Activity Report 2017

Team DOLPHIN

Parallel Cooperative Multi-criteria Optimization

Inria teams are typically groups of researchers working on the definition of a common project, and objectives, with the goal to arrive at the creation of a project-team. Such project-teams may include other partners (universities or research institutions).

RESEARCH CENTER
Lille - Nord Europe

THEME
Optimization, machine learning and statistical methods

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Team DOLPHIN

Creation of the Project-Team: 2005 May 12, updated into Team: 2017 January 01, end of the Team: 2017 June 30

Keywords:

Computer Science and Digital Science:

A6.2. - Scientific Computing, Numerical Analysis & Optimization
A8.2. - Optimization
A8.2.1. - Operations research
A8.2.2. - Evolutionary algorithms
A9.6. - Decision support
A9.7. - AI algorithmics

Other Research Topics and Application Domains:

B2. - Health
B4. - Energy
B7. - Transport and logistics

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2. Overall Objectives

2.1. Presentation

The goal of the DOLPHIN [1] project is the modeling and resolution of large multi-criteria combinatorial problems using parallel and distributed hybrid techniques. We are interested in algorithms using Pareto approaches, which generate the whole Pareto set of a given Multi-Objective Problem (MOP). For this purpose, the research actions can be summarized as follows:

- **Modeling and Analysis of MOPs:** Solving Multi-Objective Problems requires an important analysis phase to find the best suitable method to solve it. This analysis deals with the modeling of the problem and the analysis of its structure.

  To propose efficient models for a Multi-Objective Optimization problem, an important aspect is to integrate all the constraints of the problem. Therefore an interesting preliminary approach is to develop efficient models for the problem in its mono-objective forms in order to be able to develop methods that are taking the characteristics of the studied problem into account.

  While studying the problem in its multi-objective form, the analysis of the structure is another interesting approach. The analysis of the structure of the Pareto front by means of different approaches (statistical indicators, meta-modeling) allows the design of efficient and robust hybrid optimization techniques. In general, the current theory does not allow the complete analysis of optimization algorithms. Several questions are unanswered: i) why is a given method efficient? ii) why are certain instances difficult to solve? Some work is needed to guide the user in the design of efficient methods.

  The NFL (No Free Lunch) theorem shows that two optimization methods have the same global performance on the whole set of uniform optimization problems. Then, it is crucial to make some hypotheses on the studied problem. This may be done in two steps:

  - analyzing the target problem to identify its landscape properties,
  - including this knowledge in the proposed optimization method.

[1] Discrete multi-objective Optimization for Large scale Problems with Hybrid dIstributed techNiques.

Our interest in this project is to answer these questions and remarks for the multi-objective case. Another point considered is the performance evaluation of multi-objective optimization methods. We are also working on approximation algorithms with performance guarantee and the convergence properties of stochastic algorithms.

- **Cooperation of optimization methods (metaheuristics and/or exact methods):**

  The hybridization of optimization methods allows the cooperation of complementary different methods. For instance, the cooperation between a metaheuristic and an exact method allows us to take advantage of the intensification process of an exact method in finding the best(s) solution(s) in a sub-space, and the diversification process of the metaheuristic in reducing the search space to explore.

  In this context, different types of cooperation may be proposed. These approaches are under study in the project and we are applying them to different generic MOPs (flow-shop scheduling problem, vehicle routing problem, covering tour problem, access network design, and the association rule problem in data mining).

- **Parallel optimization methods:** Parallel and distributed computing may be considered as a tool to speedup the search to solve large MOPs and/or to improve the robustness of a given method. Following this objective, we design and implement parallel metaheuristics (evolutionary algorithms, Tabu search approach) and parallel exact methods (branch and bound algorithm, branch and cut algorithm) for solving different large MOPs. Moreover, the joint use of parallelism and cooperation allows the improvement of the quality of the obtained solutions.

- **Framework for parallel and distributed hybrid metaheuristics:** Our team contributes to the development of an open source framework for metaheuristics, named ParadisEO (PARAllel and DIStributed Evolving Objects). Our contribution in this project is the extension of the EO (Evolving Objects) framework [2], which consists in: i) the generalization of the framework to single solution metaheuristics such as local search, tabu search and simulated annealing; ii) the design of metaheuristics for multi-objective optimization; iii) the design of hybrid methods; iv) the development of parallel and distributed models.

  In this project, our goal is the efficient design and implementation of this framework on different types of parallel and distributed hardware platforms:cluster of workstations (COW), networks of workstations (NOW) and GRID computing platforms, using the suited programming environments (MPI, Condor, Globus, PThreads). The coupling with well-known frameworks for exact methods (such as COIN) will also be considered. The exact methods for MOPs developed in this project will be integrated in those software frameworks.

  The experimentation of this framework by different users and applications outside the DOLPHIN project is considered. This is done in order to validate the design and the implementation issues of ParadisEO.

- **Validation:** the designed approaches are validated on generic and real-life MOPs, such as:

  1. Scheduling problems: Flow-shop scheduling problem.
  2. Routing problems: Vehicle routing problem (VRP), covering tour problem (CTP).
  3. Mobile telecommunications: Design of mobile telecommunications networks (contract with France Telecom R&D) and design of access networks (contract with Mobinets).
  4. Genomics: Association rule discovery (data mining task) for mining genomic data, protein identification, docking and conformational sampling of molecules.
  5. Engineering design problems: Design of polymers.

[2] This framework was initially developed by Geneura TEAM (Spain), Inria (France), LIACS (Netherlands). http://paradiseo.gforge.inria.fr.

Some benchmarks and their associated optimal Pareto fronts or best known Pareto fronts have been defined and made available on the Web. We are also developing an open source software, named GUIMOO [3], which integrates different performance evaluation metrics and 2D/3D visualization tools of Pareto fronts.

3. Research Program

3.1. Hybrid multi-objective optimization methods

The success of metaheuristics is based on their ability to find efficient solutions in a reasonable time [43]. But with very large problems and/or multi-objective problems, efficiency of metaheuristics may be compromised. Hence, in this context it is necessary to integrate metaheuristics in more general schemes in order to develop even more efficient methods. For instance, this can be done by different strategies such as cooperation and parallelization.

The DOLPHIN project deals with *"a posteriori"* multi-objective optimization where the set of Pareto solutions (solutions of best compromise) have to be generated in order to give the decision maker the opportunity to choose the solution that interests him/her.

Population-based methods, such as evolutionary algorithms, are well fitted for multi-objective problems, as they work with a set of solutions [39], [42]. To be convinced one may refer to the list of references on Evolutionary Multi-objective Optimization maintained by Carlos A. Coello [4], which contains more than 5500 references. One of the objectives of the project is to propose advanced search mechanisms for intensification and diversification. These mechanisms have been designed in an adaptive manner, since their effectiveness is related to the landscape of the MOP and to the instance solved.

In order to assess the performances of the proposed mechanisms, we always proceed in two steps: first, we carry out experiments on academic problems, for which some best known results exist; second, we use real industrial problems to cope with large and complex MOPs. The lack of references in terms of optimal or best known Pareto set is a major problem. Therefore, the obtained results in this project and the test data sets will be available at the URL http://dolphin.lille.inria.fr/ at 'benchmark'.

3.1.1. Cooperation of metaheuristics

In order to benefit from the various advantages of the different metaheuristics, an interesting idea is to combine them. Indeed, the hybridization of metaheuristics allows the cooperation of methods having complementary behaviors. The efficiency and the robustness of such methods depend on the balance between the exploration of the whole search space and the exploitation of interesting areas.

Hybrid metaheuristics have received considerable interest these last years in the field of combinatorial optimization. A wide variety of hybrid approaches have been proposed in the literature and give very good results on numerous single objective optimization problems, which are either academic (traveling salesman problem, quadratic assignment problem, scheduling problem, etc) or real-world problems. This efficiency is generally due to the combinations of single-solution based methods (iterative local search, simulated annealing, tabu search, etc) with population-based methods (genetic algorithms, ants search, scatter search, etc). A taxonomy of hybridization mechanisms may be found in [45]. It proposes to decompose these mechanisms into four classes:

- *LRH class - Low-level Relay Hybrid*: This class contains algorithms in which a given metaheuristic is embedded into a single-solution metaheuristic. Few examples from the literature belong to this class.
- *LTH class - Low-level Teamwork Hybrid*: In this class, a metaheuristic is embedded into a population-based metaheuristic in order to exploit strengths of single-solution and population-based metaheuristics.

[3] Graphical User Interface for Multi-Objective Optimization (http://guimoo.gforge.inria.fr).
[4] http://delta.cs.cinvestav.mx/~ccoello/EMOO/EMOObib.html

- *HRH class - High-level Relay Hybrid*: Here, self contained metaheuristics are executed in a sequence. For instance, a population-based metaheuristic is executed to locate interesting regions and then a local search is performed to exploit these regions.
- *HTH class - High-level Teamwork Hybrid*: This scheme involves several self-contained algorithms performing a search in parallel and cooperating. An example will be the island model, based on GAs, where the population is partitioned into small subpopulations and a GA is executed per subpopulation. Some individuals can migrate between subpopulations.

Let us notice that, hybrid methods have been studied in the mono-criterion case, their application in the multi-objective context is not yet widely spread. The objective of the DOLPHIN project is to integrate specificities of multi-objective optimization into the definition of hybrid models.

3.1.2. Cooperation between metaheuristics and exact methods

Until now only few exact methods have been proposed to solve multi-objective problems. They are based either on a Branch-and-bound approach, on the algorithm $A^{\star}$, or on dynamic programming. However, these methods are limited to two objectives and, most of the time, cannot be used on a complete large scale problem. Therefore, sub search spaces have to be defined in order to use exact methods. Hence, in the same manner as hybridization of metaheuristics, the cooperation of metaheuristics and exact methods is also a main issue in this project. Indeed, it allows us to use the exploration capacity of metaheuristics, as well as the intensification ability of exact methods, which are able to find optimal solutions in a restricted search space. Sub search spaces have to be defined along the search. Such strategies can be found in the literature, but they are only applied to mono-objective academic problems.

We have extended the previous taxonomy for hybrid metaheuristics to the cooperation between exact methods and metaheuristics. Using this taxonomy, we are investigating cooperative multi-objective methods. In this context, several types of cooperations may be considered, according to the way the metaheuristic and the exact method cooperate. For instance, a metaheuristic can use an exact method for intensification or an exact method can use a metaheuristic to reduce the search space.

Moreover, a part of the DOLPHIN project deals with studying exact methods in the multi-objective context in order: i) to be able to solve small size problems and to validate proposed heuristic approaches; ii) to have more efficient/dedicated exact methods that can be hybridized with metaheuristics. In this context, the use of parallelism will push back limits of exact methods, which will be able to explore larger size search spaces [40].

3.1.3. Goals

Based on the previous works on multi-objective optimization, it appears that to improve metaheuristics, it becomes essential to integrate knowledge about the problem structure. This knowledge can be gained during the search. This would allow us to adapt operators which may be specific for multi-objective optimization or not. The goal here is to design auto-adaptive methods that are able to react to the problem structure. Moreover, regarding the hybridization and the cooperation aspects, the objectives of the DOLPHIN project are to deepen these studies as follows:

- *Design of metaheuristics for the multi-objective optimization:* To improve metaheuristics, it becomes essential to integrate knowledge about the problem structure, which we may get during the execution. This would allow us to adapt operators that may be specific for multi-objective optimization or not. The goal here is to design auto-adaptive methods that are able to react to the problem structure.
- *Design of cooperative metaheuristics:* Previous studies show the interest of hybridization for a global optimization and the importance of problem structure study for the design of efficient methods. It is now necessary to generalize hybridization of metaheuristics and to propose adaptive hybrid models that may evolve during the search while selecting the appropriate metaheuristic. Multi-objective aspects have to be introduced in order to cope with the specificities of multi-objective optimization.

- *Design of cooperative schemes between exact methods and metaheuristics:* Once the study on possible cooperation schemes is achieved, we will have to test and compare them in the multi-objective context.
- *Design and conception of parallel metaheuristics:* Our previous works on parallel metaheuristics allow us to speed up the resolution of large scale problems. It could be also interesting to study the robustness of the different parallel models (in particular in the multi-objective case) and to propose rules that determine, given a specific problem, which kind of parallelism to use. Of course these goals are not disjoined and it will be interesting to simultaneously use hybrid metaheuristics and exact methods. Moreover, those advanced mechanisms may require the use of parallel and distributed computing in order to easily make cooperating methods evolve simultaneously and to speed up the resolution of large scale problems.
- *Validation:* In order to validate the obtained results we always proceed in two phases: validation on academic problems, for which some best known results exist and use on real problems (industrial) to cope with problem size constraints.

  Moreover, those advanced mechanisms are to be used in order to integrate the distributed multi-objective aspects in the ParadisEO platform (see the paragraph on software platform).

3.2. Parallel multi-objective optimization: models and software frameworks

Parallel and distributed computing may be considered as a tool to speedup the search to solve large MOPs and to improve the robustness of a given method. Moreover, the joint use of parallelism and cooperation allows improvements on the quality of the obtained Pareto sets. Following this objective, we will design and implement parallel models for metaheuristics (evolutionary algorithms, tabu search approach) and exact methods (branch-and-bound algorithm, branch-and-cut algorithm) to solve different large MOPs.

One of the goals of the DOLPHIN project is to integrate the developed parallel models into software frameworks. Several frameworks for parallel distributed metaheuristics have been proposed in the literature. Most of them focus only either on evolutionary algorithms or on local search methods. Only few frameworks are dedicated to the design of both families of methods. On the other hand, existing optimization frameworks either do not provide parallelism at all or just supply at most one parallel model. In this project, a new framework for parallel hybrid metaheuristics is proposed, named *Parallel and Distributed Evolving Objects (ParadisEO)* based on EO. The framework provides in a transparent way the hybridization mechanisms presented in the previous section, and the parallel models described in the next section. Concerning the developed parallel exact methods for MOPs, we will integrate them into well-known frameworks such as COIN.

3.2.1. Parallel models

According to the family of addressed metaheuristics, we may distinguish two categories of parallel models: parallel models that manage a single solution, and parallel models that handle a population of solutions. The major single solution-based parallel models are the following: the *parallel neighborhood exploration model* and the *multi-start model*.

- *The parallel neighborhood exploration model* is basically a "low level" model that splits the neighborhood into partitions that are explored and evaluated in parallel. This model is particularly interesting when the evaluation of each solution is costly and/or when the size of the neighborhood is large. It has been successfully applied to the mobile network design problem (see Application section).
- *The multi-start model* consists in executing in parallel several local searches (that may be heterogeneous), without any information exchange. This model raises particularly the following question: is it equivalent to execute k local searches during a time t than executing a single local search during $k \times t$? To answer this question we tested a multi-start Tabu search on the quadratic assignment problem. The experiments have shown that the answer is often landscape-dependent. For example, the multi-start model may be well-suited for landscapes with multiple basins.

Parallel models that handle a population of solutions are mainly: the *island model*, the *central model* and *the distributed evaluation of a single solution*. Let us notice that the last model may also be used with single-solution metaheuristics.

- In *the island model*, the population is split into several sub-populations distributed among different processors. Each processor is responsible of the evolution of one sub-population. It executes all the steps of the metaheuristic from the selection to the replacement. After a given number of generations (synchronous communication), or when a convergence threshold is reached (asynchronous communication), the migration process is activated. Then, exchanges of solutions between sub-populations are realized, and received solutions are integrated into the local sub-population.
- *The central (Master/Worker) model* allows us to keep the sequentiality of the original algorithm. The master centralizes the population and manages the selection and the replacement steps. It sends sub-populations to the workers that execute the recombination and evaluation steps. The latter returns back newly evaluated solutions to the master. This approach is efficient when the generation and evaluation of new solutions is costly.
- *The distributed evaluation model* consists in a parallel evaluation of each solution. This model has to be used when, for example, the evaluation of a solution requires access to very large databases (data mining applications) that may be distributed over several processors. It may also be useful in a multi-objective context, where several objectives have to be computed simultaneously for a single solution.

As these models have now been identified, our objective is to study them in the multi-objective context in order to use them advisedly. Moreover, these models may be merged to combine different levels of parallelism and to obtain more efficient methods [41], [44].

3.2.2. Goals

Our objectives focus on these issues are the following:

- *Design of parallel models for metaheuristics and exact methods for MOPs*: We will develop parallel cooperative metaheuristics (evolutionary algorithms and local search algorithms such as the Tabu search) for solving different large MOPs. Moreover, we are designing a new exact method, named PPM (Parallel Partition Method), based on branch and bound and branch and cut algorithms. Finally, some parallel cooperation schemes between metaheuristics and exact algorithms have to be used to solve MOPs in an efficient manner.
- *Integration of the parallel models into software frameworks*: The parallel models for metaheuristics will be integrated in the ParadisEO software framework. The proposed multi-objective exact methods must be first integrated into standard frameworks for exact methods such as COIN and BOB++. A *coupling* with ParadisEO is then needed to provide hybridization between metaheuristics and exact methods.
- *Efficient deployment of the parallel models on different parallel and distributed architectures including GRIDs*: The designed algorithms and frameworks will be efficiently deployed on non-dedicated networks of workstations, dedicated cluster of workstations and SMP (Symmetric Multi-processors) machines. For GRID computing platforms, peer to peer (P2P) middlewares (XtremWeb-Condor) will be used to implement our frameworks. For this purpose, the different optimization algorithms may be re-visited for their efficient deployment.

4. Application Domains

4.1. Smart grids

With the smart grid revolution, house energy consumption will play a significant role in the energy system. Home users are indeed responsible for a significant portion of the world's energy needs portion, but are totally inelastic with respect to the market (i.e. the energy demand does not follow the price of the energy itself). Thus, the whole energy generation and distribution system performance can be improved by optimizing the house energy management. Those problems are concerned by multiple objectives such as cost and users' comfort, and multiple decision makers such as end-users and energy operators. We propose a home automation system that can monitor appliance scheduling in order to simultaneously optimize the total energy cost and the customer satisfaction [17].

The key challenge is to propose new optimization models and new hybrid optimization algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives. Those complex optimization problems are also characterized by the presence of both continuous and discrete variables [18].

4.2. Transportation and logistics

- **Scheduling problems under uncertainty:** The flow-shop scheduling problem is one of the most well-known problems from scheduling. However, most of the works in the literature use a deterministic single-objective formulation. In general, the minimized objective is the total completion time (makespan). Many other criteria may be used to schedule tasks on different machines: maximum tardiness, total tardiness, mean job flowtime, number of delayed jobs, maximum job flowtime, etc. In the DOLPHIN project, a bi-criteria model, which consists in minimizing the makespan and the total tardiness, is studied. A bi-objective flow-shop problem with uncertainty on the duration, minimizing in addition the maximum tardiness, is also studied. It allows us to develop and test multi-objective (and not only bi-objective) optimization methods under uncertainty.
- **Routing problems under uncertainty:** The vehicle routing problem (VRP) is a well-known problem and it has been studied since the end of the fifties. It has a lot of practical applications in many industrial areas (ex. transportation, logistics, etc). Existing studies of the VRP are almost all concerned with the minimization of the total distance only. The model studied in the DOLPHIN project introduces a second objective, whose purpose is to balance the length of the tours. This new criterion is expressed as the minimization of the difference between the length of the longest tour and the length of the shortest tour. Uncertainty on the demands has also been introduced in the model.

4.3. Bioinformatics and Health care

Bioinformatic research is a great challenge for our society and numerous research entities of different specialities (biology, medical or information technology) are collaborating on specific themes.

4.3.1. Genomic and post-genomic studies

Previous studies of the DOLPHIN project mainly deal with genomic and postgenomic applications. These have been realized in collaboration with academic and industrial partners (IBL: Biology Institute of Lille; IPL: Pasteur Institute of Lille; IT-Omics firm).

First, genomic studies aim at analyzing genetic factors which may explain multi-factorial diseases such as diabetes, obesity or cardiovascular diseases. The scientific goal was to formulate hypotheses describing associations that may have any influence on diseases under study.

Secondly, in the context of post-genomic, a very large amount of data are obtained thanks to advanced technologies and have to be analyzed. Hence, one of the goals of the project was to develop analysis methods in order to discover knowledge in data coming from biological experiments.

These problems can be modeled as classical data mining tasks (Association rules, feature selection). As the combinatoric of such problems is very high and the quality criteria not unique, we proposed to model these problems as multi-objective combinatorial optimization problems. Evolutionary approaches have been adopted in order to cope with large scale problems.

Nowadays the technology is still going fast and the amount of data increases rapidly. Within the collaboration with Genes Diffusion, specialized in genetics and animal reproduction for bovine, swine, equine and rabbit species, we study combinations of Single Nucleotide Polymorphisms (SNP) that can explain some phenotypic characteristics. Therefore feature selection for regression is addressed using metaheuristics.

4.3.2. Optimization for health care

The collaboration with the Alicante company, a major actor in the hospital decision making, deals with knowledge extraction by optimization methods for improving the process of inclusion in clinical trials. Indeed, conducting a clinical trial, allowing for example to measure the effectiveness of a treatment, involves selecting a set of patients likely to participate to this test. Currently existing selection processes are far from optimal, and many potential patients are not considered. The objective of this collaboration consists in helping the practitioner to quickly determine if a patient is interesting for a clinical trial or not. Exploring different data sources (from a hospital information system, patient data...), a set of decision rules have to be generated. For this, approaches from multi-objective combinatorial optimization are implemented, requiring extensive work to model the problem, to define criteria optimization and to design specific optimization methods.

In another project we address the problems, proper models and suitable solving approaches to optimize the design and planning of a medical laboratory. It comes from the observation that human biology laboratories tend to get bigger and more complicated. The goal of this project is to design and apply solutions to optimize human biology laboratory decisions and operations. As a result of mutualisation phenomenon, huge medical laboratories are emerging all over the world. Medical laboratories are responsible for analyzing medical tests ordered by physicians on patient's samples. Large number of prescriptions and tubes are received by a laboratory make a complicated workflow into the system. The aim of this thesis is to design and plan a medical laboratory to minimize the costs and time required to perform the tests. Medical laboratory optimization is an immense problem which encompasses many subproblems. In the literature, there are only few studies that refer directly to medical laboratory planning and optimization from different points of view. In this thesis, the problem of designing and planning of medical laboratory is studied in a comprehensive form for both existing and new labs to provide practical models and solutions that can be implemented to real cases. The problem is studied from two different aspects: strategic and operational problems. In strategic level, machine selection and analyzer configuration problem and facilities layout problem are modeled and solved to achieve an optimal medical laboratory design. Mathematical programming is used for this phase. For operational level, the problems of assignment and scheduling are emerged. Mathematical programming, heuristic and meta-heuristic algorithms are proposed to deal with such problems. Simulation as a powerful tool is applied to verify and validate the solutions proposed from the previous analytical steps and also to aid decision making in some problems0. FlexSim is a simulation software which is used in this study and provide us the ability to model and analyze complex systems. It is worth mentioning that this project is raised by Normand-Info, a Beckman Coulter subsidiary which is an international company mainly producing human biology instruments. Thus, it is a collaborative research work with industry.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- Patent with Beckman & Coulter on Intelligent handling of materials: joint selection and configuration optimization of machines (Prof. E-G. Talbi, S. Faramarzi-oghani, M. Bué)
- Best student paper award at conference SEAL'2017

BEST PAPER AWARD:

[27]

J. SHI, Q. ZHANG, B. DERBEL, A. LIEFOOGHE, S. VEREL. *Using Parallel Strategies to Speed Up Pareto Local Search*, in "11th International Conference on Simulated Evolution and Learning (SEAL 2017)", Shenzhen, China, Lecture Notes in Computer Science, November 2017, https://hal.archives-ouvertes.fr/hal-01581257

6. New Software and Platforms

6.1. Grid'5000

Grid'5000 experimental platform
FUNCTIONAL DESCRIPTION: The Grid'5000 experimental platform is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg, including Lyon. Grid'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results.

- Participants: Christian Pérez, David Loup, Frédéric Desprez, Laurent Lefèvre, Laurent Pouilloux, Marc Pinhède and Simon Delamare
- Contact: Frédéric Desprez
- URL: https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

6.2. ParadisEO

KEYWORD: Parallelisation
SCIENTIFIC DESCRIPTION: ParadisEO (PARallel and DIStributed Evolving Objects) is a C++ white-box object-oriented framework dedicated to the flexible design of metaheuristics. Based on EO, a template-based ANSI-C++ compliant evolutionary computation library, it is composed of four modules: * Paradiseo-EO provides tools for the development of population-based metaheuristic (Genetic algorithm, Genetic programming, Particle Swarm Optimization (PSO)...) * Paradiseo-MO provides tools for the development of single solution-based metaheuristics (Hill-Climbing, Tabu Search, Simulated annealing, Iterative Local Search (ILS), Incremental evaluation, partial neighborhood...) * Paradiseo-MOEO provides tools for the design of Multi-objective metaheuristics (MO fitness assignment shemes, MO diversity assignment shemes, Elitism, Performance metrics, Easy-to-use standard evolutionary algorithms...) * Paradiseo-PEO provides tools for the design of parallel and distributed metaheuristics (Parallel evaluation, Parallel evaluation function, Island model) Furthermore, ParadisEO also introduces tools for the design of distributed, hybrid and cooperative models: * High level hybrid metaheuristics: coevolutionary and relay model * Low level hybrid metaheuristics: coevolutionary and relay model
FUNCTIONAL DESCRIPTION: Paradiseo is a software framework for metaheuristics (optimisation algorithms aimed at solving difficult optimisation problems). It facilitates the use, development and comparison of classic, multi-objective, parallel or hybrid metaheuristics.

- Partners: CNRS - Université Lille 1
- Contact: El-Ghazali Talbi
- URL: http://paradiseo.gforge.inria.fr/

6.3. VRPsolve

KEYWORDS: C++ - Mobile Computing, Transportation - Optimization

SCIENTIFIC DESCRIPTION: VRPsolve is a software for solving vehicle routing problems dealing with last-mile delivery issues that arise as we approach the final customer. When modeling and solving combinatorial optimization problems, especially problems related to the transport of goods and people, the resulting models are generally subject to a specific development in order to be validated, as industrial needs are highly dependent of the application domain. However, a set of conventional objectives and constraints, such as vehicles capacities, incompatible parcels, time windows, are now commonly encountered. In addition to being efficient and effective, VRPsolve differentiates from other tools by allowing to quickly and conveniently integrate ad-hoc constraints and objectives into a generic software. Indeed, VRPsolve effectively deal with industrial last-mile delivery vehicle routing problems and is able to cope with multiple objectives and a large number of constraints by using advanced optimization algorithms which are usually not available with existing softwares. In addition, VRPsolve allows industrial collaborations to be addressed by solving real-world problems requiring geographic information systems (GIS).

- Participants: Arnaud Liefooghe and Sébastien Vérel
- Contact: El-Ghazali Talbi
- URL: http://gforge.inria.fr/projects/vrpsolve

6.4. Platform Grid'5000

The Dolphin project-team has been the Principal Investigator of the Grid5000@Lille project funded (budget: 750K€) within the framework of the CPER. This project consists in building in 2017 a new site of the Grid'5000 platform at Lille. This new site hosted by Inria Lille replaces the old one which was located in the supercomputing center (CRI) of the University of Lille. It consists in a GPU-enhanced computing cluster composed of over 1.000 CPU cores and 60.000 GPU cores corresponding to a 20FLOPS computational power. The Grid5000@Lille project allowed also the recruitment of two engineers for the system and network administration and the software development for two years. Another upgrade with more GPUs is planned for the beginning of 2018.

- Participants: F. Desprez, F. Huet, E. Jeannot, Y. Jegou, A. Lebre, L. Lefevre, F. Loui, D. Margery, N. Melab, J-M. Menaud, P. Neyron, L. Nussbaum, C. Perez, J-M. Pierson, O. Richard., S. Varette.
- Contact: Nouredine Melab
- URL: https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

7. New Results

7.1. Fitness Landscape Analysis for Algorithm Understanding, Selection, Design and Configuration

Participants: Bilel Derbel, Arnaud Liefooghe (external collaborators: Sebastien Verel, Univ. Littoral, France; Hernan Aguirre, Fabio Daolio, Hugo Monzón, Miyako Sagawa and Kiyoshi Tanaka, Shinshu University, Japan)

Fitness landscape analysis of Pareto local search on bi-objective permutation flowshop scheduling problems. In [20], we study the difficulty of solving different bi-objective formulations of the permutation flowshop scheduling problem by adopting a fitness landscape analysis perspective. Our main goal is to shed the light on how different problem features can impact the performance of Pareto local search algorithms. Specifically, we conduct an empirical analysis addressing the challenging question of quantifying the individual effect and the joint impact of different problem features on the success rate of the considered approaches. Our findings support that multi-objective fitness landscapes enable to devise sound general-purpose features for assessing the expected difficulty in solving permutation flowshop scheduling problems, hence pushing a step towards a better understanding of the challenges that multi-objective randomized search heuristics have to face.

Landscape-aware automatic algorithm configuration. The proper setting of algorithm parameters is a well-known issue that gave rise to recent research investigations from the (offline) automatic algorithm configuration perspective. Besides, the characteristics of the target optimization problem is also a key aspect to elicit the behavior of a dedicated algorithm, and as often considered from a landscape analysis perspective. In [21], we show that fitness landscape analysis can open a whole set of new research opportunities for increasing the effectiveness of existing automatic algorithm configuration methods. Specifically, we show that using landscape features in iterated racing both (i) at the training phase, to compute multiple elite configurations explicitly mapped with different feature values, and (ii) at the production phase, to decide which configuration to use on a feature basis, provides significantly better results compared against the standard landscape-oblivious approach. Our first experimental investigations on NK-landscapes, considered as a benchmark family having controllable features in terms of ruggedness and neutrality, and tackled using a memetic algorithm with tunable population size and variation operators, show that a landscape-aware approach is a viable alternative to handle the heterogeneity of (black-box) combinatorial optimization problems.

Learning variable importance to guide recombination on many-objective optimization. There are numerous many-objective real-world problems in various application domains for which it is difficult or time-consuming to derive Pareto optimal solutions. In an evolutionary algorithm, variation operators such as recombination and mutation are extremely important to obtain an effective solution search. In [25], we study a machine learning-enhanced recombination that incorporates an intelligent variable selection method. The method is based on the importance of variables with respect to convergence to the Pareto front. We verify the performance of the enhanced recombination on benchmark test problems with three or more objectives using the many-objective evolutionary algorithm AϵSϵH as a baseline algorithm. Results show that variable importance can enhance the performance of many-objective evolutionary algorithms.

Closed state model for understanding the dynamics of multi-objective evolutionary algorithms. In [22], we propose the use of simple closed state models to capture, analyze and compare the dynamics of multi- and many-objective evolutionary algorithms. Two- and three-state models representing the composition of the instantaneous population are described and learned for representatives of the major approaches to multi-objective optimization, i.e. dominance, extensions of dominance, decomposition, and indicator algorithms. The model parameters are trained from data obtained running the algorithms with various population sizes on enumerable MNK-landscapes with 3, 4, 5 and 6 objectives. We show ways to interpret and use the model parameter values in order to analyze the population dynamics according to selected features. For example, we are interested in knowing how parameter values change for a given population size with the increase of the number of objectives. We also show a graphical representation capturing in one graph how the parameters magnitude and sign relate to the connections between states.

7.2. Multi-objective Demand side management in smart grids

Participants: El-Ghazali Talbi (externel collaborators: Rachid Ellaia, Zineb Garroussi - Univ. Rabat Morocco)

Residential demand side management (DSM) is one of the most challenging topics in smart grids. In this work, a multi-objective model for the residential DSM is proposed. The smart home is composed of appliances, a battery and a photovoltaic panel. The resolution of this model is a matheuristic based on combining a multi-objective evolutionary algorithm and an exact liner programming solver (CPLEX). Candidate solutions in this hybrid approach are incompletely represented in the representation, and the exact solver is used as a decoder to determine the missing parts in an optimal way. In our case, hybridization involves solving a MILP sub-problem by CPLEX to manage the battery and the photovoltaic panel constraints. Through case studies, It is shown that the coordination between the photovoltaic panel and the battery is effective to reduce the total electricity cost, the discomfort and the standard deviation of power consumed especially in summer conditions [17][18].

7.3. Fractal based-decomposition optimization algorithm

Participants: El-Ghazali Talbi (externel collaborators: Amir Nakib - Univ. Paris 12 France)

In this work a new metaheuristic based on geometric fractal decomposition to solve large-scale continuous optimization problems is proposed. It consists of dividing the feasible search space into sub-regions with the same geometrical pattern. At each iteration, the most promising ones are selected and further decomposed. This approach tends to provide a dense set of samples and has interesting theoretical convergence properties. Under some assumptions, this approach covers all the search space only in case of small dimensionality problems. The aim of this work is to propose a new algorithm based on this approach with low complexity and which performs well in case of large-scale problems. To do so, a low complex method that profits from fractals properties is proposed. Then, a deterministic optimization procedure is proposed using a single solution-based metaheuristic which is exposed to illustrate the performance of this strategy. Obtained results on common test functions were compared to those of algorithms from the literature and proved the efficiency of the proposed algorithm [8].

7.4. Parallel High-Level Search Heuristics for Single- and Multi-objective Optimization

Participants: Bilel Derbel, Arnaud Liefooghe (external collaborators: Sebastien Verel, Univ. Littoral, France; Jialong Shi and Qingfu Zhang, City University, Hong Kong)

A parallel tabu search for the unconstrained binary quadratic programming problem. Although several sequential heuristics have been proposed for dealing with the Unconstrained Binary Quadratic Programming (UBQP), very little effort has been made for designing parallel algorithms for the UBQP. In [26], we propose a novel decentralized parallel search algorithm, called Parallel Elite Biased Tabu Search (PEBTS). It is based on D2TS, a state-of-the-art sequential UBQP metaheuristic. The key strategies in the PEBTS algorithm include: (i) a lazy distributed cooperation procedure to maintain diversity among different search processes and (ii) finely tuned bit-flip operators which can help the search escape local optima efficiently. Our experiments on the Tianhe-2 supercomputer with up to 24 computing cores show the accuracy of the efficiency of PEBTS compared with a straightforward parallel algorithm running multiple independent and non-cooperating D2TS processes.

Decomposition-based parallel strategies to speed up Pareto local search. Pareto Local Search (PLS) is a basic building block in many state-of-the-art multiobjective combinatorial optimization algorithms. However, the basic PLS requires a long time to find high-quality solutions. In [27], we propose and investigate several parallel strategies to speed up PLS using decomposition. These strategies are based on a parallel multi-search framework. In our experiments, we investigate the performances of different parallel variants of PLS on the multiobjective unconstrained binary quadratic programming problem. Each PLS variant is a combination of the proposed parallel strategies. The experimental results show that the proposed approaches can significantly speed up PLS while maintaining about the same solution quality. In addition, we introduce a new way to visualize the search process of PLS on two-objective problems, which is helpful to understand the behaviors of PLS algorithms.

7.5. Large scale GPU-centric optimization

Participants: J. Gmys, M. Gobert and N. Melab

This contribution is a joint work with M. Mezmaz and D. Tuyttens from University of Mons (UMONS), and T. C. Pessoa and F. H. De Carvalho Junior from Universidade Federal Do Cearà (UFC), Brazil. N. Melab and M. Mezmaz have been the guest editors [7] of a special issue in the CCPE journal on this topic.

Nowadays, accelerator-centric architectures offer orders-of-magnitude performance and energy improvements. The interest of those parallel resources has been recently accentuated by the advent of deep learning making them definitely key-building blocks of modern supercomputers. During the year 2017, the focus has been put on the investigation of these specific devices within the context of parallel optimization. In the following, two major contributions are reported: (1) massively parallel GPU-centric tree-based optimization for solving to optimality big permutation optimization problems; (2) Cuda Dynamic Parallelism (CDP) for backtracking. Another contribution [2] on the parallel solving of permutation (flow-shop) problems is proposed but not presented here.

- **Massively parallel GPU-centric tree-based optimization.** Within the context of the Ph.D thesis (jointly supervised with UMONS, Belgium) of Jan Gmys [1], parallel Branch-and-Bound (B&B) has been revisited for multi-core processors, (multi-)GPU accelerators and MIC coprocessors [6]. During the 2017 year, the focus was put on the extension of these contributions in order to deal with large hybrid clusters. A bi-level parallel approach is actually proposed to revisit the parallel B&B at the intra- and inter-processing node levels. The intra-node level consists in the combination of the previous contributions for an efficient exploitation of the parallelism levels provided inside a processing node which can be a multi-core processor, a GPU, a Xeon Phi or their combination (hybrid processing node). The inter-node (cluster) level deals with the parallelism provided through the use of multiple processing nodes. In the PhD thesis of M. Mezmaz, we have investigated such parallelism by proposing a grid-enabled approach called B&B@Grid, including interval-based work stealing (WS) and checkpointing mechanisms. In addition, each processing node is mainly composed of a single processing core processing a single interval at a time. Our contribution consists in revisiting those mechanisms to deal with multi- and many-core resources. Indeed, for instance a GPU explores thousands of intervals. The contribution includes a bi-level WS mechanism together with a multi-interval checkpointing mechanism. The proposed approach has been experimented on the OUESSANT GPU cluster located at IDRIS, Paris. The results show that, on the road to the exascale era, our approach scales up to 130.000 Cuda cores, reducing the execution time from 25 days (using B&B@Grid) to 9 hours.
- **Cuda Dynamic Parallelism (CDP) for backtracking.** New GPGPU technologies, such as CUDA Dynamic Parallelism (CDP), can help dealing with recursive patterns of computation, such as divide-and-conquer, used by backtracking algorithms. During 2017, in collaboration with University of Cearà (Brazil), we have investigated the CDP mechanism using highly irregular algorithms. Indeed, we have proposed a GPU-accelerated backtracking algorithm using CDP that extending a well-known parallel backtracking model. The algorithm analyzes the memory requirements of subsequent kernel generations and performs no dynamic memory allocation on GPU, unlike related works from the literature. The proposed algorithm has been extensively experimented using the N-Queens Puzzle problem and instances of the Asymmetric Traveling Salesman Problem (ATSP) as test-cases. The proposed CDP algorithm may, under some conditions, outperform its non-CDP counterpart by a factor up to 25. Compared to other CDP-based strategies from the literature, the proposed algorithm is on average $8\times$ faster.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

The Dolphin team has many bilateral contracts and grants with industry:

1. Beckman (2015-2018): the goal of this contract concerns the strategic and operational planning for medical laboratories (Phd of Sohrab Faramarzi).
2. PIXEO (2014-2018): the objective of this bilateral project is the predictive models and knowledge extraction for insurance web comparator (Phd of A-L. Bedenel).
3. Alicante (2014-2017): the objective of this CIFRE contract is the design of new optimization methods to extract knowledge from hospital data (Phd of M. Vandromme - defended in June 2017).
4. ONERA and CNES (2016-2020): this collaboration deals with the multi-disciplinary and multi-objective design of aerospace vehicles (Phd of J. Pelamatti and A. Hebbal).
5. Intel (2017) Bilateral academic and research partnership between Université Lille 1 and Intel. In this context, Intel provides Lille 1 with training (Dec 14th) and technical support help for the dissemination of its activities related to High Performance Computing.
6. Strat&Logic (2012-2017): the objective of this CIFRE contract is the optimization of economic decisions in a competitive business management simulator (Phd of S. Dufourny - Defended in October 2017).

9. Partnerships and Cooperations

9.1. Regional Initiatives

- CPER "data" (2015-2020): This project is jointly supported by the government together with the region. The Advanced Data Science and Technology (Data) CPER project aims to conduct a research program on data intelligence at a high international level in a strong synergy with the regional economic fabric and to set up a research infrastructure in line with the associated challenges. It focuses on three areas of research: Internet of Things, Intelligence of Data and Knowledge, High Performance Computing (HPC) and Optimization, and four main levers: (i) research infrastructure, (ii) attractiveness - particularly researchers from EPST, (iii) demonstrators, (iv) Transfer for innovation to SMEs. Dolphin (N. Melab) is the scientific leader of the HPC and optimization scientific area and the research infrastructure lever (Grid'5000 part). The budget for this part is 1.2M€. C. Dhaenens is coordinator of the project for the University of Lille.
- CPER ELSAT (2015-2019) of CPER (Contrat Plan Etat Région): transversal research action "Planning and scheduling of maintenance logistics in transportation".

9.2. National Initiatives

9.2.1. ANR

- ANR project Modèles Numériques "NumBBO - Analysis, Improvement and Evaluation of Numerical Blackbox Optimizers" (2012-2016) in collaboration with Inria Saclay, TAO team, Ecole des Mines de St. Etienne, CROCUS team, and TU Dortmund University, Germany (2012-2016)
- ANR project TECSAN (Technologies pour la Santé) "ClinMine - Optimisation de la prise en Charge des Patients à l'Hôpital", in collaboration with University Lille 1, University Lille 2, Inria, CHRU Lille, CHICL, Alicante (6 partners) (2014-2017) - Coordinator C. Dhaenens
- Bilateral ANR/RGC France/Hong Kong PRCI "Big Multiobjective Optimization" (2016-2021) in collaboration with City University of Hong Kong
- PGMO project "Towards a Complexity Theory for Black-Box Optimization", together with Carola Doerr (CNRS, LIP6), Benjamin Doerr (Ecole Polytechnique), Anne Auger, Nikolaus Hansen (both Inria Saclay), Timo Koetzing (University of Jena, Germany), Johannes Lengler (ETH Zurich, Switzerland), and Jonathan Rowe (The University of Birmingham, UK), (2014-2016)
- PGMO project "Demand side management in smart grids", together with EDF, (2015-2017)
- PGMO project "Multi-home Demand side management in micro grids", together with EDF, (2017-2019)

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: SYNERGY

Project title: Synergy for Smart Multi-Objective Optimisation

Duration: 02 2016 - 01 2019

Coordinator: Jožef Stefan Institute (JSI), Ljubljana, Slovenia

Other partners: University of Lille (France), Cologne University of Applied Sciences (Germany)

Abstract: Many real-world application areas, such as advanced manufacturing, involve optimization of several, often time-consuming and conflicting objectives. For example, they require the maximization of the product quality while minimizing the production cost, and rely on demanding numerical simulations in order to assess the objectives. These, so-called multi-objective optimization problems can be solved more efficiently if parallelization is used to execute the simulations simultaneously and if the simulations are partly replaced by accurate surrogate models.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST CA15140

Project acronym: ImAppNIO

Project title: Improving applicability of nature-inspired optimization by joining theory and practice

Duration: 2016-2019

Coordinator: Thomas Jansen

Abstract: The main objective of the COST Action is to bridge this gap and improve the applicability of all kinds of nature-inspired optimisation methods. It aims at making theoretical insights more accessible and practical by creating a platform where theoreticians and practitioners can meet and exchange insights, ideas and needs; by developing robust guidelines and practical support for application development based on theoretical insights; by developing theoretical frameworks driven by actual needs arising from practical applications; by training Early Career Investigators in a theory of nature-inspired optimisation methods that clearly aims at practical applications; by broadening participation in the ongoing research of how to develop and apply robust nature-inspired optimisation methods in different application areas.

9.3.3. Collaborations with Major European Organizations

University of Luxembourg: (Luxembourg)

Energy aware scheduling in Cloud computing systems

University of Oviedo: (Spain)

Optimization under uncertainty for fuzzy flow shop scheduling

University of Elche and University of Murcia: (Spain)

Matheuristics for DEA

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. MOHA

Title: Mixed Multi-objective Optimization using Hybrid Algorithms: Application to smart grids

International Partner (Institution - Laboratory - Researcher):

Ecole Mohammadia d'Ingénieurs (Morocco) - LERMA (Laboratoire d'Etudes et de Recherches en Mathématiques Appliquées) - Rachid Ellaia

Start year: 2016

See also: https://ocm.univ-lille1.fr/~talbi/momh/

The key challenge of this project is to propose new optimization models and new hybrid algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives.

Those complex optimization problems are also characterized by the presence of both continuous and discrete variables. We need to design new efficient optimization algorithms combining state-of-the-art exact and metaheuristic algorithms from the global optimization and combinatorial optimization communities

9.4.1.2. s3-bbo

Title: Threefold Scalability in Any-objective Black-Box Optimization (s3-bbo)

International Partner (Institution - Laboratory - Researcher):

Shinshu University, Japan

Duration: 2015-2017

See also: http://francejapan.gforge.inria.fr/doku.php?id=associateteam

The main scientific goals of this collaboration is to theoretically derive, analyze, design, and develop scalable evolutionary and other stochastic local search algorithms for large-scale optimization considering three different axes of scalability: (i) decision space, (ii) objective space, and (iii) availability of distributed and parallel computing resources. This research will allow us to design, control, predict, analyze and optimize parameters of recent complex, large-scale, and computationally expensive systems, providing the basic support for problem solution and decision-making in a variety of real world applications. For single-objective continuous optimization, we want to theoretically derive variants of the state-of-the-art CMA-ES with linear time and space complexity scalings with respect to the number of variables. We will exploit the information geometry framework to derive updates using parametrization of the underlying family of probability distribution involving a linear number of components. The challenges are related to finding good representations that are theoretically tractable and meaningful. For the design of robust algorithms, implementing the derived updates, we plan to follow the same approach as for the design of CMA-ES. For multi- and many-objective optimization, we will start by characterizing and defining new metrics and methodologies to analyze scalability in the objective space and in terms of computational resources. The first challenge is to accurately measure the impact of adding objectives on the search behavior and on the performance of evolutionary multi- and many- objective optimization (EMyO) algorithms. The second challenge is to investigate the new opportunities offered by large-scale computing platforms to design new effective algorithms for EMyO optimization. To this end, we plan to follow a feature-based performance analysis of EMyO algorithms, to design new algorithms using decomposition-based approaches, and to investigate their mapping to a practical parallel and distributed setting.

9.4.1.3. Informal International Partners

- Collaboration with Université de Mons (UMONS). The collaboration consists mainly in the joint supervision of the Phd thesis of Jan Gmys started in 2014.
- University of Coimbra, Portugal
- University of Lisbon, Portugal
- University of Manchester, United Kingdom
- University of Elche, Spain

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Prof. Fred Glover (University of Colorado, USA), Feb 2017
- Prof. Rachid Ellaia (EMI, Univ. Rabat, Morocco), Nov 2017
- Prof. Oliver Schutez (CINVESTAV, Mexico), Nov 2017
- Manuel López-Ibáñez, Manchester University (United Kingdom), June 2017
- Kiyoshi Tanaka, Shinshu University (Japan), March 2017
- Qingfu Zhang, City University (Hong Kong), April 2017
- Manuel López-Ibáñez, Manchester University (United Kingdom), June 2017
- Kiyoshi Tanaka, Shinshu University (Japan), March 2017
- Qingfu Zhang, City University (Hong Kong), April 2017

9.5.1.1. Internships

- Oliver Cuate, CINVESTAV, Mexico
- Jihene Serrar, EMI, Morocco
- Zineb Hattab, EMI, Morocco

9.5.2. Visits to International Teams

9.5.2.1. Sabbatical programme

Prof. El-Ghazali Talbi has been at Sabbatical from the University of Lille (2016-2017) visiting many Universities at International level (USA, Spain, Italy, Mexico, Morocco, Luxembourg, ...).

9.5.2.2. Research Stays Abroad

- B. Derbel: University of Lisbon (Portugal), 2 months
- A. Liefooghe: Shinshu University (Japan), 1 month, May 2017
- B. Derbel: Shinshu University (Japan), 1 month, June-July 2017
- E-G. Talbi: EMI, University of Rabat (Morocco), 1 month, 2017
- E-G. Talbi, JSI, Ljubljana (Slovenia), 1 month, 2017

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

- E-G. Talbi (steering committee): PDCO'2017 7th IEEE Workshop Parallel Distributed Computing and Optimization, Orlando, USA, May 2017
- N. Melab: Chair of 5 simulation and HPC-related seminars at Lille 1 oct-dec. 2017 (CENAERO, Intel, e-xtream, CRIStAL, Labs of mechanics at Lille)
- L. Jourdan et al.: Summer school ATOM 2017, June 2017, Lille, France

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- E-G. Talbi: Track chair "Metaheuristics and machine learning", MIC'2017 Metaheuristics International Conference, Barcelona, Spain, July 2017

10.1.2.2. Member of the Conference Program Committees

- IEEE Congress on Evolutionary Computation (CEC), San Sebastián, Spain, June 5-8, 2017
- The ACM Genetic and Evolutionary Computation Conference (GECCO), Berlin, Germany, July 15-19, 2017
- 12th Metaheuristics International Conference (MIC), Barcelona, Spain, July 4-7, 2017
- The 2017 International Conference on High Performance Computing & Simulation (HPCS), Genoa, Italy, July 17–21, 2017
- IEEE Intl. Workshop on Parallel/Distributed Computing and Optimization (IPDPS/PDCO), Orlando, Florida, USA, May 23-27, 2017
- 9th Intl. Conf. on Intelligent Networking and Collaborative Systems (INCoS), Track: Nature-inspired parallel collaborative systems, Ryerson University, Canada, August 24-26, 2017
- Colloque sur l'Optimisation et les Systèmes d'information (COSI), Bouira, Algérie, May 14-16, 2017

- The 3rd Intl. Conf. on Cloud Computing Technologies and Applications (CloudTech), Rabah, Morocco, Oct 24-26, 2017
- 6th Int. Conf. on Advances in Computing Communication and Informatics ICACCI'17, Manipal, India, Sept 2017
- ROADEF'2017 18ème Conférence de la Société Française de Recherche Opérationnelle et Aide à la Décision, Metz, France, Fev 2017
- EvoCOP'2017, European Conference on Evolutionary Computation in Combinatorial Optimization, Amsterdam, Netherlands, Apr 2017
- ACM GECCO'2017 (Genetic and Evolutionary Computation Conference), Berlin, Germany, July 2017
- IEEE PDCO Parallel and Distributed Computing and Optimization in IPDPS'2017, Orlando, USA, May 2017
- MIC'2017, Metaheuristics International Conference, Barcelona, Spain, July 2017
- IJCCI'2017 8th International Joint Conference on Computational Intelligence, Madeira, Portugal, Nov 2017
- EvoCOP'2017, European Conference on Evolutionary Computation in Combinatorial Optimization, Amsterdam, Netherlands, Apr 2017
- ACM Student Workshop in GECCO'2017 (Genetic and Evolutionary Computation Conference), Berlin, Germany, July 2017
- IESM'2017 Int. Conf. on Industrial Engineering and Systems Management, Saarbrucken, Germany, Sept 2017
- EA'2017 Int. Conference on Artificial Evolution, Paris, France, Nov 2017
- MOPGP'2017 Int. Conference on Multiple objective Programming and Goal Programming, Metz, France, 2017
- IEEE CEC 2017

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- E-G. Talbi : Editor of the Journal « Computers and Industrial Engineering (CAIE, Elsevier)» Area «Computational Intelligence»
- N. Melab: Guest and Managing Editor (in collaboration with A. Zomaya and I. Chakroun) of a special on Parallel Optimization using/for Multi and Many-core High Performance Computing in Journal of Parallel and Distributed Computing (JPDC), 2016-2017
- L. Jourdan: Review Editor Frontiers in Big Data

10.1.3.2. Reviewer - Reviewing Activities

- IEEE Transactions on Evolutionary Computation, Evolutionary Computation, Journal of Heuristics, Artificial Intelligence Journal
- Applied Soft Computing
- Computers in Biology and Medecine
- Computers & Industrial Engineering
- Computers & Operations Research
- EJOR European Journal of Operational Research
- IEEE Transaction on Evolutionary Computation
- International Journal of Metaheuristics
- International Journal of Molecular Sciences

- International Journal of Production research
- International Transactions in Operational
- JOH Journal of Heuristics
- JOCO Journal of Combinatorial Optimization
- JPDC Journal of Parallel and Distributed Computing
- Nature Scientific Report
- Soft Computing (SOCO)
- Transactions on Computational Biology and Bioinformatics
- ACM Computing Surveys
- Computation and Concurrency: Practice and Experience (CCPE)
- Parallel Processing Letters
- Parallel Computing
- Journal of Parallel and Distributed Computing (JPDC)
- 4OR: A Quarterly Journal of Operations Research (Springer)
- ASOC: Applied Soft Computing (Elsevier)
- CAIE: Computers & Industrial Engineering (Elsevier)
- ITOR: International Transactions in Operational Research (Wiley)
- NEUCOM: Neurocomputing (Elsevier)
- Discrete Optimization
- Annals of Operations Research
- RAIRO - Operations Research

10.1.4. Invited Talks

- E-G. Talbi: Multi-objective optimization under uncertainty, Keynote presentation, Business Clouds'2017, Luxembourg, Jan 2017.
- E-G. Talbi: Matheuristics, Invited presentation, Universidad Elche, Spain, April 2017
- E-G. Talbi: Multi-objective metaheuristics, Invited presentation, University of Catania, Catania, Italy, April 2017
- E-G. Talbi: Optimization of smart grids: opportunities and directions, Keynote speaker ICOA'2017, International Workshop on Optimization and Applications, Kenitra, Morocco, April 2017
- E-G. Talbi: Parallel and distributed metaheuristics, Invited tutorial, IEEE CEC Congress on Evolutionary Computation, San Sebastien, Spain, June 2017
- E-G. Talbi: Evolutionary multi-objective algorithms under uncertainty, Invited seminar, Jozef Stefan Institute , Ljubljana, Slovenia, Oct 2017
- E-G. Talbi: Smart grids: challenges and opportunities, Invited seminar, Ecole Centrale de Casablanca, Casablanca, Morocco, Nov 2017
- E-G. Talbi: Complex optimization problems in smart grids, Keynote speaker, Workshop MOSSYS'2017 Modélisation, Optimisation et Simulation des Systèmes, Rabat, Morocco, Oct 2017
- E-G. Talbi: Optimization of smart grids, Invited seminar, Jozef Stefan Institute, Ljubljana, Slovenia, Nov 2017

10.1.5. Leadership within the Scientific Community

- L. Jourdan : Co-president of the working group "ATOM: Multi-objective optimization", GDR RO
- L. Jourdan, A. Liefooghe : Secretary of the association "Artificial Evolution" (EA)

- L. Jourdan: nominated member of CNU 27
- C. Dhaenens: member of the scientific council of GDR RO (Operations research)
- C. Dhaenens: nominated member at Co-NRS, section 6 (National committee of CNRS)
- N. Melab: scientific leader of Grid'5000 (https://www.grid5000.fr) at Lille, since 2004
- N. Melab: Chargé de Mission of High Performance Computing and Simulation at Université Lille 1, since 2010
- E-G. Talbi : Co-president of the working group "META: Metaheuristics - Theory and applications", GDR RO and GDR MACS
- E-G. Talbi : Co-Chair of the IEEE Task force on Cloud Computing within the IEEE Computational Intelligence Society

10.1.6. Scientific Expertise

- E-G. Talbi: QS respondents (Novosibirsk State University, Russia, 2014-2017)
- E-G. Talbi: Reviewer de projets de recherche, National Science Center, Pologne (2017)
- E-G. Talbi: Dutch NOW council (Innovative Research Incentive Scheme) project, Netherlands, 2017
- E-G. Talbi: Reviewer de dossiers de qualification de Professeurs, University of Portsmouth, UK, 2017
- E-G. Talbi: Expertise projets ERC Consolidator Grant (2017)
- E-G. Talbi: Expertise projets STIC/Math Amérique du Sud – Chili et Argentine (2017)
- E-G. Talbi: Expertise projets COFECUB - Brésil (2017)
- N. Melab: Member of the advisory committee for the IT and maganement engineer training at Faculté Polytechnique de Mons
- N. Melab: Reviewer for the COFECUB scientific evaluation committee (Comité Français d'Evaluation de la Coopération Universitaire et scientifique avec le Brésil), 2017
- N. Melab: Expert for two government research agencies: CONICYT (Chile) and NCN (Poland), 2017

10.1.7. Research Administration

- C. Dhaenens: Vice-head of CRIStAL laboratory (Centre de Recherche en Informatique, Signal et Automatique de Lille), common to CNRS, University of Lille and Ecole Centrale de Lille, 430 people
- L. Jourdan: member of the Bureau du Département de domaine Informatique pour l'école doctorale SPI, University of Lille
- N. Melab: Member of the steering committee of "Maison de la Simulation" at Université Lille 1
- E-G. Talbi, Coordinator of the International Relationships of Inria Lille Nord Europe

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

- Master: Laetitia Jourdan, Business Intelligence, 30h, M1, University of Lille 1, France
- Master : Laetitia Jourdan, Datamining, 60h , M1, University of Lille 1, France
- Master: Laetitia Jourdan, Datawarehouse, 30h, M1, University of Lille 1, France
- Licence: Laetitia Jourdan, Informatique, 48h, L1 University of Lille 1, France
- Master: Laetitia Jourdan, Responsible of Master MIAGE Formation en Alternance, University of Lille 1, France

- Licence: Laetitia Jourdan, Co-responsible of Licence 1 Computer Science, University of Lille 1, France
- Engineering school: Clarisse Dhaenens, Graphs and Combinatorics, 80 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Clarisse Dhaenens, Operations Research, 70 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Clarisse Dhaenens, Algorithmics and programming, 45 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Clarisse Dhaenens, responsible of the 5th year of statistics and computer science department.
- Engineering school: Marie-Eléonore Kessaci, Graphs and Combinatorics, 44 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Marie-Eléonore Kessaci, Algorithmics and programming, 51 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Marie-Eléonore Kessaci, Databases, 71 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Marie-Eléonore Kessaci, Mathematics, 20 HeqTD, Polytech Lille, University Lille 1, France
- Engineering school: Marie-Eléonore Kessaci, responsible of the 3th year of statistics and computer science department
- Master lecture: N. Melab, Supercomputing, 24h, Master 2, University Lille 1, France
- Master lecture: N. Melab, Operations Research, 78h, Master 1, University Lille 1, France
- Master leading: N. Melab, Co-head (with B. Merlet) of the Master 2 of advanced scientific computing, U. Lille 1
- Licence: A. Liefooghe, Algorithmic and Data structure, 36h ETD, L2, Université de Lille 1, France
- Licence: A. Liefooghe, Algorithmic for Operations Research, 36h ETD, L3, Université de Lille 1, France
- Master: A. Liefooghe, Databases, 30h ETD, M1, University Lille 1, France
- Master: A. Liefooghe, Advanced Object-oriented Programming, 53h ETD, M2, University Lille 1, France
- Master: A. Liefooghe, Combinatorial Optimization, 10h ETD, M2, University Lille 1, France
- Master: A. Liefooghe, Multi-criteria Decision Aid and Optimization, 25h ETD, M2, University Lille 1, France
- A. Liefooghe is supervising the Master 2 MIAGE IPI-NT
- Master: Bilel Derbel, Combinatorial Optimization, 35h, M2, University Lille 1, France
- Master: Bilel Derbel, Grid Computing, 16h, M2, University Lille 1, France
- Master: Bilel Derbel, Parallel and Distributed Programming, 35h, M1, University Lille 1, France
- Master: Bilel Derbel, Algorithms and Applications, 28h, M1, University Lille 1, France
- Engineering school: El-Ghazali Talbi, Advanced optimization, 36h, Polytech'Lille, University Lille 1, France
- Engineering school: El-Ghazali Talbi, Data mining, 36h, Polytech'Lille, University Lille 1, France
- Engineering school: El-Ghazali Talbi, Operations research, 60h, Polytech'Lille, University Lille 1, France
- Engineering school: El-Ghazali Talbi, Graphs, 25h, Polytech'Lille, University Lille 1, France

10.2.2. Supervision

- PhD in progress: Maxence Vandromme, Datamining et optimisation combinatoire adaptés à la prévention et à l'orientation de patients, starting: 1/06/2014, CIFRE with Alicante co-supervision: Clarisse Dhaenens and Laetitia Jourdan
- PhD in progress: Aymeric Blot, Réagir et s'adapter à son environnement : Concevoir des méthodes autonomes pour l'optimisation combinatoire à plusieurs objectifs, September 2015, co-directed Laetitia Jourdan and Marie-Eléonore Marmion
- PhD in progress : Lucien Mousin, Exploiter la connaissance pour mieux optimiser, October 2015, co-directed Clarisse Dhaenens and Marie-Eléonore Marmion
- PhD in progress: AnneLise Bedenel, Classification supervisée et non supervisée en présence de descripteurs évoluant dans le temps. Application à la comparaison d'assurances en ligne, co-directed Laetitia Jourdan and Christophe Biernacki (Modal Inria Team)
- PhD defense: Sylvain Dufourny, Optimisation de décisions économiques concurrentielles dans un simulateur de gestion d'entreprise, Clarisse Dhaenens - Defended in October 2017
- PhD defense: Jan Gmys, Parallel Branch-and-Bound for solving permutation problems on multi- and many-core clusters, Nouredine Melab and Daniel Tuyttens (UMONS, Belgium), 12/2017
- PhD in progress: Sohrab Faramarzi, Optimization of medical laboratories, 02/2016, El-Ghazali Talbi
- PhD in progress: Z. Garroussi, Demand side management in smart grids: Multi-objective models, El-Ghazali Talbi and Rachid Ellaia (EMI, Morocco)
- PhD in progress: J. Pelamatti, Multi-disciplinary design of aerospace vehicles, Jan 2017, El-Ghazali Talbi
- PhD in progress: Ali Hebbal, Surrogate-assisted multi-objective evolutionary algorithms, Oct 2017, El-Ghazali Talbi and Nouredine Melab.
- PhD defense: A. Q. Nguyen, Cloud broker optimization for energy-aware in multi-clouds system, 01/2017, El-Ghazali Talbi and Pascal Bouvry (Univ. Luxembourg)
- PhD defense: Oumayma Bahri, Fuzzy multi-objective optimization, 05/2017, El-Ghazali Talbi and Nahla Ben-Omar (Univ. Tunis, Tunisia)

10.2.3. Juries

- E-G. Talbi: Phd Thesis: Urrego Agudelo Lilliam, A novel method for the approximation of risk of blackout in operational conditions, Université Paris-Est, Créteil, France, Jan 2017
- E-G. Talbi: Phd Thesis: Jonathan Oesterle, Holistic approach to designing hybrid assembly lines, Université de Technologie de Troyes, France, Apr 2017
- E-G. Talbi: Phd Thesis: Birsen Irem Selamoglu, The plant propagation algorithm for discrete optimization, University of Essex, Colchester, UK, June 2017
- E-G. Talbi: Phd Thesis: Omer Yusuf Adam Mohamed, Resource allocation for improved performance and resource efficiency in cloud computing, University of Sydney, Australia, July 2017
- E-G. Talbi: Phd Thesis: Nhan Quy Nguyen, Electric vehicle charging scheduling optimization, UTT Troyes, France, Sept 2017
- E-G. Talbi: Phd Thesis: Mohamed Afilal, Optimisation de la prévision et de la planification des activités d'un centre d'urgence hospitalier, UTT Troyes, France, Dec 2017
- E-G. Talbi: Phd Thesis: Sara Tfaili, Contribution aux graphes creux pour le problème de tournées sur arcs déterministe et robustes: théorie et algorithmes, Normandie Université, Havre, France, Dec 2017
- N. Melab: PhD thesis: Escobar Fernando, Vers une nouvelle génération d'outils d'aide à la décision s'appliquant à la prévention des risques lors de la prescription des antibiotiques : Combinaison des technologies Web sémantique et de l'aide multicritère à la décision, University de Mons, October 13th, 2017

- N. Melab: PhD thesis, GPU-based backtracking strategies for solving permutation combinatorial problems, Federal University of Cerea, Brazil, December 5th, 2017
- C. Dhaenens: PhD Thesis: Nawal Benabbou, Procédures de décision par élicitation incrémentale de préférences en optimisation multicritère, multi-agents et dans l'incertain, Université Paris 6, May 2017
- L. Jourdan: PhD Thesis: Pauline Wauquiez, Task driven representation learning, Université de Lille - May 29th 2017 (Présidente de Jury)
- L. Jourdan: PhD Thesis: Labib Yousef, Contribution à la résolution des problèmes de placement en trois dimensions, Université Picardie Jules Verne, June 29th 2017
- L. Jourdan: HDR: Karine Deschinkel, Nouveaux modèles de programmation linéaire et de flots pour la résolution de problèmes d'optimisation difficiles, Université de Belfort Franche Comté - June 6th 2017

10.3. Popularization

- E-G. Talbi: Organization of a R&D day for all students and lecturers of Polytech'Lille engineering school on "Big data and machine learning" (22/03/2018).

11. Bibliography

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Articles in International Peer-Reviewed Journals

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J. SHI, Q. ZHANG, B. DERBEL, A. LIEFOOGHE, S. VEREL. *Using Parallel Strategies to Speed Up Pareto Local Search*, in "11th International Conference on Simulated Evolution and Learning (SEAL 2017)", Shenzhen, China, Lecture Notes in Computer Science, November 2017, https://hal.archives-ouvertes.fr/hal-01581257.

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