

# Membrane Computing & Biologically Inspired Process Calculi

**G A B R I E L C I O B A N U**



Editura Universității „Alexandru Ioan Cuza” Iași

2 0 1 0

# Contents

Preface	1
Chapter 1. Membrane Systems and Their Semantics	3
1. Operational Semantics of Membrane Systems	12
2. Implementing Membrane Systems by Using Maude	17
3. Register Membranes for Rules with Promoters and Inhibitors	23
4. Reversibility in Membrane Computing	30
5. Minimal Parallelism	38
6. Membrane Transducers	56
Bibliography	81
Chapter 2. Complexity of Membrane Systems	83
1. Computational Complexity of Simple P Systems	83
2. Complexity of Evolution in Maximum Cooperative P Systems	93
3. Evolving by Maximizing the Number of Rules	101
4. Strategies of Using the Rules of a P System in a Maximal Way	108
Bibliography	117
Chapter 3. Mobile Membranes and Links to Ambients and Brane Calculi	119
1. Simple Mobile Membranes	123
2. Enhanced Mobile Membranes	127
3. Mutual Mobile Membranes	147
4. Mutual Membranes with Objects on Surface	157
5. Mobile Membranes with Timers	170
6. Mobile Membranes and Mobile Ambients	177
Bibliography	215
Chapter 4. Multiset Information Theory and Encodings	217
1. Multiset Information Theory	217
2. Data Compression on Multisets. Submultiset-Free Codes	225
3. Number Encodings and Arithmetics over Multisets	234
4. Arithmetic Expressions in Membrane Systems	246
5. Various Encodings of Multisets	252
Bibliography	263

## CONTENTS

Chapter 5. Modelling Power of Membrane Systems	265
1. Modeling Cell-Mediated Immunity by Membrane Systems	265
2. Membrane Description of the Sodium-Potassium Pump	283
3. Distributed Evolutionary Algorithms Inspired by Membranes	294
4. Membrane Systems and Distributed Computing	311
5. Membrane Computing Software Simulators	325
Bibliography	339
Bibliography	341