

Table of Contents

Introduction	1
 Specification Structures and Propositions-as-Types for Concurrency	
SAMSON ABRAMSKY, SIMON GAY AND RAJAGOPAL NAGARAJAN	5
1 Introduction	5
2 Specification Structures	7
2.1 Examples of Specification Structures	10
3 Interaction Categories	12
3.1 The Interaction Category <i>SProc</i>	12
3.2 The Interaction Category <i>ASProc</i>	22
3.3 <i>ASProc</i> as a Category	22
3.4 <i>ASProc</i> as a *-Autonomous Category	24
3.5 Time	25
4 Specification Structures for Deadlock-Freedom	25
4.1 The Synchronous Case	25
4.2 The Asynchronous Case	28
4.3 Constructing Cyclic Networks	33
5 The Dining Philosophers	34
References	39
 Automated Temporal Reasoning about Reactive Systems	
E. ALLEN EMERSON	41
1 Introduction	41
2 Preliminaries	43
2.1 Reactive Systems	43
2.2 Temporal Logics	44
2.3 Manual versus Mechanical Reasoning	45
2.4 CTL*, CTL, and PLTL	47
2.5 Mu-calculus	51
3 Model Checking	56
4 Decision Procedures I: Tableau-theoretic Approach	58
4.1 Overview	58
4.2 Tableau-based Decision Procedure for CTL	59
5 Decision Procedures II: Automata-theoretic Approach	63
5.1 Linear Time and Automata on Infinite Strings	64
5.2 Branching Time and Tree Automata	65
6 Expressiveness versus Complexity	74
6.1 Tradeoffs	75
6.2 Expressiveness Hierarchy	75

6.3 Complexity Summary	77
6.4 Automaton Ineffable Properties	80
6.5 Mu-calculus is Equivalent to Tree Automata	81
6.6 Restricted Temporal Logics	85
7 Conclusion	92
References	92

Decidability Results in Automata and Process Theory

YORAM HIRSHFELD AND FARON MOLLER	102
Preface	102
1 Grammars and Processes	103
1.1 Context-Free Grammars	104
1.2 Processes	105
1.3 Context-Free Processes	106
1.4 Concurrent Context-Free Processes	107
1.5 The Process Algebras BPA and BPP	109
2 Bisimulation Equivalence	112
2.1 Composition and Decomposition	116
2.2 Equivalence-Preserving Transformations	118
3 Decidability Results	120
3.1 Context-Free Processes	121
3.2 Concurrent Context-Free Processes	125
4 Algorithms for Normed Processes	130
4.1 Context-Free Processes	130
4.1.1 Algorithmic concerns	133
4.1.2 Simple context-free grammars	138
4.2 Concurrent Context-Free Processes	139
References	144

Modal and Temporal Logics for Processes

COLIN STIRLING	149
Preface	149
1 Processes	150
1.1 First examples	150
1.2 Concurrent interaction	154
1.3 Observable transitions	158
1.4 Renaming and linking	162
1.5 More combinations of processes	164
2 Modalities and Capabilities	166
2.1 Hennessy-Milner logic	167
2.2 More modal logics	168

2.3	Process equivalences	170
2.4	Interactive games and bisimulations	173
2.5	Modal properties and equivalences	177
2.6	Observable bisimulations	179
2.7	Equivalence checking	181
3	Temporal Properties	184
3.1	Modal properties revisited	184
3.2	Processes and their runs	185
3.3	Modal equations and fixed points	188
3.4	Modal mu-calculus	190
3.5	Approximants	193
3.6	Embedded approximants	197
3.7	Preservation of bisimulation equivalence	200
3.8	Expressing properties	202
4	Verifying Temporal Properties	206
4.1	Games and constants	206
4.2	Tableaux	211
4.3	Refinement of games and tableaux	215
4.4	Game graphs and algorithms	219
4.5	Generalizing tableaux	221
4.6	Well foundedness	227
5	Concluding Comments	232
	References	234

An Automata-Theoretic Approach to Linear Temporal Logic

MOSHE Y. VARDI	238
1 Introduction	238
2 Automata Theory	239
2.1 Automata on Finite Words – Closure	239
2.2 Automata on Infinite Words – Closure	241
2.3 Automata on Finite Words – Algorithms	245
2.4 Automata on Infinite Words – Algorithms	247
2.5 Automata on Finite Words – Alternation	248
2.6 Automata on Infinite Words – Alternation	251
3 Linear Temporal Logic and Automata on Infinite Words	253
4 Applications	256
4.1 Satisfiability	256
4.2 Verification	256
4.3 Synthesis	258
References	263