

# Membrane computing

- A model of computing which abstracts from the functioning and structure of living cells (**P systems**) – Păun, 2000
- Three essential features: a hierarchical arrangement of membranes delimiting regions (*membrane structure*) – *tree structure, some multisets of objects and finite sets of rules associated to regions*
- *A P system evolves from one configuration to the other by applying the rules according to a given strategy (maximally parallel manner)*
- *Rules can transform objects, move objects, and even modify the membrane structure (creation/division/dissolution/moving) It generalizes (includes) L systems and DNA computing*

# Membrane Computing Membrane Computing

**Marian Gheorghe, Gheorghe  
Paun, Grzegorz Rozenberg, Arto  
Salomaa, Sergey Verlan**



## **Membrane Computing Membrane Computing:**

**Membrane Computing** Gheorghe Paun, 2002-08-01 Membrane computing is an unconventional model of computation associated with a new computing paradigm The field of membrane computing was initiated in 1998 by the author of this book it is a branch of natural computing inspired by the structure and functioning of the living cell and devises distributed parallel computing models in the form of membrane systems This book is the first monograph surveying the new field in a systematic and coherent way It presents the central notions and results the main classes of P systems the main results about their computational power and efficiency a complete bibliography and a series of open problems and research topics

*Membrane Computing* David Corne, Pierluigi Frisco, Gheorghe Păun, Grzegorz Rozenberg, Arto Salomaa, 2009-01-20 This book constitutes the thoroughly refereed extended postproceedings of the 9th International Workshop on Membrane Computing WMC 2008 held in Edinburgh UK in July 2008 under the auspices of the European Molecular Computing Consortium EMCC and the Molecular Computing Task Force of IEEE Computational Intelligence Society The 22 revised full papers presented together with 5 invited papers went through two rounds of reviewing and improvement The papers in this volume cover all the main directions of research in membrane computing ranging from theoretical topics in mathematics and computer science to application issues A special attention was paid to the interaction of membrane computing with biology and computer science focusing both on the biological roots of membrane computing on applications of membrane computing in biology and medicine and on possible electronically based implementations

**Membrane Computing** Carlos Martín-Vide, Giancarlo Mauri, Gheorghe Paun, Grzegorz Rozenberg, Arto Salomaa, 2004-02-02 This book constitutes the thoroughly refereed post proceedings of the International Workshop on Membrane Computing WMC 2003 held in Tarragona Spain in July 2003 The 26 revised full papers presented were carefully selected during two rounds of reviewing and improvement All current topics in the emerging area of membrane computing are addressed ranging from issues in mathematics and theoretical computer science to potential applications in biology bioinformatics sorting ranking linguistics and computer graphics several implementations and simulations on computers computer networks and reconfigurable hardware are presented too

**Applications of Membrane Computing** Gabriel Ciobanu, Mario J. Pérez-Jiménez, Gheorghe Păun, 2007-08-06 Membrane computing is a branch of natural computing which investigates computing models abstracted from the structure and functioning of living cells and from their interactions in tissues or higher order biological structures The models considered called membrane systems P systems are parallel distributed computing models processing multisets of symbols in cell like compartmental architectures In many applications membrane systems have considerable advantages among these are their inherently discrete nature parallelism transparency scalability and nondeterminism In dedicated chapters leading experts explain most of the applications of membrane computing reported so far in biology computer science computer graphics and linguistics The book also contains detailed reviews of the software tools used to simulate P

systems     **Applications of Membrane Computing in Systems and Synthetic Biology** Pierluigi Frisco, Marian Gheorghe, Mario J. Pérez-Jiménez, 2013-12-17 Membrane Computing was introduced as a computational paradigm in Natural Computing The models introduced called Membrane or P Systems provide a coherent platform to describe and study living cells as computational systems Membrane Systems have been investigated for their computational aspects and employed to model problems in other fields like Computer Science Linguistics Biology Economy Computer Graphics Robotics etc Their inherent parallelism heterogeneity and intrinsic versatility allow them to model a broad range of processes and phenomena being also an efficient means to solve and analyze problems in a novel way Membrane Computing has been used to model biological systems becoming with time a thorough modeling paradigm comparable in its modeling and predicting capabilities to more established models in this area This book is the result of the need to collect in an organic way different facets of this paradigm The chapters of this book together with the web pages accompanying them present different applications of Membrane Systems to Biology Deterministic non deterministic and stochastic systems paired with different algorithms and methodologies show the full potential of this framework The book is addressed to researchers interested in applications of discrete biological models and the interplay between Membrane Systems and other approaches to analyze complex systems

*Membrane Computing Models: Implementations* Gexiang Zhang, Mario J. Pérez-Jiménez, Agustín Riscos-Núñez, Sergey Verlan, Savas Konur, Thomas Hinze, Marian Gheorghe, 2021-07-01 The theoretical basis of membrane computing was established in the early 2000s with fundamental research into the computational power complexity aspects and relationships with other un conventional computing paradigms Although this core theoretical research has continued to grow rapidly and vigorously another area of investigation has since been added focusing on the applications of this model in many areas most prominently in systems and synthetic biology engineering optimization power system fault diagnosis and mobile robot controller design The further development of these applications and their broad adoption by other researchers as well as the expansion of the membrane computing modelling paradigm to other applications call for a set of robust efficient reliable and easy to use tools supporting the most significant membrane computing models This work provides comprehensive descriptions of such tools making it a valuable resource for anyone interested in membrane computing models

**Membrane Computing** Hendrik Jan Hoogeboom, Gheorghe Paun, Grzegorz Rozenberg, Arto Salomaa, 2007-01-25 This book constitutes the thoroughly refereed extended post proceedings of the 7th International Workshop on Membrane Computing WMC 2006 held in Leiden Netherlands in July 2006 The papers in this volume cover all the main directions of research in membrane computing ranging from theoretical topics in mathematics and computer science to application issues Special attention was paid to the interaction of membrane computing with biology     Membrane Computing Gheorghe Paun, 2014-03-12 Membrane computing is an unconventional model of computation associated with a new computing paradigm The field of membrane computing was initiated in 1998 by the author of this book it is a branch of natural

computing inspired by the structure and functioning of the living cell and devises distributed parallel computing models in the form of membrane systems This book is the first monograph surveying the new field in a systematic and coherent way It presents the central notions and results the main classes of P systems the main results about their computational power and efficiency a complete bibliography and a series of open problems and research topics      **Membrane Computing** Marian Gheorghe,Gheorghe Paun,Grzegorz Rozenberg,Arto Salomaa,Sergey Verlan,2012-01-12 This book constitutes the thoroughly refereed post conference proceedings of the 12th International Conference on Membrane Computing CMC 2011 held in Fontainebleau France in August 2011 The 19 revised selected papers presented were carefully reviewed and selected from 27 papers and 5 posters presented at the conference The book also contains full papers or extended abstracts of the 5 invited presentations The papers address all the main directions of research in membrane computing ranging from theoretical topics in the mathematics and computer science to application issues      **Membrane Computing** Alberto Leporati,Grzegorz Rozenberg,Arto Salomaa,Claudio Zandron,2017-02-21 This book contains revised selected papers from the 17th International Conference on Membrane Computing CMC 2017 held in Milan Italy in July 2016 The 19 full papers presented in this volume were carefully reviewed and selected from 28 submissions They deal with membrane computing P systems theory an area of computer science aiming to abstract computing ideas and models from the structure and the functioning of living cells as well as from the way the cells are organized in tissues or higher order structures The volume also contains 3 invited talks in full paper length      *Membrane Computing* Gheorghe Paun,Mario J. Perez-Jimenez,Agustin Riscos-Nunez,Grzegorz Rozenberg,Arto Salomaa,2010-01-20 This book constitutes the thoroughly refereed post workshop proceedings of the 10th International Workshop on Membrane Computing WMC 2009 held in Curtea de Arges Romania during August 24 to 27 2009 under the auspices of the European Molecular Computing Consortium EMCC and the Molecular Computing Task Force of IEEE Computational Intelligence Society The 22 revised full papers presented together with 10 invited papers went through two rounds of reviewing and improvement The papers in this volume cover all the main directions of research in membrane computing ranging from theoretical topics in mathematics and computer science to application issues the invited lectures present fundamental contributions to membrane computing thus highlighting important directions of current research in this area      Membrane Computing Giancarlo Mauri,Gheorghe Paun,Mario J. Pérez-Jiménez,Grzegorz Rozenberg,Arto Salomaa,2008-01-04 This book constitutes the thoroughly refereed extended postproceedings of the 5th International Workshop on Membrane Computing WMC 2004 held in Milan Italy in June 2004 The 20 revised full papers presented together with 6 invited papers went through two rounds of reviewing and improvement All current topics in the area of membrane computing are addressed ranging from mathematics and theoretical computer science to applications in biology linguistics and computer graphics Issues related to computational power and complexity classes new classes of P systems fuzzy approaches and reversibility and energy consumption are dealt with as well      Membrane Computing George

Eleftherakis,Petros Kefalas,Gheorghe Paun,Grzegorz Rozenberg,Arto Salomaa,2007-11-25 For anyone needing to keep up to date with all the latest research in the field of membrane computing this book will come as a breath of fresh air It is the extended post proceedings of the 8th International Workshop on Membrane Computing held in June 2007 A total of 27 revised papers are presented All of them have been through two rounds of reviewing Special attention has been paid to the interaction of membrane computing with biology and computer science     Computing with Cells Pierluigi Frisco,2009-05-21 Membrane systems are a new class of distributed and parallel model of computation inspired by the subdivision of living cells into compartments delimited by membranes Their hierarchical internal structure their locality of interactions their inherent parallelism and also their capacity to create new compartments represent the distinguishing hallmarks of membrane systems Membrane computing the study of membrane systems is a fascinating and fast growing area of research The main streams of current investigations in Membrane Computing concern theoretical computer science and the modelling of complex systems In this monograph Pierluigi Frisco considers the former trend he presents an in depth study of the formal language and computational complexity aspects of the most widely investigated models of membrane systems This study gives a comprehensive understanding of the computational power of the models considered shows different proof techniques used for such study and introduces links highlighting the similarities and differences between the their computational power These models cover a broad range of features giving a grasp of the enormous flexibility of the framework offered by membrane systems Aimed at graduates and researchers in the field who can use it as a reference text and to people with an initial interest in Membrane Computing who can use it as a clear and up to date starting point for Membrane Computing

Membrane Computing Artiom Alhazov,Svetlana Cojocaru,Marian Gheorghe,Yurii Rogozhin,Grzegorz Rozenberg,Arto Salomaa,2014-01-20 This book constitutes the thoroughly refereed post conference proceedings of the 14th International Conference on Membrane Computing CMC 2013 held in Chi in u Republic of Moldova in August 2013 The 16 revised selected papers presented together with 6 invited lectures were carefully reviewed and selected from 26 papers presented at the conference Membrane computing is an area of computer science aiming to abstract computing ideas and models from the structure and the functioning of living cells as well as from the way the cells are organized in tissues or higher order structures It deals with membrane systems also called P systems which are distributed and parallel algebraic models processing multi sets of objects in a localized manner evolution rules and evolving objects are encapsulated into compartments delimited by membranes with an essential role played by the communication among compartments and with the environment     *Membrane Computing* Rudolph Freund,Gheorghe Paun,Grzegorz Rozenberg,Arto Salomaa,2005-12-23 This book constitutes the thoroughly refereed extended postproceedings of the 6th International Workshop on Membrane Computing WMC 2005 held in Vienna Austria in July 2005 The 20 revised full papers presented together with 5 invited papers went through two rounds of reviewing and improvement The papers in this volume cover all the main directions of

research in membrane computing ranging from theoretical topics in mathematics and computer science to application issues especially in biology More specifically these papers present research on topics such as computational power and complexity classes new types of P systems relationships to Petri nets quantum computing and brane calculi determinism vs nondeterminism hierarchies the size of small families algebraic approaches and designing polynomial solutions to NP complete problems through the use of membrane systems

**Membrane Computing** Marian Gheorghe,Grzegorz Rozenberg,Arto Salomaa,Petr Sosik,Claudio Zandron,2014-12-16 This book constitutes the thoroughly refereed post conference proceedings of the 15th International Conference on Membrane Computing CMC 2014 held in Prague Czech Republic in August 2014 The 19 revised selected papers presented together with 5 invited lectures were carefully reviewed and selected from 24 papers presented at the conference In addition two papers selected from the 22 papers presented at the regional version of CMC the Asian Conference on Membrane Computing ACMC 2014 held in Coimbatore India are included The papers cover a wide range of topics in the area of membrane computing which is an area of computer science aiming to abstract computing ideas and models from the structure and the functioning of living cells as well as from the way the cells are organized in tissues or higher order structures

**Membrane Computing** Erzsebet Csuhaj-Varju,Marian Gheorghe,Grzegorz Rozenberg,Arto Salomaa,György Vaszil,2013-02-26 This book constitutes the thoroughly refereed post conference proceedings of the 13th International Conference on Membrane Computing CMC 2012 held in Budapest Hungary in August 2012 The 21 revised selected papers presented together with 6 invited lectures were carefully reviewed and selected from 25 papers presented at the conference The book also deals with membrane systems also called P systems which are distributed and parallel algebraic models processing multisets of objects in a localized manner evolution rules and evolving objects are encapsulated into compartments delimited by membranes with an essential role played by the communication among compartments and with the environment

**Membrane Computing** Thomas Hinze,Grzegorz Rozenberg,Arto Salomaa,Claudio Zandron,2019-01-31 This book constitutes revised selected papers from the 19th International Conference on Membrane Computing CMC19 CMC 2018 which was held in Dresden Germany in September 2018 The 15 papers presented in this volume were carefully reviewed and selected from 20 submissions The contributions aim to abstract computing ideas and models from the structure and the functioning of living cells as well as from the way the cells are organized in tissues or higher order structures

**Membrane Computing** Gheorghe Paun,Grzegorz Rozenberg,Arto Salomaa,Claudio Zandron,2003-07-01 This book constitutes the thoroughly refereed post proceedings of the International Workshop on Membrane Computing WMC CdeA 2002 held in Curtea de Arges Romania in August 2002 The 29 revised full papers presented were carefully selected during two rounds of reviewing and revision some were especially solicited for inclusion in the book after the workshop Most papers address membrane systems and membrane computing from the point of view of theoretical computer science some papers solve open problems and present new approaches and

others provide mathematical and biological background All in all the book presents the state of the art in membrane computing



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