Foreword

Most fundamental problems in combinatorial optimization field have been proven to be computationally hard to solve to optimality and are known as NP-hard problems in the literature. Knowing that a problem of interest is NP-hard implies, on the one hand, that the problem is unlikely to be solved within a reasonable amount of computation time and, on the other, that one has to be satisfied with solving the problem approximately or near-optimally.

An important class of algorithms that have shown their usefulness in solving many computationally hard optimization problems is that of meta-heuristics. This is by no chance –meta-heuristics methods possess many good features, among which we could distinguish: they are able to find high quality solutions in a reasonable amount of computation time, are robust, generic, flexible and easy to implement on sequential, parallel and networked computer systems. This, together with the fact that for most practical applications in industry and businesses high quality solution would suffice, have converted meta-heuristics into *de facto* approaches to cope in practice with the computationally hard optimization problems. In fact, even when a polynomial time algorithm is known for a certain problem, solving large-size/real-life instances (e.g. instances at enterprise scale) calls again for the application of meta-heuristics methods. Not less importantly, meta-heuristic approaches can tackle with efficacy both single and multi-objective optimization problems.

Meta-heuristics methods have been applied for decades now. Besides using them as stand alone approaches, during the last years, the attention of researchers has shifted to consider another type of high level algorithms, namely hybrid algorithms. These algorithms do not follow any concrete meta-heuristic, but rather combine meta-heuristics with meta-heuristics and/or other methods (e.g. divide-and-conquer, linear programming, dynamic programming, constraint programming or other AI techniques) yielding thus *hybrid meta-heuristics*. One fundamental question here is how can be achieved for hybrid approaches to outperform stand alone approaches? The hybridization aims at exploring the synergies among stand alone methods in order to achieve better results for the optimization problem under study. For instance, using hybrid approaches one can explore the synergies between *exploration* of solution space (through population based meta-heuristics, such as Genetic Algorithms—GAs) with the *exploitation* of the solution space (through local search methods, such as Tabu Search –TS); the GA could them be used as a main search method while TS can improve locally the individuals of the population.

The rationale behind the hybridization resides in the ``no free lunch theorem" stating that ``... *all algorithms that search for an extremum of a cost function perform exactly the same, when averaged over all possible cost functions. In particular, if algorithm A outperforms algorithm B on some cost functions, then loosely speaking there must exist exactly as many other functions where B outperforms A."* Based on this theorem, existing algorithms can be used as components for designing new efficient search algorithms and expect improved performance of the newly obtained algorithm for some cost functions.

Naturally, there are major issues in designing hybrid meta-heuristics for a given optimization problem, such as: (a) how to choose heuristic and/or meta-heuristic methods to be combined (within the same family or from different families of existing algorithms), and, (b) how to combine the chosen methods into new hybrid approaches. Unfortunately, there are no theoretical foundations for these issues, yet there are interesting evidences, experiences and reports on the literature. For the former, different classes of search algorithms can be considered for the purposes of hybridization, such as exact methods, simple deterministic or random heuristic methods and meta-heuristics. Moreover, meta-heuristics themselves are classified into local search based methods, population based methods and other classes of nature inspired meta-heuristics. Therefore, in principle, one could combine any methods from the same class or methods from different classes. Regarding the later, there are some attempts for taxonomies of hybrid meta-heuristics; in fact, the common approach is to try out in smart ways, based on domain knowledge of problem at hand and characteristics of heuristics methods, different hybrid approaches and shed light on the performance of the resulting hybrid approach. The level of hybridization here plays an important role, namely the degree of coupling between the meta-heuristics (e.g. coercive *vs.* cooperative*)*. It should as well be noted that frameworks that facilitate fast prototyping have been also provided in the hybrid meta-heuristics literature.

This book brings excellent contributions to the field of hybrid algorithms, their design, implementation and experimental evaluation. The proposed hybrid approaches tackle fundamental problems in the domain of logistics, industry services, commercial distribution and manufacturing systems. The studied problems include routing, different forms of scheduling, such as permutation scheduling and shop scheduling problems, service allocation problems, etc. The proposed approaches include hybridization of meta-heuristic methods with other meta-heuristic methods such as Genetic Algorithms (GA) and Simulated Annealing (SA) or the hybridization of meta-heuristics with the exact solution of one or several mathematical programming models.

Besides advancing in the design of more sophisticated hybrid solution strategies for routing and scheduling problems, the contributions of the book have a practical focus for solving real life problems. The aim is to support decision processes in companies and thus to enable achieving better business objectives by solving the problems at company scale. Also, the use of benchmarks and software packages are good examples of best practices in the field.

The editors of this volume bring together experts and researchers from the field whose contributions explore new research findings, developments and future directions in the hybrid approaches for routing and scheduling problems arising in service, computing and manufacturing systems. Finally, although focused on the concrete field of the routing and scheduling for service, computing and manufacturing systems, most of the conclusions provided in the volume could be extended to routing and scheduling in other research fields.

Fatos Xhafa
Technical University of Catalonia, Spain

Fatos Xhafa *holds a PhD in Computer Science from the Department of Languages and Informatics Systems (LSI) of the Technical University of Catalonia (UPC), Barcelona, Spain. He was a Visiting Professor at the Department of Computer Science and Information Systems, Birkbeck, University of London, UK (academic year 2009-2010) and a Research Associate at College of Information Science and Technology, Drexel University, Philly, USA (Sept.2004-Feb.2005). Dr Xhafa holds a permanent position of Professor Titular at the Department of LSI, UPC (Spain). His research interests include parallel and distributed algorithms, combinatorial optimization, approximation and meta-heuristics, networking and distributed computing, Grid and P2P computing. Dr. Xhafa has widely published in peer reviewed international journals, conferences/workshops proceedings, book chapters and edited books in the field. Dr. Xhafa has an extensive editorial and reviewing service. He is Editor in Chief of the International Journal of Space-based and Situated Computing, Inderscience (http://www.inderscience.com/browse/index.php?journalCODE=ijssc) and of International Journal of Grid and Utility Computing, Inderscience (http://www.inderscience.com/browse/index.php?journalCODE=ijguc). He is also an associate/member of Editorial Board of several international peer-reviewed scientific journals and has guest co-edited several special issues of international journals.*