languages and models . . . . .	61
2.5.1	Class (SP,NME,DS): Pure nested parallelism . . . . .	61
2.5.2	Class (SP,ME,NDS): Nested parallelism with ME . . . . .	62
2.5.3	Class(NSP,NME,NDS): Mapping oriented models . . . . .	65
2.5.4	Class (NSP,ME,DS): Message passing . . . . .	68
2.5.5	Class (NSP,ME,DS): Maximum abstraction . . . . .	69
2.5.6	Conclusions about PPLs/PPMs SA . . . . .	71
2.6	Synchronization architecture of applications . . . . .	73
2.6.1	Class (SP,ME,NDS/DS) . . . . .	74
2.6.2	Class (NSP,ME,NDS/DS) . . . . .	75
2.6.3	Class (SP,NME,NDS) . . . . .	75
2.6.4	Class (SP, NME, DS) . . . . .	76
2.6.5	Class (NSP,NME,NDS) . . . . .	77
2.6.6	Class (NSP,NME,DS) . . . . .	79
2.6.7	Conclusions about applications SA . . . . .	80
2.7	Summary . . . . .	81
<b>3</b>	<b>Theoretical approach</b>	<b>83</b>
3.1	Graph preliminaries . . . . .	84
3.1.1	Basic graph concepts and notations . . . . .	85
3.1.2	Transitivities . . . . .	88
3.1.3	Topological graph parameters . . . . .	89
3.1.4	Task graphs . . . . .	90
3.2	Series-parallel graphs . . . . .	92
3.2.1	Definitions . . . . .	92
3.2.2	Distance from NSP to SP graphs . . . . .	96
3.3	Transformation problem (NSP to SP) . . . . .	98
3.3.1	SP-ization . . . . .	98
3.3.2	Local resynchronization . . . . .	101
3.3.3	Combinations of NSP problems . . . . .	104
3.3.4	Simple SP-ization techniques . . . . .	109
3.4	Algorithm 1: Local exploration . . . . .	112
3.4.1	Notations . . . . .	112
3.4.2	SP-ization technique . . . . .	113
3.4.3	JF combinations . . . . .	116
3.4.4	Mixing problems through JF combinations . . . . .	117
3.4.5	Example . . . . .	118
3.4.6	Complexity . . . . .	120
3.5	Algorithm 2: Local layering technique . . . . .	123

3.5.1	Notations . . . . .	123
3.5.2	Algorithm description . . . . .	124
3.5.3	Example . . . . .	127
3.5.4	Correctness . . . . .	131
3.5.5	Critical path property for UTC graphs . . . . .	132
3.5.6	Complexity . . . . .	133
3.5.7	Implementation . . . . .	134
3.5.8	Improvements . . . . .	136
3.6	Measuring the SP-ization impact . . . . .	136
3.6.1	Potential performance impact . . . . .	137
3.6.2	Structural impact . . . . .	140
3.6.3	Algorithms comparison . . . . .	143
3.6.4	Analytical models . . . . .	145
3.6.5	Conclusions about SP-ization impact . . . . .	147
3.7	Summary . . . . .	148
<b>4</b>	<b>Experimental study</b>	<b>151</b>
4.1	Synthetic graphs . . . . .	152
4.1.1	Workload modeling . . . . .	153
4.1.2	Random sample of the graph space . . . . .	155
4.1.3	Meshes . . . . .	160
4.1.4	Conclusions about synthetic graph results . . . . .	178
4.2	Real Applications . . . . .	180
4.2.1	Experiments design . . . . .	180
4.2.2	Application cost models at programming level . . . . .	188
4.2.3	Application cost models at implementation level . . . . .	198
4.2.4	Static applications results . . . . .	207
4.2.5	Dynamic applications results . . . . .	215
4.2.6	Conclusions about real application results . . . . .	226
4.3	Summary . . . . .	226
<b>5</b>	<b>Conclusion</b>	<b>229</b>
5.1	Contributions . . . . .	230
5.2	Conclusions . . . . .	231
	<b>Bibliography</b>	<b>233</b>