Studies in Computational Intelligence, Volume 146

Editor-in-Chief
Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

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ISBN 978-3-540-69260-7

Fatos Xhafa
Ajith Abraham
(Eds.)

Metaheuristics for Scheduling in Distributed Computing Environments

Springer

Dr. Fatos Xhafa
Departament de Llenguatges i Sistemes Informátics
Universitat Politécnica de Catalunya
Campus Nord, Ed. Omega, C/Jordi Girona 1-3
08034 Barcelona
Spain
Email: fatos@lsi.upc.edu

Dr. Ajith Abraham
Center for Quantifiable Quality of
Service in Communication Systems
Faculty of Information Technology,
Mathematics and Electrical Engineering
Norwegian University of Science and Technology
O.S. Bragstads plass 2E
7491 Trondheim
Norway
Email: ajith.abraham@ieee.org

ISBN 978-3-540-69260-7 e-ISBN 978-3-540-69277-5

DOI 10.1007/978-3-540-69277-5

Studies in Computational Intelligence ISSN 1860949X

Library of Congress Control Number: 2008928448

Typeset & *Cover Design:* Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed in acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

To our families, for their love and gratitude!

Preface

Grid computing has emerged as one of the most promising computing paradigms of the new millennium! This paradigm can be seen as a main facet of Sun's lemma "The internet is the computer": Grid computing systems are about sharing computational resources, software and data at a large scale. Grid computing, although recent, is attracting each time more large masses of researchers, projects, applications and investment from academia and industry. We are witnessing thus an explosion in Grid research projects (Google web search returns about 2,810,000 entries for "Grid project"!) To make the Grid computing fully beneficial to researchers, practitioners, academia and industry, there are still plenty of issues to deal with and currently researchers are very actively investigating. One such issue is the performance requirement on the resulting Grid system or the Virtual Grid-enabled Supercomputer. Achieving high performance Grid computing requires techniques to efficiently and adaptively allocate jobs and applications to available resources in a large scale, highly heterogenous and dynamic environment.

This volume presents meta-heuristics approaches for Grid scheduling problems. Due to the complex nature of the problem, meta-heuristics are primary techniques for the design and implementation of efficient Grid schedulers. The volume brings new ideas, analysis, implementations and evaluation of meta-heuristic techniques for Grid scheduling, which make this volume novel in several aspects. First, Grid scheduling is tackled as a family of problems, it takes different forms depending on system requirement, application requirements, user requirements, etc. The chapters of this volume have identified several important formulations of the problem, which we believe will serve as a reference for the researchers in the Grid computing community. Second, the selected chapters for this volume comprise a variety of successful meta-heuristic approaches including: (a) Local Search based meta-heuristics (Local search, Simulated Annealing, Variable Neighborhood Search, ...); (b) Population-based approaches (Genetic Algorithms, Memetic Algorithms, Ant Colony Optimization, Particle Swarm Optimization, ...); (c) Fuzzy, QoS, dynamic programming and optimization approaches; and, (d) Hybridization of meta-heuristics among them as well

as with other approaches. All these approaches aim to explore the capabilities of the meta-heuristics in dealing with many facets of the Grid scheduling. This is actually the best way to deal with the complexity of the problem, in particular with its multi-objective nature. Third, the contributed chapters in the book include formal definitions and theoretical results, implementation and experimental studies as well as practical insights on how to approach Grid scheduling.

All in all, Grid scheduling and novel meta-heuristics approaches for its resolution are presented in a comprehensive way, which we believe, makes this volume an important contribution to Grid computing, meta-heuristics and optimization research areas.

Chapters were selected after a careful review process by at least three reviewers on the basis of the originality, soundness and their contribution to both meta-heuristics and Grid scheduling. The volume consists of 13 chapters, which are organized as follows.

In Chapter 1, *Xhafa and Abraham* present Grid scheduling problems by first introducing different types of current Grid systems. Several computational models for the problem and multi-objective optimization criteria that arise in Grid scheduling are presented. An in depth analysis in the chapter shows why meta-heuristics are a defacto approach for this problem.

Montana and Zinky in Chapter 2 address the problem of optimizing the flow of compute jobs in a distributed system of compute servers through a hybrid approach of dynamic programming and a Genetic Algorithm.

In Chapter 3, *Gu and Welch* study task allocation and scheduling approach for dynamic, distributed real-time systems. The authors present an approach that offers systems explicit real-time guarantees as well as maximized robustness of unpredictable changes in computing environment.

LaTorre et al. in the fourth Chapter propose a theoretical framework to combine multi evolutionary algorithms and use it to combine multiple codings and genetic operators for Supercomputer scheduling.

In the fifth Chapter *Kaya et al.* consider the problem of scheduling an application on a computing system consisting of heterogeneous processors and one or more file repositories. The authors present iterative-improve-based heuristics by exploring complex neighborhood structures for the considered scheduling problem.

Byun et al. in the sixth Chapter report an advanced job scheduler based on Markov model in desktop Grid computing environment. The authors propose and analyze several advanced resource selection schemes in order to satisfy time requirements to complete job allocation and adapt to the needs of the user and the application on the fly.

In the seventh Chapter *Yu et al.* present workflow scheduling algorithms for Grid computing. Several heuristic methods and meta-heuristics including Simulated Annealing and Genetic Algorithms for Grid workflow scheduling are considered. Examples of experimental comparisons for workflow scheduling algorithms are also given.

Iordache et al. in the eighth Chapter address a Genetic Algorithms approach for decentralized Grid scheduling. GAs are combined with lookup services for obtaining a scalable and highly reliable Grid scheduler. The authors experimentally analyze their approach and compare it with other scheduling approaches using a monitoring environment.

Abraham et al. in the ninth Chapter introduce several nature inspired meta-heuristics for Grid scheduling including Simulated Annealing, Genetic Algorithms, Ant Colony optimization and Particle Swarm Optimization. Also, the authors illustrate the usage of Multi-objective Evolutionary Algorithm for two scheduling problems.

In the tenth Chapter *Xhafa et al.* exploit the capabilities of a new class of population-based meta-heuristics, namely the Cellular Memetic Algorithms aiming, at minimizing the makespan and flowtime simultaneously using a weighted sum method. The approach is analyzed under a simulation model and showed to be effective for batch scheduling problem in Grids.

Bendjoudi et al. in the eleventh Chapter present a P2P hybrid approach that combines B&B and GA for the Flow-Shop Scheduling Problem. The authors aim at distributing at large scale the computation, using Peer-to-Peer computing to reach high computing performance. To this end, the authors propose P2P-based parallelization of the B&B and GA algorithms for the computational Grid.

In the eleventh Chapter, *Liu et al.* introduce the Peer-to-Peer neighbor selection problem for which single and multi-objective population-based meta-heuristics are presented. Specifically, the authors address the Particle Swarm Optimization and Genetic Algorithms for the problem. The performance and effectiveness of the proposed approach is also illustrated with computational examples.

Khoo and Veeravalli in the last Chapter propose an approach for resource-scheduling strategy capable of handling multiple resource requirements for jobs that arrive in a Grid Computing Environment. The authors include in their method the resource availabilities in the Grid environment. The performance of the proposed approach is experimentally analyzed.

We are very much grateful to the authors of this volume and to the reviewers for their great efforts by reviewing and providing interesting feedback to authors of the chapter. The editors would like to thank Dr. Thomas Ditzinger (Springer Engineering Inhouse Editor, Studies in Computational Intelligence Series), Professor Janusz Kacprzyk (Editor-in-Chief, Springer Studies in Computational Intelligence Series) and Ms. Heather King (Editorial Assistant, Springer Verlag, Heidelberg) for the editorial assistance and excellent cooperative collaboration to produce this important scientific work. We hope that the reader will share our joy and will find it useful!

Fatos Xhafa acknowledges partial support by Projects ASCE TIN2005-09198-C02-02, FP6-2004-ISO-FETPI (AEOLUS) and MEC TIN2005-25859-E and FORMALISM TIN2007-66523. *Ajith Abraham* acknowledges the support by the

Centre for Quantifiable Quality of Service in Communication Systems, Norwegian Centre of Excellence, appointed by The Research Council of Norway, and funded by the Research Council, Norwegian University of Science and Technology and UNINETT.

Fatos Xhafa
Departament de Llenguatges i Sistemes Informàtics
Universitat Politècnica de Catalunya
Barcelona (Spain)

Ajith Abraham
Centre for Quantifiable Quality of Service in Communication Systems
Norwegian University of Science and Technology
Trondheim (Norway)

April 2008 Barcelona (Spain), Trondheim (Norway)

Contents

List of Contributors

Ajith Abraham Center for Quantifiable Quality of Service in Communication Systems, Faculty of Information Technology, Mathematics and Electrical Engineering, Norwegian University of Science and Technology, Norway
ajith.abraham@ieee.org

Enrique Alba Dpto. de Lenguajes y Ciencias de la Computación, E.T.S.I. Informática, Campus de Teatinos, 29071 Málaga, Spain
eat@lcc.uma.es

Cevdet Aykanat Department of Computer Engineering, Bilkent University, Turkey
aykanat@cs.bilkent.edu.tr

Ahcene Bendjoudi Université A/Mira de Béjaia, Département d'Informatique CEntre de Recherche sur l'Information Scientique et Technique (CERIST), Laboratoire d'Ingénierie et Théories des Systèmes Informatiques, Algiers, Algeria
ahcene.bendjoudi@gmail.com

Marcela Boboila Stony Brook University, USA
mboboila@cs.sunysb.edu

Rajkumar Buyya Grid Computing and Distributed Systems (GRIDS) Laboratory, Department of Computer Science and Software Engineering, The University of Melbourne, Austraila
raj@csse.unimelb.edu.au

EunJoung Byun Department of Computer Science & Engineering, Korea University, Korea
fvision@disys.korea.ac.kr

SungJin Choi Department of Computer Science & Engineering, Korea University, Korea
lotieye@disys.korea.ac.kr

Pedro de Miguel CeSViMa, Department of Computer Architecture and Technology, Universidad Politéecnica de Madrid, Spain
pmiguel@fi.upm.es

Bernabé Dorronsoro Faculty of Science, Technology

and Communication University of Luxembourg 6, rue Richard Coudenhove-Kalergi L-1359 Luxembourg
bernabe.dorronsoro@uni.lu

Bernat Duran Department of Languages and Informatics Systems, Polytechnic University of Catalonia, Barcelona, Spain
bduran@lsi.upc.edu

Dazhang Gu Center for Intelligent, Distributed, and Dependable Systems, School of Electrical Engineering and Computer Science, Ohio University, USA
gud@ohio.edu

Crina Grosan Department of Computer Science, Faculty of Mathematics and Computer Science, Babeş Bolyai University, Romania
cgrosan@cs.ubbcluj.ro

Samir Guerdah Université Mouloud Mammeri de Tizi Ouzou, Département Informatique, Tizi Ouzou, Algeria
samir.guerdah@gmail.com

ChongSun Hwang Department of Computer Science & Engineering, Korea University, Korea
hwangg@disys.korea.ac.kr

George Iordache Stony Brook University, USA
georgei@cs.sunysb.edu

Kamer Kaya Department of Computer Engineering, Bilkent University, Ankara, Turkey
kamer@cs.bilkent.edu.tr

Benjamin Khoo B.T. Department of ECE, Singapore

HongSoo Kim Department of Computer Science & Engineering, Korea University, Korea
hera@disys.korea.ac.kr

Antonio LaTorre CeSViMa, Department of Computer Architecture and Technology, Universidad Politécnica de Madrid, Spain
atorre@fi.upm.es

Hongbo Liu School of Computer Science and Engineering, Dalian Maritime University and Department of Computer and Dalian University of Technology, Dalian, China
lhb@dlut.edu.cn

SangKeun Lee Department of Computer Science & Engineering, Korea University, Korea
yalphy@korea.ac.kr

Madjid Mansoura Université Mouloud Mammeri de Tizi Ouzou, Département Informatique, Tizi Ouzou, Algeria
madjid.mansoura@gmail.com

Nouredine Melab Universitée des Sciences et Technologies de Lille, France
melab@lifl.fr

David Montana BBN Technologies, Cambridge, MA, USA
dmontana@bbn.com

José María Peña CeSViMa, Department of Computer

Architecture and Technology,
Universidad Politécnica de Madrid,
Spain
jmpena@fi.upm.es

Florin Pop University "Politehnica" of Bucharest,
Romania
florinpop@cs.pub.ro

Kotagiri Ramamohanarao Grid Computing and
Distributed Systems (GRIDS) Laboratory, Department of Computer Science and Software Engineering,
The University of Melbourne,
Austraila
rao@csse.unimelb.edu.au

Víctor Robles CeSViMa,
Department of Computer Architecture and Technology,
Universidad Politécnica de Madrid,
Spain
vrobles@fi.upm.es

Corina Stratan University "Politehnica" of
Bucharest, Romania
corina@cs.pub.ro

El-Ghazali Talbi Universitée des Sciences et
Technologies de Lille, France
talbi@lifl.fr

Bora Uçar CERFACS, France
ubora@cerfacs.fr

Bharadwaj Veeravalli Department of ECE, Singapore
elebv@nus.edu.sg

Fatos Xhafa Department of Languages and Informatics Systems, Polytechnic University of Catalonia, Barcelona, Spain
fatos@lsi.upc.edu

Jia Yu Grid Computing and Distributed Systems
(GRIDS) Laboratory, Department of Computer Science and Software Engineering, The University of Melbourne, Australia
jiayu@csse.unimelb.edu.au

John Zinky BBN Technologies,
Cambridge, MA, USA
jzinky@bbn.com

Lonnie Welch Center for Intelligent, Distributed,
and Dependable Systems, School of Electrical Engineering and
Computer Science,
Ohio University, USA
welch@ohio.edu