

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Alfred Kobsa

University of California, Irvine, CA, USA

Friedemann Mattern

ETH Zurich, Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Germany

Madhu Sudan

Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbruecken, Germany

Rainer Keller David Kramer
Jan-Philipp Weiss (Eds.)

Facing the Multicore-Challenge

Aspects of New Paradigms and Technologies
in Parallel Computing

Volume Editors

Rainer Keller
High Performance Computing Center Stuttgart (HLRS)
Universität Stuttgart
Nobelstr. 19
70569 Stuttgart, Germany
E-mail: keller@hls.de

David Kramer
Institute of Computer Science and Engineering
Karlsruhe Institute of Technology, Germany
Haid-und-Neu-Str. 7
76131 Karlsruhe, Germany
E-mail: kramer@kit.edu

Jan-Philipp Weiss
Engineering Mathematics and Computing Lab (EMCL)
& Institute for Applied and Numerical Mathematics 4
Karlsruhe Institute of Technology, Germany
Fritz-Erler-Str. 23
76133 Karlsruhe, Germany
E-mail: jan-philipp.weiss@kit.edu

Library of Congress Control Number: 2010935359

CR Subject Classification (1998): D.1-3, C.1.4, C.4, I.3.1, F.2.1, G.1

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

ISSN 0302-9743
ISBN-10 3-642-16232-0 Springer Berlin Heidelberg New York
ISBN-13 978-3-642-16232-9 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

springer.com

© Springer-Verlag Berlin Heidelberg 2010
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper 06/3180

Preface

The proceedings at hand are the outcome of the conference for young scientists titled *Facing the Multicore-Challenge* held at the Heidelberger Akademie der Wissenschaften, March 17–19, 2010. The conference focused on topics related to the impact of multicore and coprocessor technologies in science and for large-scale applications in an interdisciplinary environment. The conference was funded by the Heidelberger Akademie der Wissenschaften and placed emphasis on the support and advancement of young scientists.

The aim of the conference was to bring together leading experts as well as motivated young researchers in order to discuss, recent developments, the present status of the field, and its future prospects the exchange of ideas, in a pleasant atmosphere that stimulates. It was the designated goal to address current issues including mathematical modeling, design of parallel algorithms, aspects of microprocessor architecture, parallel programming languages, compilers, hardware-aware computing, heterogeneous platforms, emerging architectures, tools, performance tuning, and requirements for large-scale applications. This broad range of issues is reflected by the present conference proceedings. The results of the presented research papers clearly show the potential of emerging technologies in the area of multicore and manycore processors that are paving the way towards personal supercomputing. However, many issues related to parallel programming environments, development of portable and future-proof concepts, and the design of scalable and manycore-ready algorithms still need to be addressed in future research. Some of these points are the subject of the presented papers.

These proceedings include diverse and interdisciplinary research work. An assessment of parallel programming environments like the RapidMind platform and the perspective of GPGPU computing in large data centers is presented. The proceedings further address issues of hardware architecture by exploring way-adaptable caches. The management of parallel units is considered in papers on thread affinities and on thread creation. Application aspects on modern processor technologies are investigated for the Cell Broadband Engine by means of the G-means application for data mining and a numerical study on 3D multigrid methods. A complex fluid dynamic application modeled by the lattice Boltzmann equations is considered on multi- and manycore processors like the multicore CPUs, GPUs, and Cell. The potential of FPGA and GPU technology is outlined for a sorting problem. Application studies on GPUs include image segmentation and parallel volume rendering. Furthermore, fault tolerance of pipeline workflows is the subject of presented research work.

The conference organizers and editors would like to thank the Heidelberger Akademie der Wissenschaften for giving us the opportunity to organize this conference at this inspiring venue. Without the funding of the Heidelberger

Akademie der Wissenschaften and the comprehensive support for this fruitful event this conference would not have been possible. In particular, we would like to thank all the friendly people at the Heidelberger Akademie der Wissenschaften for making this conference happen. Last but not least, thank you very much to all the contributors submitting exciting, novel work and providing multi-facetted input to the discussions.

March 2010

Rainer Keller
David Kramer
Jan-Philipp Weiss

Preface from the Heidelberg Academy of Sciences and Humanities

The focus of this publication is: How are innovative computer systems going to have a crucial impact on all branches of science and technology? Multicore systems are opening up new perspectives to cope with challenges which seemed to have been out of range to be mastered up to now. However, they are also posing new challenges in adapting all domains, ranging from mathematical modeling, numerical methods and algorithms to software and hardware design and development. The contributions presented in this volume offer a survey on the state of the art, the concepts and perspectives for future developments. They are an outcome of an inspiring conference conceived and organized by the editors within the junior scientist program of Heidelberg Academy for Sciences and Humanities. The Academy is happy to promote junior scientists getting involved in innovative research and daring to break new ground. Springer deserves high recognition for handling the publication efficiently and thus helping to face the multicore challenges.

Willi Jäger

Acknowledgements

The conference *Facing the Multicore-Challenge* has been kindly funded and supported by the Heidelberger Akademie der Wissenschaften, Karlstr. 4, 69117 Heidelberg. The Shared Research Group 16-1 of Jan-Philipp Weiss has received financial support by the Concept for the Future of Karlsruhe Institute of Technology in the framework of the German Excellence Initiative and the industrial collaboration partner Hewlett-Packard.

Organization

General Chair

Jan-Philipp Weiss	Karlsruhe Institute of Technology, Germany
Rainer Keller	Oak Ridge National Laboratory, USA
David Kramer	Karlsruhe Institute of Technology, Germany

Mentorship

Willi Jäger	University of Heidelberg, Germany
-------------	-----------------------------------

Program Committee

David A. Bader	Georgia Tech, Atlanta, USA
Michael Bader	University of Stuttgart, Germany
Rosa Badia	Barcelona Supercomputing Center, Spain
Richard Barrett	Oak Ridge National Labs, USA
Mladen Berekovic	TU Braunschweig, Germany
Arndt Bode	TU Munich, Germany
George Bosilca	University of Tennessee Knoxville, USA
Jim Bovay	Hewlett-Packard, USA
Rainer Buchty	Karlsruhe Institute of Technology, Germany
Mark Bull	EPCC, Edinburgh, UK
Hans-Joachim Bungartz	TU Munich, Germany
Franck Cappello	LRI, Université Paris Sud, France
Claudia Fohry	Kassel University, Germany
Richard Graham	Oak Ridge National Labs, USA
Thomas Herault	Université Paris Sud, France
Hans Herrmann	ETH, Zürich, Switzerland
Vincent Heuveline	Karlsruhe Institute of Technology, Germany
Michael Hübner	Karlsruhe Institute of Technology, Germany
Ben Juurlink	TU Berlin, Germany
Wolfgang Karl	Karlsruhe Institute of Technology, Germany
Rainer Keller	Oak Ridge National Labs, USA
Hiroaki Kobayashi	Tohoku University, Japan
Manfred Krafczyk	TU Braunschweig, Germany
Hsin-Ying Lin	Intel, USA
Anton Lokhmotov	Imperial College, London, UK
Dieter an Mey	RWTH Aachen, Germany
Bernd Mohr	FZ Jülich, Germany
Claus-Dieter Munz	Stuttgart University, Germany

VIII Organization

Norihiro Nakajima	JAEA and CCSE, Japan
Wolfgang Nagel	TU Dresden, Germany
Christian Perez	INRIA, France
Franz-Josef Pfreundt	ITWM Kaiserslautern, Germany
Rolf Rabenseifner	HLRS, Stuttgart, Germany
Thomas Rauber	Bayreuth University, Germany
Michael Resch	HLRS, Stuttgart, Germany
Gudula Rünger	Chemnitz Technical University, Germany
Olaf Schenk	Basel University, Basel, Switzerland
Martin Schulz	Lawrence Livermore National Labs, USA
Masha Sosonkina	Ames Lab, USA
Thomas Steinke	ZIB, Berlin, Germany
Carsten Trinitis	TUM, Munich, Germany
Stefan Turek	Dortmund University, Germany
Wolfgang Wall	TUM, Munich, Germany
Gerhard Wellein	RRZE, Erlangen, Germany
Josef Weidendorfer	TUM, Munich, Germany
Jan-Philipp Weiss	Karlsruhe Institute of Technology, Germany
Felix Wolf	FZ Jülich, Germany
Stephan Wong	TUD, Delft, The Netherlands

Table of Contents

Invited Talks

Analyzing Massive Social Networks Using Multicore and Multithreaded Architectures	1
<i>David Bader</i>	
MareIncognito: A Perspective towards Exascale	2
<i>Jesus Labarta</i>	
The Natural Parallelism	3
<i>Robert Strzodka</i>	

Computer Architecture and Parallel Programming

RapidMind: Portability across Architectures and Its Limitations	4
<i>Iris Christadler and Volker Weinberg</i>	
A Majority-Based Control Scheme for Way-Adaptable Caches	16
<i>Masayuki Sato, Ryusuke Egawa, Hiroyuki Takizawa, and Hiroaki Kobayashi</i>	
Improved Scalability by Using Hardware-Aware Thread Affinities	29
<i>Sven Mallach and Carsten Gutwenger</i>	
Thread Creation for Self-aware Parallel Systems	42
<i>Martin Schindewolf, Oliver Mattes, and Wolfgang Karl</i>	

Applications on Multicore

G-Means Improved for Cell BE Environment	54
<i>Aislan G. Foina, Rosa M. Badia, and Javier Ramirez-Fernandez</i>	
Parallel 3D Multigrid Methods on the STI Cell BE Architecture	66
<i>Fabian Oboril, Jan-Philipp Weiss, and Vincent Heuveline</i>	
Applying Classic Feedback Control for Enhancing the Fault-Tolerance of Parallel Pipeline Workflows on Multi-core Systems	79
<i>Tudor B. Ionescu, Eckart Laurien, and Walter Scheuermann</i>	
Lattice-Boltzmann Simulation of the Shallow-Water Equations with Fluid-Structure Interaction on Multi- and Manycore Processors	92
<i>Markus Geveler, Dirk Ribbrock, Dominik Göddeke, and Stefan Turek</i>	

FPGA vs. Multi-core CPUs vs. GPUs: Hands-On Experience with a
Sorting Application 105
Cristian Grozea, Zorana Bankovic, and Pavel Laskov

GPGPU Computing

Considering GPGPU for HPC Centers: Is it Worth the Effort? 118
*Hans Hacker, Carsten Trinitis, Josef Weidendorfer, and
Matthias Brehm*

Real-Time Image Segmentation on a GPU 131
*Alexey Abramov, Tomas Kulvicius, Florentin Wörgötter, and
Babette Dellen*

Parallel Volume Rendering Implementation on Graphics Cards Using
CUDA 143
Jens Fangerau and Susanne Krömker

Author Index 155