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# Parallel Processing and Applied Mathematics

8th International Conference, PPAM 2009  
Wroclaw, Poland, September 13-16, 2009  
Revised Selected Papers, Part II

## Volume Editors

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Konrad Karczewski

Czestochowa University of Technology

Institute of Computational and Information Sciences, Poland

E-mail: {roman, xeno}@icis.pcz.pl

Jack Dongarra

University of Tennessee, Department of Electrical Engineering

and Computer Science, Knoxville, TN 37996-3450, USA

E-mail: dongarra@cs.utk.edu

Jerzy Wasniewski

Technical University of Denmark, Department of Informatics

and Mathematical Modeling, 2800 Kongens Lyngby, Denmark

E-mail: jw@imm.dtu.dk

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# Preface

We are pleased to present the proceedings of the 8th International Conference on Parallel Processing and Applied Mathematics – PPAM 2009, which was held in Wrocław, Poland, September 13–16, 2009. It was organized by the Department of Computer and Information Sciences of the Częstochowa University of Technology, with the help of the Wrocław University of Technology, Faculty of Computer Science and Management. The main organizer was Roman Wyrzykowski.

PPAM is a biennial conference. Seven previous events have been held in different places in Poland since 1994. The proceedings of the last four conferences have been published by Springer in the *Lecture Notes in Computer Science* series (Nałęczów, 2001, vol.2328; Częstochowa, 2003, vol.3019; Poznań, 2005, vol.3911; Gdańsk, 2007, vol. 4967).

The PPAM conferences have become an international forum for exchanging ideas between researchers involved in parallel and distributed computing, including theory and applications, as well as applied and computational mathematics. The focus of PPAM 2009 was on models, algorithms, and software tools which facilitate efficient and convenient utilization of modern parallel and distributed computing architectures, as well as on large-scale applications.

This meeting gathered more than 210 participants from 32 countries. A strict refereeing process resulted in the acceptance of 129 contributed presentations, while approximately 46% of the submissions were rejected. Regular tracks of the conference covered such important fields of parallel/distributed/grid computing and applied mathematics as:

- Parallel/distributed architectures and mobile computing
- Numerical algorithms and parallel numerics
- Parallel and distributed non-numerical algorithms
- Tools and environments for parallel/distributed/grid computing
- Applications of parallel/distributed computing
- Applied mathematics and neural networks

## Plenary and Invited Speakers

The plenary and invited talks were presented by:

- Srinivas Aluru from the Iowa State University (USA)
- Dominik Behr from AMD (USA)
- Ewa Deelman from the University of Southern California (USA)
- Jack Dongarra from the University of Tennessee and Oak Ridge National Laboratory (USA)
- Iain Duff from the Rutherford Appleton Laboratory (UK)
- Anne C. Elster from NTNU, Trondheim (Norway)

- Wolfgang Gentzsch from the DEISA Project
- Michael Gschwind from the IBM T.J. Watson Research Center (USA)
- Fred Gustavson from the IBM T.J. Watson Research Center (USA)
- Simon Holland from Intel (UK)
- Vladik Kreinovich from the University of Texas at El Paso (USA)
- Magnus Peterson from the Synective Labs (Sweden)
- Armin Seyfried from the Juelich Supercomputing Centre (Germany)
- Bolesław Szymański from the Rensselaer Polytechnic Institute (USA)
- Jerzy Waśniewski from the Technical University of Denmark (Denmark)

## Workshops and Minisymposia

Important and integral parts of the PPAM 2009 conference were the workshops:

- Minisymposium on GPU Computing organized by José R. Herrero from the Universitat Politècnica de Catalunya (Spain), Enrique S. Quintana-Ortí from the Universitat Jaume I (Spain), and Robert Strzodka from the Max-Planck-Institut für Informatik (Germany)
- The Second Minisymposium on Cell/B.E. Technologies organized by Roman Wyrzykowski from the Czestochowa University of Technology (Poland), and David A. Bader from the Georgia Institute of Technology (USA)
- Workshop on Memory Issues on Multi- and Manycore Platforms organized by Michael Bader and Carsten Trinitis from the TU München (Germany)
- Workshop on Novel Data Formats and Algorithms for High-Performance Computing organized by Fred Gustavson from the IBM T.J. Watson Research Center (USA), and Jerzy Waśniewski from the Technical University of Denmark (Denmark)
- Workshop on Scheduling for Parallel Computing - SPC 2009 organized by Maciej Drozdowski from the Poznań University of Technology (Poland)
- The Third Workshop on Language-Based Parallel Programming Models - WLPP 2009 organized by Ami Marowka from the Shenkar College of Engineering and Design in Ramat-Gan (Israel)
- The Second Workshop on Performance Evaluation of Parallel Applications on Large-Scale Systems organized by Jan Kwiatkowski, Dariusz Konieczny and Marcin Pawlik from the Wrocław University of Technology (Poland)
- The 4th Grid Application and Middleware Workshop - GAMW 2009 organized by Ewa Deelman from the University of Southern California (USA), and Norbert Meyer from the Poznań Supercomputing and Networking Center (Poland)
- The 4th Workshop on Large Scale Computations on Grids - LaSCoG 2009 organized by Marcin Paprzycki from IBS PAN and SWPS in Warsaw (Poland), and Dana Petcu from the Western University of Timisoara (Romania)
- Workshop on Parallel Computational Biology - PBC 2009 organized by David A. Bader from the Georgia Institute of Technology in Atlanta (USA), Denis Trystram from ID-IMAG in Grenoble (France), Alexandros Stamatakis from the TU München (Germany), and Jarosław Żola from the Iowa State University (USA)

- Minisymposium on Applications of Parallel Computations in Industry and Engineering organized by Raimondas Čiegis from the Vilnius Gediminas Technical University (Lithuania), and Julius Žilinskas from the Institute of Mathematics and Informatics in Vilnius (Lithuania)
- The Second Minisymposium on Interval Analysis organized by Vladik Kreinovich from the University of Texas at El Paso (USA), Paweł Sewastjanow from the Częstochowa University of Technology (Poland), Bartłomiej J. Kubica from the Warsaw University of Technology (Poland), and Jerzy Waśniewski from the Technical University of Denmark (Denmark)
- Workshop on Complex Collective Systems organized by Paweł Topa and Jarosław Wąs from the AGH University of Science and Technology in Cracow (Poland)

## Tutorials

The PPAM 2009 meeting began with four tutorials:

- GPUs, OpenCL and Scientific Computing, by Robert Strzodka from the Max-Planck-Institut für Informatik (Germany), Dominik Behr from AMD (USA), and Dominik Göddeke from the University of Dortmund (Germany)
- FPGA Programming for Scientific Computing, by Magnus Peterson from the Synective Labs (Sweden)
- Programming the Cell Broadband Engine, by Maciej Remiszewski from IBM (Poland), and Maciej Cytowski from the University of Warsaw (Poland)
- New Data Structures Are Necessary and Sufficient for Dense Linear Algebra Factorization Algorithms, by Fred Gustavson from the the IBM T.J. Watson Research Center (USA), and Jerzy Waśniewski from the Technical University of Denmark (Denmark)

## Best Poster Award

The PPAM Best Poster Award is given to the best poster on display at the PPAM conferences, and was first awarded at PPAM 2009. This award is bestowed by the Program Committee members to the presenting author(s) of the best poster. The selection criteria are based on the scientific content and on the quality of the poster presentation. The PPAM 2009 winner was Tomasz Olas from the Częstochowa University of Technology, who presented the poster “Parallel Adaptive Finite Element Package with Dynamic Load Balancing for 3D Thermomechanical Problems.”

## New Topics at PPAM 2009

*GPU Computing:* The recent advances in the hardware, functionality, and programmability of graphics processors (GPUs) have greatly increased their appeal

as add-on co-processors for general-purpose computing. With the involvement of the largest processor manufacturers and the strong interest from researchers of various disciplines, this approach has moved from a research niche to a forward-looking technique for heterogeneous parallel computing. Scientific and industry researchers are constantly finding new applications for GPUs in a wide variety of areas, including image and video processing, molecular dynamics, seismic simulation, computational biology and chemistry, fluid dynamics, weather forecast, computational finance, and many others.

GPU hardware has evolved over many years from graphics pipelines with many heterogeneous fixed-function components over partially programmable architectures towards a more and more homogeneous general purpose design, although some fixed-function hardware has remained because of its efficiency. The general-purpose computing on GPU (GPGPU) revolution started with programmable shaders; later, NVIDIA Compute Unified Device Architecture (CUDA) and to a smaller extent AMD Brook+ brought GPUs into the mainstream of parallel computing. The great advantage of CUDA is that it defines an abstraction which presents the underlying hardware architecture as a sea of hundreds of fine-grained computational units with synchronization primitives on multiple levels. With OpenCL there is now also a vendor-independent high-level parallel programming language and an API that offers the same type of hardware abstraction.

GPU are very versatile accelerators because besides the high hardware parallelism they also feature a high bandwidth connection to dedicated device memory. The latency problem of DRAM is tackled via a sophisticated thread scheduling and switching mechanism on-chip that continues the processing of the next thread as soon as the previous stalls on a data read. These characteristics make GPUs suitable for both compute- and data-intensive parallel processing.

The PPAM 2009 conference recognized the great impact of GPUs by including in its scientific program two major related events: a minisymposium on GPU Computing, and a full day tutorial on “GPUs, OpenCL and Scientific Computing.”

The minisymposium received 18 submissions, of which 10 were accepted (55%). The contributions were organized in three sessions. The first group was related to *Numerics*, and comprised the following papers: “Finite Element Numerical Integration on GPUs,” “Reduction to Condensed Forms for Symmetric Eigenvalue Problems on Multi-core Architectures,” “On Parallelizing the MRRR Algorithm for Data-Parallel Coprocessors,” and “A Fast GPU Implementation for Solving Sparse Ill-Posed Linear Equation Systems.” The second session dealt with *Applications*. The papers presented were: “Simulations of the Electrical Activity in the Heart with Graphic Processing Units,” “Stream Processing on GPUs Using Distributed Multimedia Middleware,” and “A GPU Approach to the Simulation of Spatio-temporal Dynamics in Ultrasonic Resonators.” Finally, a third session about *General GPU Computing* included presentations of three papers: “Fast In-Place Sorting with CUDA Based on Bitonic Sort,” “Parallel Minimax

Tree Searching on GPU,” and “Modeling and Optimizing the Power Performance of Large Matrices Multiplication on Multi-core and GPU Platform with CUDA.”

The tutorial covered a wide variety of GPU topics and also offered hands-on examples of OpenCL programming that any participant could experiment with on their laptop. The morning sessions discussed the basics of GPU architecture, ready-to-use libraries and OpenCL. The afternoon session went in depth on OpenCL and scientific computing on GPUs. All slides are available at <http://gpgpu.org/ppam2009>.

*Complex Collective Systems:* Collective aspects of complex systems are attracting an increasing community of researchers working in different fields and dealing with theoretical aspects as well as practical applications. In particular, analyzing local interactions and simple rules makes it possible to model complex phenomena efficiently. Collective systems approaches show great promise in establishing scientific methods that could successfully be applied across a variety of application fields. Many studies in complex collective systems science follow either a cellular automata (CA) method or an agent-based approach. Hybridization between these two complementary approaches gives a promising perspective. The majority of work presented during the workshop on complex collective systems represents the hybrid approach.

We can distinguish four groups of subjects presented during the workshop.

The first group was modeling of pedestrian dynamics: Armin Seyfried from the Juelich Supercomputing Center presented actual challenges in pedestrian dynamics modeling. Another important issue of crowd modeling was also taken into account during the workshop: modeling of stop-and-go waves (Andrea Portz and Armin Seyfried), calibration of pedestrian stream models (Wolfram Klein, Gerta Köster and Andreas Meister), parallel design patterns in a pedestrian simulation (Sarah Clayton), floor fields models based on CA (Ekaterina Kirik, Tat'yana Yurgel'yan and Dmitriy Krouglov), and discrete potential field construction (Konrad Kułakowski and Jarosław Wąs).

The second group dealt with models of car traffic: a fuzzy cellular model of traffic (Bartłomiej Płaczek), and an adaptive time gap car-following model (Antoine Tordeux and Pascal Bouvry).

The third group included work connected with cryptography based on cellular automata: weakness analysis of a key stream generator (Frederic Pinel and Pascal Bouvry), and properties of safe CA-based S-Boxes (Mirosław Szaban and Franciszek Seredyński).

The fourth group dealt with various applications in a field of complex collective systems: frustration and collectivity in spatial networks (Anna Mańka-Krasoń, Krzysztof Kułakowski), lava flow hazard modeling (Maria Vittoria Avolio, Donato D'Ambrosio, Valeria Lupiano, Rocco Rongo and William Spataro), FPGA realization of a CA-based epidemic processor (Pavlos Progiás, Emmanouela Vardaki and Georgios Sirakoulis)



## Acknowledgements

The organizers are indebted to the PPAM 2009 sponsors, whose support was vital to the success of the conference. The main sponsor was the Intel Corporation. The other sponsors were: Hewlett-Packard Company, Microsoft Corporation, IBM Corporation, Action S.A., and AMD. We thank to all members of the International Program Committee and additional reviewers for their diligent work in refereeing the submitted papers. Finally, we thank all of the local organizers from the Częstochowa University of Technology and Wrocław University of Technology who helped us to run the event very smoothly. We are especially indebted to Grażyna Kołakowska, Urszula Kroczevska, Łukasz Kuczyński, and Marcin Woźniak from the Częstochowa University of Technology; and to Jerzy Świątek, and Jan Kwiatkowski from the Wrocław University of Technology.

## PPAM 2011

We hope that this volume will be useful to you. We would like everyone who reads it to feel invited to the next conference, PPAM 2011, which will be held September 11–14, 2011, in Toruń, a city in northern Poland where the great astronomer Nicolaus Copernicus was born.

February 2010

Roman Wyrzykowski  
Jack Dongarra  
Konrad Karczewski  
Jerzy Waśniewski

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