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Activity Report 2014

Project-Team DOLPHIN

Parallel Cooperative Multi-criteria Optimization

IN COLLABORATION WITH: Laboratoire d'informatique fondamentale de Lille (LIFL)

RESEARCH CENTER
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THEME
Optimization, machine learning and statistical methods

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Project-Team DOLPHIN

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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, etc.) 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.

  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):**

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

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.

  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.

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

[3] Graphical User Interface for Multi-Objective Optimization (http://guimoo.gforge.inria.fr).

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 [58]. 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 [53], [57]. 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 [62]. 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.
- *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.

[4] http://www.lania.mx/~ccoello/EMOO/EMOObib.html

- *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 [55].

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 [56], [61].

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. Academic Benchmark Problems

- ρMNK-landscapes constitute a problem-independent model used for constructing multiobjective multimodal landscapes with objective correlation. They extend single-objective NK-landscapes [59] and multiobjective NK-landscapes with independent objective functions [54]. The four parameters defining a ρMNK-landscape are: (i) the size of (binary string) solutions N, (ii) the variable correlation $K < N$, (iii) the number of objective functions M, and (iv) the correlation coefficient ρ. A number of problem instances and an instance generator are available at the following URL: http://mocobench.sf.net/.
- The Unconstrained Binary Quadratic Programming (UBQP) problem is known to be a unified modeling and solution framework for many combinatorial optimization problems [60]. Given a collection of n items such that each pair of items is associated with a profit value that can be positive, negative or zero, UBQP seeks a subset of items that maximizes the sum of their paired values. We proposed an extension of the single-objective UBQP to the multiobjective case (mUBQP), where multiple objectives are to be optimized simultaneously. We showed that the mUBQP problem is both NP-hard and intractable. Some problem instances with different characteristics and an instance generator are also available at the following URL: http://mocobench.sf.net/.

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 uncertanty.
- **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.

5. New Software and Platforms

5.1. Comparing Continuous Optimizers (Coco) Platform

Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran.

The Coco Platform (coco.gforge.inria.fr) provides the functionality to automatically benchmark optimization algorithms for unbounded, unconstrained optimization problems in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The Coco platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The Coco platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 123 algorithms and algorithm variants by contributors from all over the world have been benchmarked with the platform so far and all data is publicly available for the research community (see for example http://coco.gforge.inria.fr/doku.php?id=bbob-2013-algorithms for the submissions to BBOB-2013).

Via the ANR project NumBBO, also Dolphin team members are involved in the development of Coco and it is one of the main purposes of NumBBO to extend the Coco platform towards expensive, large-scale, constrained and multiobjective optimization. In order to facilitate these extensions, a complete overhaul of the platform is currently underway—rewriting the whole functionality from scratch in a single language (ANSI C) which will then be called from all other provided languages (Java, python, Matlab/Octave, R) instead of multiple independent implementations which are highly difficult to maintain. A first release of the new code base is expected in the first half of 2015.

For the rewriting of the source code, we also moved to a publicly available open source code repository at https://code.google.com/p/numbbo/ which, in addition, provides for the first time a bug and feature request tracking system for Coco. As the first Coco-related deliverable of the NumBBO project, the extension towards expensive optimization has been finished this year. Its full functionality will be provided for the first time for the upcoming BBOB special session at the IEEE Congress on Evolutionary Computation (CEC'2015). Coco is also currently extended towards multiobjective optimization in close relation to the PhD topic of Thanh-Do Tran. A first working (but still preliminary) version of the multiobjective Coco has been developed and is expected to be merged with the newly rewritten Coco code just after its first release.

Inria software self-assessment for Coco: [A-4/5, SO-4, SM-3-up4, EM-3, SDL-4-up5][DA-3, CD-3, MS-3, TPM-2]

5.2. MO-Mine

Participants: Clarisse Dhaenens, Benjamin Fisset, Laetitia Jourdan.

The MO-Mine platform (mo-mine.gforge.inria.fr) aims at providing optimization algorithms, and in particular multi-objective approaches, to deal with data-mining classical tasks (Classification, association rules...). The platform is still in development in the context of an Inria ADT.
$MO-Mine_{clust}$ is the first package of the platform and is dedicated to clustering (unsupervised classification). Indeed, it is well-known that clustering may be seen as a bi-objective optimization problem as the goal is both to minimize distances between data belonging to a same cluster, while maximizing distances between data belonging to different clusters. Several models (objective functions used,...) and engines (optimization algorithms) have been implemented. The framework searches, for a given dataset, the best association of model/engine/parameter without specifiing the number of clusters. $MO-Mine_{clust}$ shows very interesting behavior and shows that the choice of the model and the engine has a great importance in the performance of the method and depends on the dataset to analyze.

Inria software self-assessment for $MO-Mine_{clust}$: [A-1, SO-4, SM-3-up4, EM-2, SDL-1,DA-4,CD-4]

5.3. Platforms

Grid'5000 [5] is a French nation-wide computational grid infrastructure composed of several clusters of processors distributed over 11 sites including Lille. Since 2004, the Dolphin team is the scientific leader of the Grid'5000 site located at Lille. The role of the team is mainly threefold consisting in ensuring (1) the maintenance and evolution of the platform, (2) the local and national coordination of the related activities, and (3) the scientific animation around Grid'5000. Regarding the evolution of the infrastructure, this later has been extended in 2014 with a new powerful storage server hosting mainly the NFS system. In addition, the team has contributed to the 5-year CPER project called "data" proposed by the Inria Lille research center. The project includes a part related to the Grid'5000 platform. From the coordination point of view, Dolphin has participated to the monthly meetings of the national Grid'5000 committee. Finally, regarding the scientific animation, first, Dolphin has organized in December 20th, 2014, a training [6] around Grid'5000. Second, Dolphin has participated to the program committee of the Grid'5000 spring school [7] held in Lyon in June 2014. Third, the team has also been involved in the final evaluation of the scientific nation-wide Hemera research project [8] related to Grid'5000.

6. New Results

6.1. Highlights of the Year

In [23], we have revisited the design and implementation of the Branch and Bound algorithm for solving on large scale distributed environments challenging permutation-based optimization problems such as Q3AP. The new approach includes original ways to efficiently deal with some crucial issues mainly, dynamic adaptive load balancing and fault tolerance. The approach allowed to solve to optimality for the first time a difficult Q3AP instance (Nug15) on the nation-wide Grid'5000 computational grid. The resolution was completed within less than 12 days using an average of 1,123 processing cores distributed over 6 Grid'5000 sites and peaked at 3,427.

[5] https://www.grid5000.fr/
[6] http://www.lifl.fr/~melab/HTML/Journee-G5K-Lille.htm
[7] https://www.grid5000.fr/mediawiki/index.php/Grid5000:School2014
[8] https://www.grid5000.fr/Hemera

6.2. Fitness Landscape Analysis for Multiobjective Optimization

Participant: Arnaud Liefooghe.

The properties of local optimal solutions in multi-objective combinatorial optimization problems are crucial for the effectiveness of local search algorithms, particularly when these algorithms are based on Pareto dominance. Such local search algorithms typically return a set of mutually non-dominated Pareto local optimal (PLO) solutions, that is, a PLO-set. In [34], we investigate two aspects of PLO-sets by means of experiments with Pareto local search (PLS). First, we examine the impact of several problem characteristics on the properties of PLO-sets for multi-objective NK-landscapes with correlated objectives. In particular, we report that either increasing the number of objectives or decreasing the correlation between objectives leads to an exponential increment on the size of PLO-sets, whereas the variable correlation has only a minor effect. Second, we study the running time and the quality reached when using bounding archiving methods to limit the size of the archive handled by PLS, and thus, the maximum size of the PLO-set found. We argue that there is a clear relationship between the running time of PLS and the difficulty of a problem instance.

Complementarily, in [25] we study the behavior of three elitist multi- and many-objective evolutionary algorithms in generating a high-resolution approximation of the Pareto set. Several search-assessment indicators are defined to trace the dynamics of survival selection and measure the ability to simultaneously keep optimal solutions and discover new ones under different population sizes, set as a fraction of the Pareto set size. Our study clarifies the ability and efficiency of the algorithms assuming scenarios where it is relatively easy to hit the Pareto set, showing the importance to properly assess algorithm's performance according to the task of the optimizer in many-objective optimization.

6.3. Combining dynamic programming and metaheuristics for the Unit Commitment Problem

Participants: Sophie Jacquin, Laetitia Jourdan, El-Ghazali Talbi.

DYNAMOP (DYNAmic programming using Metaheuristic for Optimization Problems) is a new dynamic programming based on genetic algorithm. It uses a representation based on a path in the graph of states of dynamic programming which is adapted to dynamic structure of the problem and facilitates the hybridization between evolutionary algorithms and dynamic programming. Experiments indicate that the proposed approach outperforms the best known in literature [44].

6.4. Multi-decoding strategy for Multi-objective Unit Commitment Problem

Participants: Sophie Jacquin, Lucien Mousin, Igor Machado, Laetitia Jourdan, El-Ghazali Talbi.

In the multiobjective version of the UCP taking the emission of gas into account, the dispatching problem remains easy to solve whereas considering it separatly remains interesting. A multi-objective GA handling binary vectors is applied. However for a binary representation there is a set of solutions of the dispatching problem that are pareto equivalent. In this approach a genotypic solution is associated with a set of phenotypic solutions. This set of solutions is from the optimal pareto front solution of the dispatching problem associated with the genotypic solution. As many phenotypic solutions are attached to a single genotypic solution, the fitness assignment and diversity assignment methods of NSGA-II have to be adapted. The multi decoding embedded approach has shown very good performances in comparison to two other less complex decoding systems.

6.5. Decomposition-Based Algorithms for Multiobjective Optimization

Participants: Dimo Brockhoff, Bilel Derbel, Arnaud Liefooghe, Gauvain Marquet, El-Ghazali Talbi.

Recently, there has been a renewed interest in decomposition-based approaches for evolutionary multiobjective optimization. Those algorithms decompose a multiobjective optimization problem into several single-objective optimization problems by using so-called scalarizing functions which are then simultaneously optimized by single-objective algorithms in a cooperative manner.

Our contributions to decomposition-based algorithms in 2014 has been three-fold. Firstly, we investigated in [28] the general impact of different scalarizing functions and their parameters on the search performance. We thereby abstracted from any specific algorithm and only considered the difficulty of the single scalarized problems in terms of the search ability of a (1+lambda)-EA on bi-objective NK-landscapes. Secondly, in [16], we proposed a new distributed heuristic for approximating the Pareto set of bi-objective optimization problems. Given a number of computing nodes, we self-coordinate them locally, in order to cooperatively search different regions of the Pareto front. As local information, every node uses only the positions of its neighbors in the objective space and evolves its local solution adaptively, based on what we term a 'localized fitness function'. We deployed our distributed algorithm using a computer cluster of hundreds of cores. At last, we enhanced the algorithm MOEA/D, a prominent example of a decomposition-based algorithm from the literature, by investigating the idea of evolving the whole population simultaneously at once. We thereby proposed new alternative selection and replacement strategies that can be combined in different ways within a generic and problem-independent framework [36].

6.6. Link-Heterogeneous work stealing for Branch-and-Bound Algorithms

Participants: T-T Vu, Bilel Derbel.

In this work [41], we push forward the design of parallel and distributed optimization algorithms running on link-heterogeneous systems where network latencies can deeply impact performance. We consider parallel Branch-and-Bound (B&B), viewed as a generic algorithm searching in a dynamic tree representing a set of candidate solutions built dynamically. A major challenge is then to deal with the irregularity of B&B computations and to distribute workload evenly at runtime. In this context, the random work-stealing paradigm has been proved to be extremely beneficial. However, it is known to perform loosely in non-homogeneous distributed systems where communications costs are a major obstacle for high performance. We there-by investigate the design of an effective work-stealing protocol dealing with the heterogeneity of network link latencies. We propose a generic distributed algorithm which can be easily implemented to fit different types of heterogeneity. The proposed algorithm extends on reference approaches, namely Probabilistic Work Stealing (PWS), and Adaptive Cluster-aware Random Stealing (ACRS); by introducing new adaptive control operations that are shown to be highly accurate in increasing work locality and decreasing steals cost. Through emulations on top of a real test-bed, we provide a comprehensive experimental analysis including: (i) a comparative study on a broad range of harsh network scenarios going from flat networks to more hierarchical grid-like networks, and (ii) an in-depth analysis of protocols' behavior at the aim of gaining new insights into dynamic load-balancing in heterogeneous distributed environments. Over all experimented configurations, our results show that although the proposed protocol is not tailored for a specific networked platform, it can save 30% execution time in average compared to its competitors, while demonstrating high quality self-adjusting capabilities.

6.7. New data structure for solving large permutation problems using multi-core B&B

Participants: Rudi Leroy, Nouredine Melab.

Solving large permutation problems using parallel B&B algorithms results in the generation of a very large pool of subproblems. Defining an efficient data structure is highly required to store and manage efficiently that pool. In [31], we have proposed a new dedicated data structure called *Integer-Vector-Matrix* (or *IVM* and redefined the operators of the B&B algorithm acting on it. We have also revisited the Work Stealing mechanism on multi-core processors. In the proposed approach, work units are coded in a coalesced way using factoradic-based intervals, and private IVMs are used to store and explore locally subsets of subproblems. The IVM-based approach has been experimented and compared to the approach based on concurrent linked-list, which is often used. The results show that our approach is more efficient in terms of memory usage and management time. In [31], we have investigated various work stealing strategies based on different victim selection and granularity policies. This later paper has been selected for a special issue in the CCPE international journal.

6.8. B&BGrid revisited for solving challenging Q3AP instances on large volatile computational environments

Participants: Nouredine Melab, El-Ghazali Talbi.

We have revisited the design and implementation of parallel B&B algorithms on multi-core (collaboration with UMONS, Belgium) and grid-wide environments (collaboration with University of Luxembourg and UMONS, Belgium)) for solving to otimality and efficiently large permutation problem instances. We have proposed a gridification approach of the B&B algorithm called B&B@Grid. This later includes a dynamic load balancing technique and a checkpointing mechanism for permutation problems. The approach has been validated through single-permutation Flowshop problem. In [23], we have extended the approach to deal with more than one permutation. To do that, we have revisited the design and implementation of the dynamic load balancing and checkpointing mechanisms for multiple permutation-problems. The new approach allowed the optimal resolution on a nation-wide grid (Grid'5000) of a difficult instance of the 3D quadratic assignment problem (Q3AP). To solve the instance, an average of 1,123 processing cores were used during less than 12 days with a peak of around 3,427 CPU cores.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- **EDF** (2011-2014): the goal of this bilateral contract is to formulate pricing problems of electrical energy using bilevel mathematical programs.
- **EDF** (2011-2014): this contract models and solves scheduling outages of nuclear plants under uncertainty (Phd of N. Dupin).
- **BeTravel** (2012-2014): this CIFRE project deals with the optimization of group travel plannings (Phd of M. Bue).
- **Tasker** (2011-2014): the goal of this CIFRE project is the multi-objective scheduling of applications in public cloud computing systems (Phd of F. Legillon).
- **Strat-Logic** (2012-2015): the objective of this CIFRE contract is the optimization of economic decisions in a competitive business management simulator (Phd of S. Dufourny).
- **Vekia** (2012-2015): the goal of the CIFRE project is to develop an efficient and generic software for employee scheduling in retail (Phd of M. Gérard).
- **PIXEO** (2014-2015): the objective of this bilateral project is the predictive models and knowledge extraction for insurance web comparator.

8. Partnerships and Cooperations

8.1. Regional Initiatives

- PPF (Bioinformatics): This national program within the University of Lille 1 deals with solving bioinformatics and computational biology problems using combinatorial optimization techniques.
- PPF HPC (High performance computing).

8.2. National Initiatives

8.2.1. ANR

- ANR project Transports Terrestres Durable "RESPET - Gestion de réseaux de service porte-à-porte efficace pour le transport de marchandises", in collaboration with LAAS (Toulouse), DHL, JASSP, LIA (Univ. Avignon) (2011-2014).

- 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, Université Lille 2, CHRU Lille, CHRU Montpelier, CHICL, Alicante (7 partners) (2014-2017) - Coordinator -
- 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)

8.3. European Initiatives

8.3.1. Collaborations in European Programs, except FP7 & H2020

Program: COST

Project acronym: cHiPSet

Project title: High-Performance Modelling and Simulation for Big Data Applications

Duration: 01 2015 - 01 2018

Coordinator: Joanna Kolodziej

Other partners: organisme, labo (pays): Spain, Poland, Germany, France, Luxembourg, italy, ...

Abstract: The Big Data era poses a critically difficult challenge and striking development opportunities in High-Performance Computing (HPC): how to efficiently turn massively large data into valuable information and meaningful knowledge. Computationally effective HPC is required in a rapidly-increasing number of data-intensive domains, such as Life and Physical Sciences, and Socio-economical Systems.

Modelling and Simulation (MS) offers suitable abstractions to manage the complexity of analysing Big Data in various scientific and engineering domains. Unfortunately, Big Data problems are not always easily amenable to efficient MS over HPC. Also, MS communities may lack the detailed expertise required to exploit the full potential of HPC solutions, and HPC architects may not be fully aware of specific MS requirements.

Therefore, there is an urgent need for European co-ordination to facilitate interactions among data-intensive MS and HPC experts, ensuring that the field, which is strategic and of long-standing interest in Europe, develops efficiently - from academic research to industrial practice. This Action will provide the integration to foster a novel, coordinated Big Data endeavour supported by HPC. It will strongly support information exchange, synergy and coordination of activities among leading European research groups and top global partner institutions, and will promote European software industry competitiveness

8.3.2. Collaborations with Major European Organizations

University of Luxembourg: organisme 1, labo 1 (Luxembourg)

Energy aware scheduling in Cloud computing systems

University of Tunis: LARODEC (Tunisia)

Multi-objective optimization under uncertainty using possibility theory

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. STEM

Title: deciSion Tools for Energy Management (STEM)

International Partner (Institution - Laboratory - Researcher):

Université de Montréal (CANADA)

Duration: 2012-2014

See also: http://dolphin.lille.inria.fr/Dolphin/STEM

The economic rise of developing countries, together with the need to meet ever more stringent pollution reduction targets, will increase the stress on the global energy system. Within this framework, the goal of the current project is to develop decision tools for energy management in a context of market deregulation. We will focus on two issues, namely demand management and production planning.

The first problem is concerned with the efficient management of consumption. More precisely, the short or long term behaviour of customers can be influenced through signals sent by a utility (or several utilities) to the end-users. These signals can take the form of an "optimal" pricing scheme, or yet of devices (timers, automatic switches, etc.) designed to induce an "optimal" behaviour from the users.

The second issue is concerned with efficient management of sustainable energy production . Indeed the development of renewable energy introduces new parameters in the supply/demand global equilibrium process. The issue is to achieve the right trade-off according to costs when determining the daily generation, usage and storage of renewable energy within an environment where grid prices and renewable energy level productions are stochastic.

The first problem is modeled as a bilevel program, the second one as a integer mutli-objective stochastic program. Efficient and effective solution methods are developed and implemented to solve these problems.

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

- Memorandum of Understanding between Shinshu University (Nagano, Japan) and Inria, signed on March 2014

8.4.2.2. Informal International Partners

- University of Coimbra, Portugal.
- VUB, Brussels, Belgium.
- IRIDIA, Université Libre de Bruxelles.
- Cologne University of Applied Sciences, Germany.
- Leiden University, Netherlands.
- UMONS University and Tractebel company, Belgium.
- EMI - Univ. Rabat, Morocco.

8.4.3. Participation In other International Programs

- JSPS-MEXT project on Evolutionary multi-objective optimization, landscape analysis, and search performance, with Shinshu University, Nagano, Japan (2013—2016).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Prof. Hernan Aguirre, Shinshu University, Nagano, Japan
- Prof. Bernard Gendron, University of Montreal, Canada
- Prof. Kiyoshi Tanaka, Shinshu University, Nagano, Japan

- Fabio Daolio [PostDoc, Shinshu University, Nagano, Japan, from Sept 2014 to Sept 2015]
- Saúl Zapotecas-Martínez [PostDoc, Shinshu University, Nagano, Japan, from Nov 2014 to March 2015]
- Prof. Bernard Gendron, University of Montreal, Canada

8.5.1.1. Internships

- Martin Drozdik [PhD student, Shinshu University, Nagano, Japan, from Nov 2013 to Sept 2014]
- Miyako Sagawa [Master student, Shinshu University, Nagano, Japan, from Oct 2014 to Nov 2014]

8.5.2. Visits to International Teams

8.5.2.1. Explorer programme

Liefooghe Arnaud

Date: June 2014 - Jul 2014

Institution: Shinshu (Japan)

8.5.2.2. Research stays abroad

- A. Liefooghe, Oct 2014, IRIDIA, Univ. Libre de Bruxelles, Belgium
- D. Brockhoff, Research visit (invited) in China in October 2014 including East China Normal University, Shanghai, China (group of Aimin Zhou), Jiaotong University, Xi'An, China (group of Hui Li), and Xidian University, Xi'An, China (group of Maoguo Gong)
- L. Brotcorne, Sept 2014, Polytechnic School of Montreal
- L. Brotcorne, Oct 2014, Huhne Logisitc University, Hamburg
- E-G. Talbi, Mar 2014, Univ. Murcia, Spain
- E-G. Talbi, Juin 2014, EMI, Univ. Agdal Rabat, Morocco

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific events organisation

9.1.1.1. General chair, Scientific chair

- E-G. Talbi: META'2014 Int. Conf. on Metaheuristics and Nature Inspired Computing, Marrakech, Morocco, Oct 2014.
- E-G. Talbi: IEEE NIDISC'2015 Workshop on Nature Inspired distributed Computing, Phoenix, USA, May 2014.
- L. Brotcorne, Stream Chair IFORS 2014, Revenue Management and Pricing, Barcelona, Spain, July 2014.

9.1.1.2. Member of the organizing committee

- L. Jourdan: META'2014 Int. Conf. on Metaheuristics and Nature Inspired Computing, Marrakech, Morocco, Oct 2014.
- N. Melab: Organization of Grid'5000 training at Inria Lille, November 20th, 2014
- N. Melab: Organization of 5 seminars on high performance computing (Idris, UMONS, Nvidia, EDF R&D and Laboratoire d'Infochimie, Univ. of Strasbourg).
- L. Brotcorne, Chair of the "Prix Jeune Chercheur de la ROADEF", Bordeaux, Feb 2014.
- L. Brotcorne, Vice-President of the Euro Working Group on Pricing and Revenue Management.
- L. Brotcorne, Board Member of the ROADEF Society.

- Vice-President of the Euro Working Group on Pricing and Revenue Management.

9.1.2. Scientific events selection

9.1.2.1. Responsable of the conference program committee

- D. Brockhoff: ACM GECCO'2014 track chair EMO (Evolutionary Multi-objective Optimization) track.

9.1.2.2. Member of the conference program committee

- ECAI 2014, 21st European Conference on Artificial Intelligence (Prague, Czech Republic, 2014)
- GECCO 2014, Genetic and Evolutionary Computation Conference, Evolutionary Combinatorial Optimization and Metaheuristics (ECOM) track (Vancouver, Canada, 2014)
- EvoCOP 2014: 14th European Conference on Evolutionary Computation in Combinatorial Optimisation (Granada, Spain, 2014)
- LION 2015: 9th Learning and Intelligent OptimizatioN Conference (Lille, France, 2015)
- EMO 2015: 8th International Conference on Evolutionary Multi-criterion Optimization (Guimarães, Portugal, 2015)

9.1.3. Journal

9.1.3.1. Member of the editorial board

- Guest editors of a special issue on Evolutionary Multiobjective Optimization, European Journal of Operational Research, co-edited by Dimo Brockhoff, Bilel Derbel, Arnaud Liefooghe and Sébastien Verel.
- Guest editors of a special issue on Computational intelligence for Cloud computing, IEEE Computational Intelligence Magazine, co-edited by El-ghazali Talbi, Pascal Bouvry.

9.1.3.2. Reviewer

- A Quarterly Journal of Operations Research (4OR, Springer)
- Discrete Applied Mathematics (DAM, Elsevier)
- European Journal of Operational Research (EJOR, Elsevier)
- Journal of Heuristics (HEUR, Springer)
- Soft Computing (SOCO, Springer)
- IEEE Transactions on Evolutionary Computation
- Applied Soft Computing
- Journal of Supercomputing
- International Transactions in Operational Research
- EEE/ACM Transactions on Computational Biology and Bioinformatics
- Evolving Systems Journal
- Evolutionary Computation
- Computers and Operations Research
- IEEE Transactions on Cybernetics
- ACM Computing Surveys
- Computation and Concurrency: Practice and Experience
- International Journal of Parallel, Emergent and Distributed Systems

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

- 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, Université de Lille 1, France
- Master: A. Liefooghe, Advanced Object-oriented Programming, 53h ETD, M2, Université de Lille 1, France
- Master: A. Liefooghe, Combinatorial Optimization, 10h ETD, M2, Université de Lille 1, France
- B. Derbel is the co-supervising the Master 2 MOCAD (Complex Models, Algorithms, Data)
- 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, Advanced Object Programming, 132h, M1, University Lille 1, France
- Master : Bilel Derbel, Algorithms and Applications, 28h, M1, University Lille 1, France
- Laetitia Jourdan: Master in Computer Sciences and Master MIAGE of University of Lille 1: Business Intelligence (30h), Datamining (60h), Datawarehouse (30h)
- Laetitia Jourdan : Informatique L1 University of Lille 1 48h
- Laetitia Jourdan: Responsible of sandwich courses in Master Lille 1
- Laetitia Jourdan: Co-responsible of Licence 1 Computer Science
- Master: D. Brockhoff, Advanced Control, 18.25h, M2, Ecole Centrale Paris, Chatenay-Malabry, France
- Master : N. Melab, Supercomputing, 33h, M2, Université Lille 1, France
- Master : N. Melab, Operations Research, 82h, M1, Université Lille 1, France
- Master leading: N. Melab, Co-head (with C. Chainais) of the master 2 of advanced scientific computing, U. Lille 1
- Master creation: N. Melab, Participation to the proposition of a new master of engineering at Lille 1
- 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 : Luce Brotcorne, Optimisation, 17h ETD, IMA4, Polytech Lille, France
- Engineering school : Luce Brotcorne, Recherche Opérationnelle, 24 h ETD, IEESP2, Polytech Lille, France
- Engineering school : Luce Brotcorne, Analyse Numérique et Optimisation, 18h ETD, Ecole Centrale de Lille, France
- Engineering school : Luce Brotcorne, Modèles d'affectation du traffic, 6hETD, Ecole Centrale de Lille, 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

- Polytech Lille : Marie-Eléonore Marmion, Database, 67h ETD, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Algorithm and Programming, 45h ETD, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Graph, 10h ETD, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Data Mining, 10h ETD, 3rd year, Université Lille 1, France

E-learning

Lecture in a E-learning master degree at the University of Lille 1 : Bilel Derbel, Cluster et Grille de Calcul, 2 days on-site, and 3 distance courses, COROLIA Training - Digital Learning Pole, Lille TELECOM , Master 2 TIIR E-learning, continuing education, ten students enrolled.

9.2.2. Supervision

PhD : Nadia Dahmani, Multi-objective packing problems, 02/2014, El-Ghazali Talbi and François Clautiaux

PhD : A. Stathakis, Satellite payload reconfiguration optimization, 10/2014, El-Ghazali Talbi and Pascal Bouvry

PhD in progress : : Sophie Jacquin, Combining exact method and metaheuristics for production problems, début : 1/10/2012, Co-direction : El-Ghazali Talbi et Laetitia Jourdan

PhD in progress: Datamining et optimisation combinatoire adaptés à la prévention et à l'orientation de patients, Maxence Vandromme début : 1/06/2014, CIFRE with Alicante Co-direction : Clarisse Dhaenens and Laetitia Jourdan

PhD in progress: Gauvain Marquet, Mono-objective decomposiiton for multi-objective optimization, University Lille 1, Sep. 2014, Bilel Derbel and El-Ghazali Talbi

PhD : Trong-Tuan Vu, Heterogenity and locality-aware work stealing for large scale branch-and-bound irregular algorithms, Inria University Lille 1, 12 Dec 2014, Bilel Derbel and Nouredine Melab

PhD in progress : Thanh-Do Tran, Benchmarking Continuous Multiobjective Optimization Algorithms, since 12/2011, Dimo Brockhoff and El-Ghazali Talbi

PhD defended: Trong Tuan VU, Heterogeneity and Locality-aware Work Stealing for Large Scale Brand-and-Bound Irregular Algorithms, Nouredine Melab and Bilel Derbel, December 12th, 2014

New PhD: Jan GMYS, Optimization and simulation of electrical networks using massively parallel heterogeneous computing, Nouredine Melab and Daniel Tuyttens (UMONS, Belgium), since October 2014.

PhD in progress : Rudi LEROY, Massively parallel tree-based exact algorithms for hybrid clusters, 11/05/2012, Nouredine Melab

PhD in progress : Francois LEGILLON, Static and Dynamic Resource Brokering on multi-clouds, 09/01/2010, Nouredine Melab and El-Ghazali Talbi

PhD in progress : Sylvain Dufourny, Optimisation de décisions économiques concurrentielles dans un simulateur de gestion d'entreprise, Novembre 2012, Clarisse Dhaenens

PhD in progress : Sezin Afsar, Bilevel models for energy pricing problems , 09/2011, L. Brotcorne

PhD in progress : Martin Bue, Optimisation d'un service de réservation hôtellière, 09/2011, L. Brotcorne, F. Clautiaux.

PhD in progress : Bayrem Tounsi, Optimisation conjointe des opérations de transport et préparation dans le cadre du E-commerce, 09/2011, L. Brotcorne.

PhD in progress : A. Q. Nguyen, Green scheduling on cloud computing systems, 11/2012, El-Ghazali Talbi and Pascal Bouvry

PhD in progress : Oumayma Bahri, Fuzzy multi-objective optimization, 11/2013, El-Ghazali Talbi and Nayla Ben-Omar

PhD in progress : Asma Gannouni, Stochastic multi-objective optimization using metaheuristics , 11/2013, El-Ghazali Talbi and Rachid Ellaia

9.2.3. Juries

- D. Brockhoff: external reviewer for the Luxembourg National Research Fund (FNR).
- N. Melab: HDR Matthieu Basseur, Université d'Angers, December 3rd, 2014.
- C. Dhaenens: President of the recruiting committee for associate professorship in computer science (COS McF 27 - Univ. Lille 1 - 2014) - 3 positions.
- C. Dhaenens: Problème de caractérisation multiple - Application à la détection de souches bactériennes phytopathogènes de Fabien Chhel, Université d'Angers, encadrants : Frédéric Lardeux, Frédéric Saubion, Octobre 2014, (Présidente)
- C. Dhaenens: Modèles d'abstraction pour la résolution de problèmes combinatoires, HDR de Adrien Goeffon, Université d'Angers, garant : Frédéric Saubion, Novembre 2014, (Rapporteur)
- L. Brotcorne, Member of the commission for the Concours CR Inria 2014.
- L. Brotcorne, Member of the COST GTRI Inria.
- Luce Brotcorne : Planification des opérations de cross-docking, de Anne-Laure Ladier, University of Grenoble, Encadrants : G. Alpan november 2014 (Rapporteur).

9.3. Popularization

- Bioinspired computing - talk in undergraduate and graduate schools
- Inaugural conference of Math en Jean - Bioinspired computing (see http://lille1tv.univ-lille1.fr/videos/video.aspx?id=6b894d87-bcd3-4ee5-a69c-7af3a2b6446f
- Operational research - for 2nde during integration week (June 2015)
- E-learning in algorithmics http://ressources.unisciel.fr/progcartes/co/_web.html
- Optimisation des données, Interstice
- Invited GECCO'2013 tutorial on Evolutionary Multiobjective Optimization
- Invited tutorial on Evolutionary Multiobjective Optimization (Reseau Mexico meeting, November 2014 in La Rochelle, France)
- Invited talk at PGMO-COPI conference on Multiobjective CMA-ES (November 2014 in Palaiseau, France)

10. Bibliography

Major publications by the team in recent years

[1] J.-C. BOISSON, L. JOURDAN, E.-G. TALBI. *Metaheuristics based de novo protein sequencing: A new approach*, in "Applied Soft Computing", 2011, vol. 11, n^{o} 2, pp. 2271-2278

[2] C. DHAENENS, J. LEMESRE, E.-G. TALBI. *K-PPM: A new exact method to solve multi-objective combinatorial optimization problems*, in "European Journal of Operational Research", 2010, vol. 200, n^{o} 1, pp. 45-53

[3] J. FIGUEIRA, A. LIEFOOGHE, E.-G. TALBI, A. P. WIERZBICKI. *A parallel multiple reference point approach for multi-objective optimization*, in "European Journal of Operational Research", 2010, vol. 205, n^{o} 2, pp. 390 - 400

[4] N. JOZEFOWIEZ, F. SEMET, E.-G. TALBI. *Target Aiming Pareto Search and its application to the vehicle routing problem with route balancing*, in "Journal of Heuristics", 2007, vol. 13, pp. 455-469

[5] A. KHANAFER, F. CLAUTIAUX, E.-G. TALBI. *New lower bounds for bin packing problems with conflicts*, in "European Journal of Operational Research", 2010, vol. 2, n° 206

[6] A. LIEFOOGHE, L. JOURDAN, E.-G. TALBI. *A software framework based on a conceptual unified model for evolutionary multiobjective optimization: ParadisEO-MOEO*, in "European Journal of Operational Research", 2010

[7] A. LIEFOOGHE, L. PAQUETE, J. FIGUEIRA. *On local search for bi-objective knapsack problems*, in "Evolutionary Computation", 2013, vol. 21, n° 1, pp. 179-196 [*DOI :* 10.1162/EVCO_A_00074], http://hal.inria.fr/hal-00676625

[8] T. V. LUONG, N. MELAB, E.-G. TALBI. *GPU Computing for Parallel Local Search Metaheuristics*, in "IEEE Transactions on Computers", 2013, vol. 62, n° 1, pp. 173-185, http://hal.inria.fr/inria-00638805

[9] M.-E. MARMION, L. JOURDAN, C. DHAENENS. *Fitness Landscape Analysis and Metaheuristics Efficiency*, in "Journal of Mathematical Modelling and Algorithms in Operations Research", 2013, vol. 12, n° 1, pp. 3-26 [*DOI :* 10.1007/S10852-012-9177-5], http://hal.inria.fr/hal-00807352

[10] E.-G. TALBI. *Metaheuristics: From Design to Implementation*, Wiley, 2009

Publications of the year

Articles in International Peer-Reviewed Journals

[11] A. BENDJOUDI, N. MELAB, E.-G. TALBI. *FTH-B&B: A Fault-Tolerant HierarchicalBranch and Bound for Large ScaleUnreliable Environments*, in "IEEE Transactions on Computers", September 2014, vol. 63, n° 09, pp. 2302 - 2315 [*DOI :* 10.1109/TC.2013.40], https://hal.inria.fr/hal-01107787

[12] I.-C. BILEGAN, L. BROTCORNE, D. FEILLET, Y. HAYEL. *Revenue management for rail container transportation*, in "EURO Journal on Transportation and Logistics", 2014, forthcoming, http://hal-emse.ccsd.cnrs.fr/emse-01092226

[13] I. CHAKROUN, N. MELAB. *Towards a heterogeneous and adaptive parallel Branch-and-Bound algorithm*, in "Journal of Computer and System Sciences (JCSS)", 2015, vol. 81, n° 1, 13 p. , https://hal.inria.fr/hal-01095425

[14] F. CLAUTIAUX, M. DELL AMICO, M. IORI, A. KHANAFER. *Lower and Upper Bounds for the Bin Packing Problem with Fragile Objects*, in "Discrete Applied Mathematics", 2014, vol. 163, n° 1, pp. 73-86, https://hal.archives-ouvertes.fr/hal-00689038

[15] N. DAHMANI, F. CLAUTIAUX, S. KRICHEN, E.-G. TALBI. *Self-adaptive metaheuristics for solving a multi-objective 2-dimensional vector packing problem*, in "Applied Soft Computing", 2014, vol. 16, pp. 124-136 [*DOI :* 10.1016/J.ASOC.2013.12.006], https://hal.inria.fr/hal-01107680

[16] B. DERBEL, J. HUMEAU, A. LIEFOOGHE, S. VEREL. *Distributed Localized Bi-objective Search*, in "European Journal of Operational Research", August 2014, vol. 239, pp. 731-743 [*DOI :* 10.1016/J.EJOR.2014.05.040], https://hal.archives-ouvertes.fr/hal-01002520

[17] Y. HAYEL, D. QUADRI, T. JIMENEZ, L. BROTCORNE. *Decentralized optimization of last-mile delivery services with non-cooperative bounded rational customers*, in "Annals of Operations Research", June 2014 [*DOI :* 10.1007/S10479-014-1647-X], https://hal.inria.fr/hal-01053487

[18] S. ITURRIAGA, S. NESMACHNOW, P. RUIZ, P. BOUVRY, D. BERNABE. *AEDB Protocol Tuning with a Fast Efficient Parallel Multi-Objective Local Search*, in "International Journal of Ad Hoc and Ubiquitous Computing", January 2015, https://hal.inria.fr/hal-00931308

[19] Y. KESSACI, N. MELAB, E.-G. TALBI. *A multi-start local search heuristic for an energy efficient VMs assignment on top of the OpenNebula cloud manager*, in "Future Generation Computer Systems", July 2014, vol. 36, pp. 237–256 [*DOI :* 10.1016/J.FUTURE.2013.07.007], https://hal.inria.fr/hal-01107763

[20] A. LIEFOOGHE, S. VEREL, J.-K. HAO. *A hybrid metaheuristic for multiobjective unconstrained binary quadratic programming*, in "Applied Soft Computing", 2014, vol. 16, pp. 10-19 [*DOI :* 10.1016/J.ASOC.2013.11.008], https://hal.archives-ouvertes.fr/hal-00801793

[21] G. MATEUSZ, J. E. PECERO-SANCHEZ, D. BERNABE, P. BOUVRY. *Multi-objective evolutionary algorithms for energy-aware scheduling on distributed computing systems*, in "Applied Soft Computing", July 2014, vol. 24, pp. 432-446, https://hal.inria.fr/hal-01056192

[22] N. MELAB, I. CHAKROUN, A. BENDJOUDI. *Graphics processing unit-accelerated bounding for branch-and-bound applied to a permutation problem using data access optimization*, in "Journal of Concurrency and Computation: Practice and Experience", 2014, vol. 26, n^{o} 16, 17 p. [*DOI :* 10.1002/CPE.3155], https://hal.inria.fr/hal-01095244

[23] M. MEZMAZ, M. MEHDI, P. BOUVRY, N. MELAB, E.-G. TALBI, D. TUYTTENS. *Solving the three dimensional quadratic assignment problem on a computational grid*, in "Journal of Cluster Computing", 2014, vol. 17, n^{o} 2, 13 p. [*DOI :* 10.1007/S10586-013-0313-4], https://hal.inria.fr/hal-01095464

[24] J. SCHLEICH, G. DANOY, D. BERNABE, P. BOUVRY. *Optimising small-world properties in VANETs: Centralised and distributed overlay approaches*, in "Applied Soft Computing", May 2014, vol. 21, pp. 637-646, https://hal.inria.fr/hal-00997510

International Conferences with Proceedings

[25] H. AGUIRRE, A. LIEFOOGHE, S. VEREL, K. TANAKA. *An Analysis on Selection for High-Resolution Approximations in Many-Objective Optimization*, in "Parallel Problem Solving from Nature - PPSN XIII", Ljubljana, Slovenia, T. BARTZ-BEIELSTEIN, J. BRANKE, B. FILIPIČ, J. SMITH (editors), Lecture Notes in Computer Science, Springer International Publishing, September 2014, vol. 8672, pp. 487-497, https://hal.archives-ouvertes.fr/hal-01066206

[26] O. BAHRI, N. BEN AMOR, E.-G. TALBI. *Optimization algorithms for multi-objective problems with fuzzy data*, in "IEEE SSCI'2014 Symposium Series on Computational Intelligence", Orlando, United States, December 2014, pp. 194 - 201 [*DOI :* 10.1109/MCDM.2014.7007207], https://hal.inria.fr/hal-01107767

[27] D. BROCKHOFF, Y. HAMADI, S. KACI. *Using Comparative Preference Statements in Hypervolume-Based Interactive Multiobjective Optimization*, in "LION: Learning and Intelligent Optimization", Gainesville, FL, United States, Learning and Intelligent Optimization, Springer, February 2014, vol. LNCS, pp. 121-136 [*DOI :* 10.1007/978-3-319-09584-4_13], https://hal.inria.fr/hal-00935231

[28] B. DERBEL, D. BROCKHOFF, A. LIEFOOGHE, S. VEREL. *On the Impact of Multiobjective Scalarizing Functions*, in "Parallel Problem Solving from Nature - PPSN XIII", Ljubljana, Slovenia, T. BARTZ-BEIELSTEIN, J. BRANKE, B. FILIPIČ, J. SMITH (editors), Lecture Notes in Computer Science, Springer International Publishing, September 2014, vol. 8672, pp. 548-557, https://hal.archives-ouvertes.fr/hal-01066139

[29] M. DROZDIK, K. TANAKA, H. AGUIRRE, S. VEREL, A. LIEFOOGHE, B. DERBEL. *An Analysis of Differential Evolution Parameters on Rotated Bi-objective Optimization Functions*, in "The Tenth International Conference on Simulated Evolution And Learning (SEAL 2014)", Dunedin, New Zealand, Springer, December 2014, pp. 1 - 12, https://hal.archives-ouvertes.fr/hal-01066221

[30] Y. HAYEL, L. BROTCORNE, B. TOUNSI, D. QUADRI, T. JIMENEZ. *Solution d'un modèle de Logit imbriqué pour un problème de distribution des colis dans le cadre du e-commerce*, in "ROADEF - 15ème congrès annuel de la Société française de recherche opérationnelle et d'aide à la décision", Bordeaux, France, Société française de recherche opérationnelle et d'aide à la décision, February 2014, https://hal.archives-ouvertes.fr/hal-00946415

[31] R. LEROY, M. MEZMAZ, N. MELAB, D. TUYTTENS. *Work Stealing Strategies For Multi-Core Parallel Branch-and-Bound Algorithm Using Factorial Number System*, in "ACM PPOPP/PMAM-2014", Orlando, Florioda, France, February 2014, https://hal.inria.fr/hal-01095213

[32] A. LIEFOOGHE, S. VEREL, F. DAOLIO, H. AGUIRRE, K. TANAKA. *A feature-based performance analysis in evolutionary multiobjective optimization*, in "8th International Conference on Evolutionary Multi-Criterion Optimization (EMO 2015)", Guimarães, Portugal, Lecture Notes in Computer Science, 2015, forthcoming, https://hal.archives-ouvertes.fr/hal-01093266

[33] A. LIEFOOGHE, S. VEREL, L. PAQUETE, J.-K. HAO. *Experiments on local search for bi-objective unconstrained binary quadratic programming*, in "8th International Conference on Evolutionary Multi-Criterion Optimization (EMO 2015)", Guimarães, Portugal, Lecture Notes in Computer Science, 2015, forthcoming, https://hal.archives-ouvertes.fr/hal-01093261

[34] M. LÓPEZ-IBÁÑEZ, A. LIEFOOGHE, S. VEREL. *Local Optimal Sets and Bounded Archiving on Multi-objective NK-Landscapes with Correlated Objectives*, in "Parallel Problem Solving from Nature - PPSN XIII", Ljubljana, Slovenia, T. BARTZ-BEIELSTEIN, J. BRANKE, B. FILIPIČ, J. SMITH (editors), Lecture Notes in Computer Science, Springer International Publishing, September 2014, vol. 8672, pp. 621-630 [*DOI :* 10.1007/978-3-319-10762-2_61], https://hal.archives-ouvertes.fr/hal-01066123

[35] M. LÓPEZ-IBÁÑEZ, F. MASCIA, M.-E. MARMION, T. STÜTZLE. *A Template for Designing Single-Solution Hybrid Metaheuristics*, in "Genetic and evolutionary computation companion, GECCO Comp'14", Vancouver, Canada, C. IGEL (editor), ACM, 2014, https://hal.inria.fr/hal-01094686

[36] G. MARQUET, B. DERBEL, A. LIEFOOGHE, E.-G. TALBI. *Shake them all! Rethinking Selection and Replacement in MOEA/D*, in "Parallel Problem Solving from Nature (PPSN)", Ljubljana, Slovenia, LNCS, September 2014, https://hal.inria.fr/hal-00987800

[37] F. MASCIA, M. LÓPEZ-IBÁÑEZ, J. DUBOIS-LACOSTE, M.-E. MARMION, T. STÜTZLE. *Algorithm comparison by automatically configurable stochastic local search frameworks: a case study using flow-shop scheduling problems*, in "Hybrid Metaheuristics 9th International Workshop (HM 2014)", Hamburg, Germany, M. J. BLESA, C. BLUM, S. VOSS (editors), Lecture Notes in Computer Science, Springer International Publishing, 2014, vol. 8457, 15 p. , https://hal.inria.fr/hal-01094683

[38] M. MEZMAZ, R. LEROY, N. MELAB, D. TUYTTENS. *A Multi-Core Parallel Branch-and-Bound Algorithm Using Factorial Number System*, in "IPDPS 2014 : 28th IEEE International Parallel & Distributed Processing Symposium", Phoenix (Arizona), United States, IEEE, May 2014, https://hal.inria.fr/hal-00934841

[39] K. SERIDI, L. JOURDAN, E.-G. TALBI. *Multi-objective path relinking for bi-clustering: Application to microarray data*, in "EMO 2013 : 7th Int. Conf. On Evolutionary Multi-criterion Optimization", Sheffield, United Kingdom, March 2014, pp. 200-214 [*DOI :* 10.1007/978-3-642-37140-0_18], https://hal.inria.fr/hal-01107757

[40] T.-D. TRAN, I. GONZÁLEZ-RODRÍGUEZ, E.-G. TALBI. *A Multiobjective Memetic Approach to Job-Shop Scheduling under Uncertainty*, in "The 5th International Conference on Metaheuristics and Nature Inspired Computing (META'14)", Marrakech, Morocco, October 2014, https://hal.inria.fr/hal-01110315

[41] T.-T. VU, B. DERBEL. *Link-Heterogeneous Work Stealing*, in "IEEE/ACM CCGrid 2014: 14th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing", Chicago, United States, May 2014, https://hal.inria.fr/hal-00938835

Conferences without Proceedings

[42] M. BUÉ, F. CLAUTIAUX, L. BROTCORNE. *Conception d'un système de rangement à deux niveaux*, in "ROADEF - 15ème congrès annuel de la Société française de recherche opérationnelle et d'aide à la décision", Bordeaux, France, Société française de recherche opérationnelle et d'aide à la décision, February 2014, https://hal.archives-ouvertes.fr/hal-00946388

[43] M. GERARD, F. CLAUTIAUX. *planification hebdomadaire sur plusieurs sites d'un personnel hétérogène et poly-compétent sous contraintes multiples*, in "ROADEF - 15ème congrès annuel de la Société française de recherche opérationnelle et d'aide à la décision", Bordeaux, France, Société française de recherche opérationnelle et d'aide à la décision, February 2014, https://hal.archives-ouvertes.fr/hal-00946320

[44] S. JACQUIN, L. JOURDAN, E.-G. TALBI. *Dynamic Programming Based Metaheuristic for Energy Planning Problems*, in "evo*", Granada, Spain, April 2014, pp. 165–176, https://hal.archives-ouvertes.fr/hal-01096029

[45] S. JACQUIN, L. JOURDAN, E.-G. TALBI. *Dynamic Programming Based Metaheuristic for the Unit Commitment Problem*, in "META", Marrakech, Morocco, October 2014, https://hal.inria.fr/hal-01110444

[46] S. JACQUIN, L. JOURDAN, E.-G. TALBI. *Une metaheuristique basée sur la programmation dynamique pour l'UCP*, in "ROADEF - 15ème congrès annuel de la Société française de recherche opérationnelle et d'aide à la décision", Bordeaux, France, Société française de recherche opérationnelle et d'aide à la décision, February 2014, https://hal.archives-ouvertes.fr/hal-00946437

[47] S. JACQUIN, L. JOURDAN, E.-G. TALBI. *DYNAMOP Applied to the Unit Commitment Problem*, in "LION", Lille, France, January 2015, https://hal.inria.fr/hal-01110448

[48] S. JACQUIN, L. MOUSIN, I. MACHADO, E.-G. TALBI, L. JOURDAN. *A Comparison of Decoding Strategies for the 0/1 Multi-objective Unit Commitment Problem*, in "EMO", Guimaraes, Portugal, March 2015, https://hal.archives-ouvertes.fr/hal-01110753

[49] B. TOUNSI, L. BROTCORNE. *Modélisation et résolution d'un problème de gestion d'entrepôt avec prise en compte du transport*, in "ROADEF - 15ème congrès annuel de la Société française de recherche opérationnelle et d'aide à la décision", Bordeaux, France, Société française de recherche opérationnelle et d'aide à la décision, February 2014, https://hal.inria.fr/hal-01096374

[50] B. TOUNSI, Y. HAYEL, D. QUADRI, L. BROTCORNE, T. JIMENEZ. *Sensitivity analysis of stochastic user equilibrium and its application to delivery services pricing*, in "The 5th International Conference on Metaheuristics and Nature Inspired Computing", Marrakech, Morocco, October 2014, https://hal.inria.fr/hal-01096380

Research Reports

[51] B. DERBEL, D. BROCKHOFF, A. LIEFOOGHE, S. VEREL. *On the Impact of Scalarizing Functions on Evolutionary Multiobjective Optimization*, March 2014, n° RR-8512, https://hal.inria.fr/hal-00968145

[52] T.-T. VU, B. DERBEL. *Parallel Branch-and-Bound in Multi-core Multi-CPU Multi-GPU Heterogeneous Environments*, September 2014, 25 p. , https://hal.inria.fr/hal-01067662

References in notes

[53] C. A. COELLO COELLO, D. A. VAN VELDHUIZEN, G. B. LAMONT (editors). *Evolutionary algorithms for solving multi-objective problems*, Kluwer Academic Press, 2002

[54] H. AGUIRRE, K. TANAKA. *Working principles, behavior, and performance of MOEAs on MNK-landscapes*, in "European Journal of Operational Research", 2007, vol. 181, n° 3, pp. 1670–1690

[55] M. BASSEUR. *Design of cooperative algorithms for multi-objective optimization: Application to the Flow-shop scheduling problem*, University of Sciences and Technology of Lille, France, June 2005

[56] C. COTTA, E.-G. TALBI, E. ALBA. *Parallel hybrid approaches*, in "Parallel Metaheuristics", USA, J. Wiley and Sons, 2005, pp. 347–370

[57] K. DEB. *Multi-objective optimization using evolutionary algorithms*, John Wiley and sons, 2001

[58] D. E. GOLDBERG. *Genetic Algorithms in Search, Optimization, and Machine Learning*, Addison-WesleyReading, Massachusett, USA, 1989

[59] S. A. KAUFFMAN. *The Origins of Order*, Oxford University Press, 1993

[60] G. KOCHENBERGER, F. GLOVER, B. ALIDAEE, C. REGO. *A unified modeling and solution framework for combinatorial optimization problems*, in "OR Spectrum", 2004, vol. 26, n° 2, pp. 237–250

[61] A. J. NEBRO, F. LUNA, E.-G. TALBI, E. ALBA. *Parallel multi-objective optimization*, in "Parallel Metaheuristics", USA, J. Wiley and Sons, 2005, pp. 371–394

[62] E.-G. TALBI. *A Taxonomy of Hybrid Metaheuristics*, in "Journal of Heuristics", 2002, vol. 8, n^{o} 5, pp. 541–564