

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

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

University of Dortmund, Germany

Madhu Sudan

Massachusetts Institute of Technology, MA, USA

Demetri Terzopoulos

New York University, NY, USA

Doug Tygar

University of California, Berkeley, CA, USA

Moshe Y. Vardi

Rice University, Houston, TX, USA

Gerhard Weikum

Max-Planck Institute of Computer Science, Saarbruecken, Germany

María J. Blesa Christian Blum
Andrea Roli Michael Sampels (Eds.)

Hybrid Metaheuristics

Second International Workshop, HM 2005
Barcelona, Spain, August 29-30, 2005
Proceedings

Volume Editors

María J. Blesa
Universitat Politècnica de Catalunya
Omega 213 Campus Nord
Jordi Girona 1-3, 08034 Barcelona, Spain
E-mail: mjblesa@lsi.upc.edu

Christian Blum
Universitat Politècnica de Catalunya
Omega 112 Campus Nord
Jordi Girona 1-3, 08034 Barcelona, Spain
E-mail: cblum@lsi.upc.edu

Andrea Roli
Università degli Studi "G. D'Annunzio"
Viale Pindaro 42, 65127 Pescara, Italy
E-mail: a.roli@unich.it

Michael Sampels
Université Libre de Bruxelles
IRIDIA CP 194/6
Avenue Franklin D. Roosevelt 50, 1050 Bruxelles, Belgium
E-mail: msampels@ulb.ac.be

Library of Congress Control Number: 2005930813

CR Subject Classification (1998): F.2, F.1, G.1.6, G.1.2, G.2.1, I.2

ISSN	0302-9743
ISBN-10	3-540-28535-0 Springer Berlin Heidelberg New York
ISBN-13	978-3-540-28535-9 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 is a part of Springer Science+Business Media

springeronline.com

© Springer-Verlag Berlin Heidelberg 2005
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11546245 06/3142 5 4 3 2 1 0

Preface

Combinatorial optimization and in particular the great variety of fascinating problems that belong to this area have attracted many researchers for more than half a century. Due to the practical relevance of solving hard real-world problems, much research effort has been devoted to the development of heuristic methods aimed at finding good approximate solutions in a reasonable computation time. Some solution paradigms that are not specific for one particular problem have been deeply studied in the past, and the term *metaheuristic* is now common for such optimization heuristics. Several metaheuristics – simulated annealing, genetic and evolutionary algorithms, tabu search, ant colony optimization, scatter search, iterated local search, and greedy randomized adaptive search procedures being some of them – have found their own research communities, and specialized conferences devoted to such techniques have been organized.

Plenty of classical hard problems, such as the quadratic assignment problem, the traveling salesman problem, problems in vehicle routing, scheduling, and timetabling, etc., have been tackled successfully with metaheuristic approaches. Several thereof are currently considered state-of-the-art methods for solving such problems. However, for many years the main focus of research was on the application of single metaheuristics to given problems. A tendency to compare different metaheuristics against each other could be observed, and sometimes this competition led to thinking in stereotypes in the research communities.

In recent years, it has become evident that the concentration on a sole metaheuristic is rather restrictive for advancing the state of the art of tackling both academic and practical optimization problems. A skilled combination of concepts stemming from different metaheuristics can lead to more efficient behavior and greater flexibility. Also the hybridization of metaheuristics with other techniques known from classical artificial intelligence areas, for example data mining, machine learning, etc., can be very fruitful. Further, the incorporation of typical operations research techniques, such as integer or linear programming techniques, branch-and-bound techniques, etc., can be very beneficial. Combinations of metaheuristic components with components from other metaheuristics or optimization strategies from artificial intelligence or operations research are called *hybrid metaheuristics*.

The design and implementation of hybrid metaheuristics raises problems going beyond questions about the composition of a single metaheuristic. A careful analysis of the single components is very important for their interaction. Choice and tuning of parameters is more important for the quality of the algorithms than before. Different concepts of interaction at low-level and at high-level are

studied. As a result, the design of experiments and the proper statistical evaluation is more important than before.

The growing interest in research on hybrid metaheuristics and the observed tendency that techniques uncommon in standard metaheuristic research had become of special importance led us to organize a workshop devoted to this particular area. The First International Workshop on Hybrid Metaheuristics (HM 2004) took place in August 2004 in Valencia, Spain. The proceedings of HM 2004 were published as ISBN 3-00-015331-4, and they are available online (<http://iridia.ulb.ac.be/~hm2004/proceedings>). They contain 13 papers selected from 25 submission.

The success of the first workshop encouraged us to organize a Second International Workshop on Hybrid Metaheuristics (HM 2005) in Barcelona, Spain. The program committee of HM 2005 consisted of 23 researchers and practitioners mostly coming from the hybrid metaheuristics research community, but also from related areas, and from business. We received 37 paper submissions to HM 2005. Each submitted paper was sent to at least three reviewers. We are very grateful to the members of the program committee and the additional reviewers for the effort they made carefully examining the papers and for the many valuable comments and suggestions they gave to the authors. Based on their comments, we finally accepted 13 submissions for publication and for presentation at HM 2005, resulting in an acceptance rate of roughly 35 %. The selection of papers was rather strict in order to guarantee the high quality of the proceedings and the workshop itself. We would like to thank all the authors for their interest in our workshop.

We believe that the combination of elements coming from different metaheuristics, and from methods from both artificial intelligence and operations research, promises to become one of the main tracks of research in applied artificial intelligence. It seems to be a propitious and rewarding alternative to the still existing mutual contempt between the fields of exact methods and approximate techniques, and also to the competition between the different schools of metaheuristics, which sometimes focused more on a proof of concept than on good results.

Still, we have to realize that research on hybrid metaheuristics is mostly based on experimental methods, thus being probably more related to natural sciences than to computer science. It can be stated that both the design and the evaluation of experiments have still not reached the standard they have in physics or chemistry for example. The validity of analyses of experimental work on algorithms is a key aspect in hybrid metaheuristics, and the attention of researchers to this aspect seems to be important for the future of the field.

We observed that the subject matter covered by the submissions to HM 2005 already showed a slight shift from academic to practical and real-world optimization problems. To mention the practical applicability of hybrid metaheuristics as a *raison d'être* seems no longer to be an academic excuse but a real fact. It

would be a great success if the growing interdisciplinary cooperation could help to continue the trend of contributing more and more to the area of real-world optimization problems by hybrid metaheuristic approaches.

June 2005

María J. Blesa¹
Christian Blum²
Andrea Roli
Michael Sampels

¹ María J. Blesa acknowledges partial support by the FET Programme of the EU under contract number IST-2004-15964 (AEOLUS) and COST-295 (DYNAMO), and also by the Spanish Science and Technology Ministry (MCyT) under contract number TIC2002-04498-C05-03 (TRACER).

² Christian Blum acknowledges the support of a post-doctoral fellowship under the “Juan de la Cierva” program of the Spanish Ministry of Science and Technology.

Organization

Workshop Chairs

María J. Blesa	Universitat Politècnica de Catalunya, Barcelona, Spain
Christian Blum	Universitat Politècnica de Catalunya, Barcelona, Spain
Andrea Roli	Università degli Studi “G. D’Annunzio”, Chieti-Pescara, Italy
Michael Sampels	Université Libre de Bruxelles, Belgium

Program Committee

Enrique Alba	Universidad de Málaga, Spain
Mauro Birattari	Université Libre de Bruxelles, Belgium
Thomas Bousonville	ILOG, France
Kirsten Bremke	AT Kearney, Germany
Ralf Bruns	Fachhochschule Hannover, Germany
Óscar Cordon	Universidad de Granada, Spain
Carlos Cotta	Universidad de Málaga, Spain
Luca Di Gaspero	Università degli Studi di Udine, Italy
Marco Dorigo	Université Libre de Bruxelles, Belgium
Filippo Focacci	ILOG, France
Joshua Knowles	University of Manchester, England
Frank Köster	Universität Oldenburg, Germany
Andrea Lodi	Università di Bologna, Italy
Vittorio Maniezzo	Università degli Studi di Bologna, Italy
Monaldo Mastrolilli	IDSIA, Switzerland
Daniel Merkle	Universität Leipzig, Germany
Bernd Meyer	Monash University, Australia
Michela Milano	Università di Bologna, Italy
Olivia Rossi-Doria	Università di Padova, Italy
Andrea Schaerf	Università degli Studi di Udine, Italy
Thomas Stützle	Technische Universität Darmstadt, Germany
El-Ghazali Talbi	École Polytechnique Universitaire de Lille, France
Fatos Xhafa	Universitat Politècnica de Catalunya, Spain

Additional Referees

Prasanna Balaprakash, Max Manfrin, Jose Santamaría, Andrew Tuson

Sponsoring Institutions

Universitat Politècnica de Catalunya, Spain

Turisme de Barcelona (<http://www.barcelonaturisme.com>)

Direcció General de Turisme de Catalunya (<http://www.gencat.net/ctc/turisme>)

Transports Metropolitans de Barcelona (<http://www.tmb.net>)

Caves Freixenet

Caja Madrid

Punto Blanco

Table of Contents

Comparing Parallelization of an ACO: Message Passing vs. Shared Memory <i>Pierre Delisle, Marc Gravel, Michaël Krajecki, Caroline Gagné, Wilson L. Price</i>	1
An LP-Based Hybrid Heuristic Procedure for the Generalized Assignment Problem with Special Ordered Sets <i>Alan P. French, John M. Wilson</i>	12
Parametrized Greedy Heuristics in Theory and Practice <i>Armin Fügenschuh</i>	21
A Taxonomy of Cooperative Search Algorithms <i>Mohammed El-Abd, Mohamed Kamel</i>	32
A Hybrid Genetic and Variable Neighborhood Descent for Probabilistic SAT Problem <i>Zoran Ognjanović, Uroš Midić, Nenad Mladenović</i>	42
A Hybrid Meta-heuristic Approach for Natural Gas Pipeline Network Optimization <i>C. Borraz-Sánchez, R.Z. Ríos-Mercado</i>	54
Hybrid Tabu Search for Lot Sizing Problems <i>João Pedro Pedroso, Mikio Kubo</i>	66
Fast Ejection Chain Algorithms for Vehicle Routing with Time Windows <i>Herman Sontrop, Pieter van der Horn, Marc Uetz</i>	78
3D Inter-subject Medical Image Registration by Scatter Search <i>Oscar Cordon, Sergio Damas, J. Santamaría, Rafael Martí</i>	90
Evolution Strategies and Threshold Selection <i>Thomas Bartz-Beielstein</i>	104
A Hybrid GRASP with Data Mining for the Maximum Diversity Problem <i>L.F. Santos, M.H. Ribeiro, A. Plastino, S.L. Martins</i>	116
A New Multi-objective Particle Swarm Optimization Algorithm Using Clustering Applied to Automated Docking <i>Stefan Janson, Daniel Merkle</i>	128

A Hybrid *GRASP-Path Relinking* Algorithm for the Capacitated
p – *hub* Median Problem
 Melquíades Pérez, Francisco Almeida, J. Marcos Moreno-Vega 142

Author Index 155