
IN PARTNERSHIP WITH:
**Université des sciences et technologies de Lille (Lille 1)**

Activity Report 2015

# Project-Team DOLPHIN

## Parallel Cooperative Multi-criteria Optimization

IN COLLABORATION WITH: Centre de Recherche en Informatique, Signal et Automatique de Lille

RESEARCH CENTER
**Lille - Nord Europe**

THEME
**Optimization, machine learning and statistical methods**

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## Project-Team DOLPHIN

*Creation of the Project-Team: 2005 May 12*

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**Computer Science and Digital Science:**

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1.1.6. - Cloud
3.1.4. - Uncertain data
6. - Modeling, simulation and control
7.1. - Parallel and distributed algorithms
7.3. - Operations research, optimization, game theory

**Other Research Topics and Application Domains:**

1. - Life sciences
2.7. - Medical devices
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# 1. Members

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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.

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

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):**

  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.

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

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.

# 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 [69]. 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 [65], [68]. 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.

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

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 [71]. 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.
- *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 [66].

### *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 [67], [70].

### *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. 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.

## 4.2. 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.

### *4.2.1. 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.

### *4.2.2. 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.

### *4.2.3. Molecular sampling and docking on large hybrid clusters*

A Phd thesis is started in September 2015 in this context in collaboration with UMONS and University of Strasbourg. Flexible molecular docking is a very complex combinatorial opitmization problem especially when two components (ligand and protein) involved in the mechanism are together flexible. To deal in a reasonable time with such highly combinatorial process approximate optimization methods and massively parallel computing are absolutely The focus of the Ph.D thesis is on the flexibility-aware modeling and the design and implementation of near-approached optimization methods for solving the docking problem on large hybrid clusters including GPU accelerators and MIC coprocessors.

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### *5.1.1. Awards*

- Best paper award at GECCO 2015 (ECOM track, Madrid, Spain, 2015) for the paper “Global vs local search on multi-objective NK-landscapes: contrasting the impact of problem features” , by F. Daolio, A. Liefooghe, S. Verel, H. Aguirre, K. Tanaka. This work is part of our collaboration with Shinshu University in Japan (Associate team s3-bbo and JSPS-MEXT project) on fitness landscape analysis and search performance. In this paper, we consider two prototypical multi-objective optimization algorithms and relate their performance on combinatorial optimization problems with tunable ruggedness, objective space dimension, and objective correlation. Our study departs from simple performance comparison by systematically analyzing the correlation between runtime and problem features, contrasting their association with search performance within and across problem classes. A mixed-model approach allows us to further generalize from the experimental design, supporting a sound assessment of the joint impact of problem features on the search performance.
- Best paper award of “$11^{th}$ Intl. Conf. on Parallel Processing and Applied Mathematics" (PPAM’2015, Krakow, September 6-9). assigned to Jan Gmys, Mohand Mezmaz, Nouredine Melab and Daniel Tuyttens for their article entitled "IVM-based Work Stealing for Parallel Branch-and-Bound on GPU" . This work falls within the framework of the Ph.D thesis of Jan Gmys from University of Mons in cotutelle with Université Lille 1. The contribution consists in revisiting on GPU the parallel design and implementation (based on the Work Stealing paradigm) of the Branch-and-Bound algorithm applied to permutation problems. The raised challenge, which is the originality of the contribution, is to efficiently perform highly irregular exploration process entirely on the GPU having a SIMD architecture.
- Thesis Prize: 26th Nov 2015: Julie Jacques (Phd 2011) won the "Force Awards Nord de France" trophee in the category "thesis with an industrial". Her thesis work, in collaboration with the Dolphin team and the Alicante company, aimed at providing new datamining approaches in order to optimize inclusion in clinical trials.

BEST PAPERS AWARDS:

[31]
F. DAOLIO, A. LIEFOOGHE, S. VEREL, H. AGUIRRE, K. TANAKA. *Global vs local search on multi-objective NK-landscapes: contrasting the impact of problem features*, in "GECCO'15 - Proceedings of the 24th ACM Annual Conference on Genetic and Evolutionary Computation", Madrid, Spain, 2015, pp. 369-376, Best paper award (ECOM track), https://hal.archives-ouvertes.fr/hal-01151882

[54]
J. GMYS, M. MEZMAZ, N. MELAB, D. TUYTTENS. *IVM-based Work Stealing for Parallel Branch-and-Bound on GPU*, in "11th Intl. Conf. on Parallel Processing and Applied Mathematics", Krakov, Poland, September 2015, https://hal.inria.fr/hal-01248329

# 6. New Software and Platforms

## 6.1. COCO

COmparing Continuous Optimizers
KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization

### *6.1.1. SCIENTIFIC DESCRIPTION*

COmparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (3) LaTeX templates of articles which present the figures and tables in a single document. The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, R, Python) which allows to run and log experiments on multiple test functions testbeds of functions (noisy and noiseless) are provided (ii) a Python tool for generating figures and tables that can be used in the LaTeX templates. In 2015, we extended the software towards multiobjective optimization and will provide a first release in early 2016.

### *6.1.2. FUNCTIONAL DESCRIPTION*

The Coco Platform 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, 151 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. For 2016, a new suite of benchmark functions for bi-objective problems is expected to build the basis of the next BBOB workshop at GECCO 2016 for which a new software release is planned for January.

- Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran, Dejan Tušar, Tea Tušar (all Dolphin), Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara, Asma Atamna, Phillipe Sampaio, and Duc Manh Nguyen (all TAO team)
- Partners: TU Dortmund University, Germany and Czech Technical University, Czech Republic
- Contact: Dimo Brockhoff
- URL: http://coco.gforge.inria.fr/, https://github.com/numbbo/coco

## 6.2. MO-Mine

SCIENTIFIC DESCRIPTION

MO-Mineclust 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-Mineclust 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.

FUNCTIONAL DESCRIPTION

MO-Mine is a process of tests and evaluations of multi-objective optimisation algorithms for data mining. MO-Mine platform will provide data sets (literature + synthetics benchmarks), data mining (Features selection, Clustering, Classification and Association rules) algorithms based on multi-objective metaheuristics (Evolutionary algorithm), validation methods and tools to compare algorithms. MO-Mine is based on evolutionary algorithms implemented in ParadisEO and adapted to solve problem of data mining. MO-Mine proposed to users to compare their own methods with different approaches following protocols clearly identified and shared.

- Participants: B. Fisset, L. Jourdan and C. Dhaenens
- Contact: Laetitia Jourdan
- URL: http://mo-mine.gforge.inria.fr/doku.php

## 6.3. 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/

## 6.4. VRPsolve

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

- Participants: Clive Ferret-Canape, Arnaud Liefooghe and Sébastien Vérel
- Contact: Arnaud Liefooghe
- URL: http://gforge.inria.fr/projects/vrpsolve (limited access)

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).

FUNCTIONAL DESCRIPTION

The current release includes the following functional and technical specifications:

- A modular architecture which allows for an easy integration into a global information system (with respect to data standards, weak coupling with external libraries, etc),
- An independent geographic information system with graphic display,
- A resolution engine based on metaheuristics (running in a high-performance computing mode),
- The possibility of coupling with other optimization solvers and frameworks like Paradiseo (in order to enable a quick prototyping of new optimization algorithms),
- Objective- and constraint-handling that can be easily configured by the user,
- Software engineering (build system testing, continuous integration, etc).

## 6.5. Platforms

### *6.5.1. Grid'5000*

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: 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: Frédéric Desprez
- URL: https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

# 7. New Results

## 7.1. Benchmarking Numerical Optimizers

*Participants: D. Brockhoff, B. Derbel, A. Liefooghe, T.-D. Tran, D. Tušar, T. Tušar (DOLPHIN), O. Ait Elhara, A. Atamna, A. Auger, N. Hansen (TAO team, Inria Saclay), P. Preux (Univ. Lille 3), O. Mersmann, T. Wagner (TU Dortmund University, Germany), B. Bischl (LMU Munich, Germany), Y. Akimoto (Shinshu University, Japan)*

In terms of benchmarking numerical optimization algorithms, our research effort went into two different directions. On the one hand, we continued our work on benchmarking single-objective optimization algorithms via the Coco platform in which we started to focus on algorithms for expensive optimization (problems for which only a few function evaluations are affordable). In particular, we benchmarked algorithm variants from the MATSuMoTo library [52], [50] and from the bandits-based global optimizer SOO (Simultaneous optimistic optimization) [33], and organized two workshops at CEC 2015 and GECCO 2015 (see also http://coco.gforge.inria.fr/). On the other hand, we started to develop an extension of the Coco platform towards multiobjective optimization and tried to establish the state of the art in single-objective benchmarking (target-based runtimes, data profiles, ...) also in the multi-objective case [30]. At the same time, we proposed a new bi-objective test suite, consisting of 300 well-understood, scalable test problems.

## 7.2. Handling numeric and temporal data in a local search-based classification algorithm

*Participants: J. Jacques, L. Jourdan, C. Dhaenens, M. Vandomme*
MOCA-I [20] is a highly efficient classification algorithm, primarily designed for knowledge extraction on large-scale, real-life medical data. This algorithm has been first extended to deal with numeric data [58], [46], through the definition of a model for classification rules on numeric attributes. Several neighborhood operators have been proposed, and compared, as components of the overarching local search metaheuristic guiding the discovery and optimization of these rules. A new model has also been proposed to handle temporal data. This model allows for the inclusion of sequences of events in classification rules, in addition to non-temporal attributes, thus building more informative classifiers. This model, along with various optimizations in the local search process, has been favorably compared to the previous MOCA-I algorithm and other standard classification algorithms. It is now used on real hospital data in order to evaluate its performance in a real environment.

## 7.3. MO-DYNAMOP

*Participants: S. Jacquin, L. Jourdan, E-G. Talbi*
The proposed method, MO-DYNAMOP generalize to multi-objective optimization, DYNAMOP, a state of the art optimizer, which was successfully applied to several MO problems. The specificity of this method is to combine aMO dynamic programming (MO-DP) with a MO evolutionary algorithm (MOEA). MO-DYNAMOP is applied to the first stage of the MO-UCP problem including minimization of gas emission. Since the second stage of the problem is now multi-objective, each solution of the first stage problem induces an entire Pareto front of the second stage problem. MO-UCP is solved by assigning an approximation of this Pareto front to each solution of the first stage problem. A comparison study with methods previously proposed in literature is performed. Experiments indicate that MO-DYNAMOP performs considerably better.

## 7.4. Decomposition-based multi-objective optimization

*Participants: Dimo Brockhoff, Bilel Derbel, Arnaud Liefooghe, Gauvain Marquet, El-Ghazali Talbi, Saul Zapotecas-Martinez (external collaborators: Hernan Aguirre and Kiyoshi Tanaka, Shinshu Univ., Japan; Juan Palacios Alonso, Univ. Oviedo, Spain)*
MOEA/D is an aggregation-based evolutionary algorithm which has been proved extremely efficient and effective for solving multi-objective optimization problems. It is based on the idea of decomposing the original multi-objective problem into several single-objective subproblems by means of well-defined scalarizing functions. Those single-objective subproblems are solved in a cooperative manner by defining a neighborhood relation between them. This makes MOEA/D particularly interesting when attempting to plug and to leverage single-objective optimizers in a multi-objective setting. For continuous optimization, we investigate in [49] the benefits that MOEA/D can achieve when coupled with CMA-ES, which is believed to be a powerful single-objective optimizer. We rely on the ability of CMA-ES to deal with injected solutions in order to update different covariance matrices with respect to each subproblem defined in MOEA/D. We show that

by cooperatively evolving neighboring CMA-ES components, we are able to obtain competitive results for different multi-objective benchmark functions. Moreover, in the combinatorial case, we study in [48] the incorporation of geometric differential evolution (gDE), the discrete generalization of DE, into the MOEA/D framework. We conduct preliminary experiments in order to study the effectiveness of gDE when coupled with MOEA/D. Our results indicate that the proposed approach is highly competitive with respect to the original version of MOEA/D, when solving a combinatorial optimization problem having between two and four objective functions. In [36], we consider a bi-objective scheduling combinatorial problem in which task durations and due-dates are uncertain as a case study for MOEA/D. In particular, we investigate existing variants of MOEA/D and we propose a novel and simple alternative replacement component at the aim of maintaining population diversity. Through extensive experiments, we then provide a comprehensive analysis on the relative performance and the behavior of the considered algorithms. Besides being able to outperform existing MOEA/D variants, as well as the standard NSGA-II algorithm, our investigations provide new insights into the search ability of MOEA/D and highlight new research opportunities for improving its design components. At last, in [32], we propose the first large-scale message passing distributed scheme for parallelizing the computational flow of MOEA/D. We show how synchronicity and workload granularity can impact both quality and computing time, in an extremely fine-grained configuration. We deploy our distributed protocol using a large-scale environment of 128 computing cores. Besides being able to show significant speed-ups while maintaining competitive search quality, our experimental results provide insights into the behavior of the proposed scheme in terms of quality/speed-up trade-offs; thus pushing a step towards the achievement of effective and efficient parallel decomposition-based approaches for large-scale multi-objective optimization.

## 7.5. Fitness landscape analysis for multi-objective optimization

*Participants: F. Daolio, A. Liefooghe (external collaborators: Sébastien Verel, Univ. Littoral Côte d'Opale, France; Hernan Aguirre and Kiyoshi Tanaka, Shinshu Univ., Japan)*

Computationally hard multi-objective combinatorial optimization problems are common in practice, and numerous evolutionary multi-objective optimization (EMO) algorithms have been proposed to tackle them. Our aim is to understand which (and how) problem features impact the search performance of such approaches. In [38], we adopt a statistical approach, based on simple and multiple linear regression analysis, to enquire the expected running time of global SEMO with restart for identifying a (1+$\varepsilon$)-approximation of the Pareto set for small-size enumerable instances. Our analysis provides further insights on the EMO search behavior and on the most important features that characterize the difficulty of an instance for this class of problems and algorithms. In [31], we consider two prototypical dominance-based algorithms: a global EMO strategy using an ergodic variation operator (GSEMO) and a neighborhood-based local search heuristic (PLS). Their respective runtime is estimated on a benchmark of combinatorial problems with tunable ruggedness, objective space dimension, and objective correlation ($\rho$MNK-landscapes). In other words, benchmark parameters define classes of instances with increasing empirical problem hardness; we enumerate and characterize the search space of small instances. Our study departs from simple performance comparison to systematically analyze the correlations between runtime and problem features, contrasting their association with search performance within and across instance classes, for both chosen algorithms. A mixed-model approach then allows us to further generalize from the experimental design, supporting a sound assessment of the joint impact of instance features on EMO search performance. Next, in [28], we analyse the behavior and compares the performance of MOEA/D, IBEA using the binary additive epsilon and the hypervolume difference indicators, and A$\varepsilon$S$\varepsilon$H as representative algorithms of decomposition, indicators, and $\varepsilon$-dominance based approaches for many-objective optimization. We use small MNK-landscapes to trace the dynamics of the algorithms generating high-resolution approximations of the Pareto optimal set. Also, we use large MNK-landscapes to analyze their scalability to larger search spaces. At last, in [39], we report an experimental analysis on stochastic local search for approximating the Pareto set of bi-objective unconstrained binary quadratic programming problems. First, we investigate two scalarizing strategies that iteratively identify a high-quality solution for a sequence of sub-problems. Each sub-problem is based on a static or adaptive definition of weighted-sum aggregation coefficients, and is addressed by means of a state-of-the-art single-objective tabu search procedure. Next, we design a Pareto local search that iteratively improves a set of solutions based on a neighborhood

structure and on the Pareto dominance relation. At last, we hybridize both classes of algorithms by combining a scalarizing and a Pareto local search in a sequential way. A comprehensive experimental analysis reveals the high performance of the proposed approaches, which substantially improve upon previous best-known solutions. Moreover, the obtained results show the superiority of the hybrid algorithm over non-hybrid ones in terms of solution quality, while requiring a competitive computational cost. In addition, a number of structural properties of the problem instances allow us to explain the main difficulties that the different classes of local search algorithms have to face.

## 7.6. Fitness Landscape of the Factoradic Representation on the PFSP

*Participants: Marie-Eléonore Marmion (external collaborators: Olivier Regnier-Courdert, University of Aberdeen, UK)*
Because permutation problems are particularly challenging to model and optimise, the possibility to represent solutions by means of factoradics has recently been investigated, allowing algorithms from other domains to be used. Initial results have shown that methods using factoradics can efficiently explore the search space, but also present difficulties to exploit the best areas. In [57], the fitness landscape of the factoradic representation and one of its simplest operator is studied on the Permutation Flowshop Scheduling Problem (PFSP). The analysis highlights the presence of many local optima and a high ruggedness, which confirms that the factoradic representations is not suited for local search. In addition, comparison with the classic permutation representation establishes that local moves on the factoradic representation are less able to lead to the global optima on the PFSP.

## 7.7. How Neutrality Helps Multiobjective Local Search Algorithms

*Participants: Aymeric Blot, Clarisse Dhaenens, Laetitia Jourdan, Marie-Eléonore Marmion(external collaborators: Hernan Aguirre and Kiyoshi Tanaka, Shinshu Univ., Japan)*
We extend the concept of neutrality used in single-objective optimization to the multi-objective context and investigate its effects on the performance of multi-objective dominance-based local search methods [29]. We discuss neutrality in single-objective optimization and fitness assignment in multi-objective algorithms to provide a general definition for neutrality applicable to multi-objective landscapes. We also put forward a definition of neutrality when Pareto dominance is used to compute fitness of solutions. Then, we focus on dedicated local search approaches that have shown good results in multi-objective combinatorial optimization. In such methods, particular attention is paid to the set of solutions selected for exploration, the way the neighborhood is explored, and how the candidate set to update the archive is defined. We investigate the last two of these three important steps from the perspective of neutrality in multi-objective landscapes, propose new strategies that take into account neutrality, and show that exploiting neutrality allows to improve the performance of dominance-based local search methods on bi-objective permutation flowshop scheduling problems. This work is a first step to integrate learning in strategies of local search algorithms.

## 7.8. Surrogate-assisted multiobjective evolutionary algorithm for fuzzy job shop problems

*Participants: E-G. Talbi and Juan José Palacios, Jorge Puente, Camino R. Vela, Inés Gonzalez-Rodrıguez (Univ. Oviedo, Spain)*
We have considered a job shop scheduling problem with uncertain processing times modelled as triangular fuzzy numbers and propose a multiobjective surrogate assisted evolutionary algorithm to optimise not only the schedule's fuzzy makespan but also the robustness of schedules with respect to different perturbations in the durations. The surrogate model is defined to avoid evaluating the robustness measure for some individuals and estimate it instead based on the robustness values of neighbouring individuals, where neighbour proximity is evaluated based on the similarity of fuzzy makespan values. The experimental results show that by using fitness estimation, it is possible to reach good fitness levels much faster than if all individuals are evaluated.

## 7.9. Bipartite matching approximation

*Participants: F. Dufossé*

Bipartite matching is a classical academic problem on bipartite graphs. Many iterative heuristics need an initial approximate matching with linear computational time. We have designed two randomized highly parallelizable algorithms with linear execution time and quality guarantee. The approximation guarantees have been proved to reach respectively 63demonstrate the speed-ups and validate the applicability and efficiency of these algorithms on general bipartite graphs. Comparisons with the more efficient suboptimal linear algorithms of bipartite matching demonstrate a lower efficiently in average but a similar execution time, and validate the quality guarantee on all experiments. This work has been published in [16].

## 7.10. Parallel B&B revisited for coprocessors using our new IVM data structure dedicated to permutation problems

*Participants: J. Gmys, R. Leroy and N. Melab*

This contribution is a joint work with M. Mezmaz and D. Tuyttens from University of Mons (UMONS).
Solving large permutation Combinatorial Optimization Problems (COPs) using Branch-and-Bound (B&B) algorithms results in the generation of a very large pool of subproblems. Therefore, defining a dedicated data structure is crucial to store and manage efficiently that pool. In the Ph.D thesis of R. Leroy [11], we have proposed an original data structure called Integer-Vector-Matrix (IVM) for permutation COPs based on the factorial number system. Consequently, we have redefined the operators of the B&B algorithm acting on it. For performance evaluation in terms of memory footprint and CPU time usage, we conduct a complexity analysis and an extensive experimentation using the permutation Flow-Shop Scheduling Problem (FSP) as a case study. Compared to the Head-Tail Linked List (LL) data structure often used for parallel B&B as in our work [11], IVM requires up to $n$ times less memory than LL, $n$ being the size of permutations. Moreover, the IVM-based B&B is up to one order of magnitude faster than its LL-based counterpart in managing the pool of subproblems. Another major contribution of this thesis is to revisit parallel B&B for multi-core processors and many-core coprocessors (GPU and MIC) using IVM and LL-based work stealing. Several challenging issues are addressed including work distribution using factoradic-based intervals on multi-core processors, thread/branch divergence and data placement optimization on GPU, and vectorization on Intel Xeon Phi. The contribution and some of its extensions have been published in [40], [18]. An extensive experimental study shows that the IVM-based approach outperforms its LL-based counterpart by a significant margin on multi-core processors as well as on coprocessors.
A major extension of this work has been proposed in [54] and awarded as a best paper consists in offloading all the operators of the B&B algorithm to the GPU. Four interval-based WS strategies have been investigated using IVM. An extensive experimentation allowed us to demontrate that the GPU-accelerated approach is 5 times faster than its multi-core counterpart.

## 7.11. large scale heterogeneous parallel B&B based on hybrid work-stealing

*Participants: Bilel Derbel, Tuan Trong Vu*

In [27], we investigate the design of parallel B&B in large scale heterogeneous compute environments where processing units can be composed of a mixture of multiple shared memory cores, multiple distributed CPUs and multiple GPUs devices. We describe two approaches based on hybrid work-stealing in shared and distributed memory systems, addressing the critical issue of how to map B&B workload with the different levels of parallelism exposed by the target compute platform. We also contribute a throughout large scale experimental study which allows us to derive a comprehensive and fair analysis of the proposed approaches under different system configurations using up to 16 GPUs and up to 512 distributed cores. Our results shed more light on the main challenges one has to face when tackling B&B algorithms while describing efficient techniques to address them. In particular, we are able to obtain linear speed-ups at moderate scales where adaptive load balancing among the heterogeneous compute resources is shown to have a significant impact on performance. At the largest scales, intra-node parallelism and hybrid decentralized load balancing is shown to

have a crucial importance in order to alleviate locking issues among shared memory threads and to scale the distributed resources while optimizing communication costs and minimizing idle times.

## 7.12. A Multi-objective Evolutionary Algorithm for Cloud Platform Reconfiguration

*Participants: F. Legillon, N. Melab and E-G. Talbi*
This contribution published in [37] is a result of an industrial collaboration with Tasker Cloud services company.
Offers of public IAAS providers are dynamic: new providers enter the market, existing ones change their pricing or improve their offering. The decision on whether and how to improve already deployed platforms, either by reconfiguration or migration to another provider, can be modelled as an NP-hard optimization problem. In this paper, we define a new realistic model for this migration problem, based on a multi-objective Optimization formulation. An evolutionary approach is introduced to tackle the problem, using newly defined specific operators. Experiments are conducted on multiple realistic data-sets, showing that the evolutionary approach is viable to tackle real-size instances in a reasonable amount of time.

## 7.13. A multi-objective approach for energy-efficient scheduling of large workloads in multicore distributed systems

*Participants: E-G. Talbi and B. Dorronsoro (Univ. Cadiz, Spain), S. Nesmachnow (Universidad de la República, Uruguay), J. Taheri, A. Zomaya (Univ. Sydney, Australia), P. Bouvry (Univ. Luxembourg*
This work proposes a two-level strategy for scheduling large workloads of parallel applications in multicore distributed systems, taking into account the minimization of both the total computation time and the energy consumption of solutions. Nowadays, energy efficiency is of major concern when using large computing systems such as cluster, grid, and cloud computing facilities. In the approach proposed, a combination of higher-level (i.e., between distributed systems) and lower-level (i.e., within each data-center) schedulers are studied for finding efficient mappings of workflows into the resources in order to maximize the quality of service, while reducing the energy required to compute them. The experimental evaluation demonstrates that accurate schedules are computed by using combined list scheduling heuristics (accounting for both problem objectives) in the higher level, and ad-hoc scheduling techniques to take advantage of multicore infrastructures in the lower level. Solutions are also evaluated with two user- and administrator-oriented metrics. Significant improvements are reported on the two problem objectives when compared with traditional load-balancing and round-robin techniques [15].

# 8. Bilateral Contracts and Grants with Industry

## 8.1. Bilateral Contracts with Industry

- Intel (2015-2016) Bilateral academic and research partnarship between Université Lille 1 and Intel. In this context, Intel will provide Lille 1 with technical support help for the dissemination of its activities related to High Performance Computing.
- 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 (2014-2018): the objective of this bilateral project is the predictive models and knowledge extraction for insurance web comparator.
- Normand (2014-2015]: the objective of this contract is the modelling of a dynamic multi-objective scheduling problem in the medical analysis.

- Beckman (2015-2018]: the goal of this contract concerns the strategic and operational planning medical laboratories.

## 8.2. Bilateral Grants with Industry

- Intel 2015-2016 Bilateral grant with Intel. Intel has supported with a budget equivalent to 25K€ the acquisition of a cluster of 2 multi-core servers and 8 Intel Xeon Phi coprocessors. The objective is to develop research and teaching on multi and many-core computing on coprocessors.

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

- CPER "data" (2015-2020) : co-leader of a workpackage "Research infrastructure". The objective is to support research related to data science including high performance computing for combinatorial optimization using the Grid'5000 grid infrastructure.
- ELSAT (2015-2019) of CPER (Contrat Plan Etat Région) : transversal research action "Planning and scheduling of maintenance logistics in transportation".
- 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) : the objective is to support the coordination in terms of scientific animation, training, equipement and patnership development related to simulation and high performance computing. This action is granted 17K€ per year by University Lille 1.

## 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, 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), (2014-2016)
- PGMO project "Demand side management in smart grids", together with EDF, (2015-2017).

## 9.3. European Initiatives

### *9.3.1. 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

### *9.3.2. Collaborations with Major European Organizations*

University of Luxembourg: (Luxembourg)

Energy aware scheduling in Cloud computing systems

## 9.4. International Initiatives

### *9.4.1. Inria International Labs projects*

- Collaboration with University of Mons (UMONS). The collaboration consists mainly in the joint supervision of three Ph.D theses: the thesis of Rudi Leroy defended on November 19$^{th}$, 2015, the thesis of Jan Gmys started last year, and the thesis of Gautier Vaillant started in September 2015.

### *9.4.2. Inria Associate Teams not involved in an Inria International Labs*

#### *9.4.2.1. 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.

### *9.4.3. Inria International Partners*

*9.4.3.1. Declared Inria International Partners*

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

*9.4.3.2. Informal International Partners*

- University of Coimbra, Portugal.
- IRIDIA, Université Libre de Bruxelles.
- Cologne University of Applied Sciences, Germany.
- Leiden University, Netherlands.
- UMONS University and Tractebel company, Belgium.
- EMI - Univ. Rabat, Morocco.
- Univ. Oviedo, Spain.
- Univ. Istanbul, Turkey.
- University of KULAK Team Codes (Belgium) - Data science for Optimization
- University of KENT (UK) - Knowledge and Optimization
- University of Aberdeen (UK) - Fitness landscape, representation and performance
- University of British Columbia, Canada
- University of Münster, Germany

### *9.4.4. 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).
- Excellencia project(2015-2017) with University of Valencia (Spain) and University of Oviedo (Spain) on intelligent techniques for robust scheduling and energy-aware transportation systems.

## 9.5. International Research Visitors

### *9.5.1. Visits of International Scientists*

- Prof. Hernan Aguirre, Shinshu University, Nagano, Japan
- 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 Dec 2015]
- Prof. Qingfu Zhang, CityU, Hong-Kong
- Dr. Oliver Schuetze, CINVESTAV-IPN, Mexico
- Prof. H-J. Siegel (Univ. Colorado, USA)
- Prof. R. Ellaia (EMI, Morocco)

- Prof. A. Tchernik (Mexico)
- Prof. B. Gendron (Canada)
- Dr. Myriam Delgado (Federal University of Technology of Paraná, Brazil), 1 week, December 2015
- Tiago-Carneiro Pessoa [Universidade Federal do CEARA, Brazil, from 09/2015 to 08/2016]

*9.5.1.1. Internships (Master & PhD)*

- Tiago-Carneiro Pessoa [Phd student from Universidade Federal do CEARA, Brazil. from Sept 2015 to Jan 2017].
- Juan Palacios Alonso (Univ. Oviedo Spain).
- Igor Machado Coelho (Univ. Fluminense Brazil).

*9.5.1.2. Research stays abroad*

- A. Liefooghe, May 2015, Shinshu University, Nagano, Japan.
- A. Liefooghe, Dec 2015, Shinshu University, Nagano, Japan.
- M-E Marmion, C. Dhaenens, invited at Shinshu University (1 week, february 2015)
- E-G. Talbi, Mar 2015, Univ. Murcia, Spain.
- E-G. Talbi, Juin 2015, EMI, Univ. Agdal Rabat, Morocco.
- E-G. Talbi, Jul 2015, Univ. Luxembourg.

# 10. Dissemination

## 10.1. Promoting Scientific Activities

### *10.1.1. Scientific events organisation*

*10.1.1.1. General chair, scientific chair*

- L. Jourdan, C. Dhaenens, M-E. Marmion: Learning and Intelligent OptimizatioN Conference; LION 9, Lille, FRANCE, Jan. 12-15, 2015.
- N. Melab: Chair of the McM'2015 workshop (Multi/Many-core computing for parallel Metaheuristics) organized in conjunction with MIC'2015, Agadir, June $7^{\text{th}}$ 2015.
- N. Melab: Chair of 5 simulation and HPC-related seminars at Lille 1 oct-dec. 2015 (UPMC, Nvidia, LATMOS/UPMC, VU Leuven, Intel).
- E-G. Talbi: General chair MIC'2015 Int. Conf. on Metaheuristics, Agadir, Morocco, June 2015.

*10.1.1.2. Member of the organizing committees*

- D. Brockhoff: Lorentz Center workshop "SAMCO - Surrogate-Assisted Multi-Criteria Optimization", Leiden, Netherlands together with Michael Emmerich, Boris Naujoks, and Tobias Wagner, March 2016
- D. Brockhoff: special session on "Evolutionary Multiobjective Optimization" at the MCDM'2015 conference, Hamburg, Germany, together with Joshua Knowles, Boris Naujoks, and Karthik Sindhya, August 2015
- D. Brockhoff: GECCO 2015 workshop entitled "Blackbox Optimization Benchmarking", Madrid, Spain, together with Youhei Akimoto, Anne Auger, Nikolaus Hansen, Olaf Mersmann, and Petr Pošík, July 2015
- D. Brockhoff: CEC 2015 special session entitled "Blackbox Optimization Benchmarking", Sendai, Japan, together with Youhei Akimoto, Anne Auger, Nikolaus Hansen, Olaf Mersmann, and Petr Pošík, May 2015

- L. Jourdan: MIC'2015 Int. Conf. on Metaheuristics and Nature Inspired Computing, Agadir, Morocco, June 2015.
- L. Jourdan: EA'2015 Biennial International Conference on Artificial Evolution Publicity chair
- A. Liefooghe: CEC 2015 special session entitled "Fitness landscape analysis and search space structure", Sendai, Japan, together with Hernan Aguirre, Kiyoshi Tanaka and Sébastien Verel, May 2015

### *10.1.2. Scientific events selection*

*10.1.2.1. Chair of conference program committees*

- E-G. Talbi: Track chair « Big data and smart applications » of IIT'2015 11th IEEE Int. Conf. on Innovation in Information Technology, Dubai, Nov 2015.
- E-G. Talbi: Program chair IEEE NIDISC'2015 Workshop on Nature Inspired distributed Computing, Hyderabad, India, May 2015.

*10.1.2.2. Member of the conference program committees*

- CEC'2015: IEEE Congress on Evolutionary Computation (Sendai, Japan, 2015)
- EA'2015: 12th International Conference on Artificial Evolution (Lyon, France 2015)
- EMO'2015: 8th International Conference on Evolutionary Multi-criterion Optimization (Guimarães, Portugal, 2015)
- EPIA'2015: 17th Portuguese Conference on Artificial Intelligence, Track on Artificial Life and Evolutionary Algorithms (Coimbra, Portugal, 2015)
- EvoCOP'2015: 15th European Conference on Evolutionary Computation in Combinatorial Optimisation (Copenhagen, Denmark, 2015)
- GECCO'2015: Genetic and Evolutionary Computation Conference, Evolutionary Combinatorial Optimization and Metaheuristics (ECOM) track (Madrid, Spain, 2015)
- LION'2015: 9th Learning and Intelligent OptimizatioN Conference (Lille, France, 2015)
- ICCS'2015 International Conference on Computational Science, Reykjavik, Iceland, June 1-3, 2015.
- IEEE IPDPS/NIDISC'2015 IEEE International Workshop on Nature Inspired Distributed Computing, Hyderabad, India, May 25-29, 2015.
- IEEE IPDPS/PCO'2015 IEEE Intl. Workshop on Parallel Computing and Optimization, Hyderabad, India, May 25-29, 2015.
- MIC'2015 Metaheuristics Intl. Conf., Agadir, Morocco, June 7-10, 2015.
- COSI'2015 Colloque sur l'Optimisation et les Systèmes d'information, Oran, Algérie, June 1-3, 2015.
- INCoS 2015 Intl. Conf. on Intelligent Networking and Collaborative Systems, Taipei, Taiwan, Sep. 2-4, 2015.
- CoCoNet'2015 Intl. Conf. on Computing and Network Communications, Trivandrum, India, Dec. 16-19, 2015.
- IC3'2015 Intl. Conf. on Contemporary Computing, Noida, India, Aug. 20-22, 2015.
- CloudTech'2015 Intl. Conf. of Cloud Computing Technologies and Applications, Marrakech, Morocco, June 2-4, 2015.
- Workshop on Foundations of Genetic Algorithms (FOGA 2015).

### *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».
- D. Brockhoff, B. Derbel, A. Liefooghe and S. Verel: Guest editors of a special issue on Evolutionary Multiobjective Optimization, European Journal of Operational Research.
- N. Melab Guest Editor for the special issue on Multi/Many-core Computing for Parallel Metaheuristics. In Concurrency and Computation: Practice and Experience, 2015.
- E-G. Talbi, P. Bouvry : Guest editor of a special issue on Computational intelligence for Cloud computing, IEEE Computational Intelligence Magazine, Vol.10, No.1, 2015.
- D. Brockhoff : Special Issue "Evolutionary Multiobjective Optimization" of Computers and Operations Research journal (C&OR), together with Joshua Knowles, Boris Naujoks, and Karthik Sindhya, submission deadline in September 2015
- L. Jourdan : Review Editor Frontiers in Big Data.

*10.1.3.2. Reviewer - Reviewing activities*

- A Quarterly Journal of Operations Research (4OR, Springer)
- European Journal of Operational Research (EJOR, Elsevier)
- Journal of Heuristics (HEUR, Springer)
- Soft Computing (SOCO, Springer)
- IEEE Transactions on Evolutionary Computation
- Applied Soft Computing
- International Transactions in Operational Research (ITOR)
- IEEE/ACM Transactions on Computational Biology and Bioinformatics
- Computers & Operations Research (COR, Elsevier)
- Computers & Industrial Engineering (CAIE, Elsevier)
- ACM Computing Surveys
- Computation and Concurrency: Practice and Experience
- Parallel Processing Letters
- Omega, The International Journal of Management Science

### *10.1.4. Invited talks*

- L. Jourdan, Combinatorial optimization for Bioinformatcs, invited talk (1day), summer school of Bioinformatics, Angers, 2015.
- A. Liefooghe, "On multi-objective fitness landscapes and the performance of EMO algorithms", Dec 2015, Shinshu University, Nagano, Japan
- D. Brockhoff, invited tutorial "Evolutionary Multiobjective Optimization", GECCO 2015, Madrid, Spain, July 12, 2015, together with Tobias Wagner
- N. Melab, Invited lecture "Basics on parallel programming", HPC day organized in conjunction with COSI'2015, May $31^{th}$, Oran, Algeria, 2015.
- E-G. Talbi, "Combining metaheuristics with mathematical programming, constraint programming and machine learning", Keynote speaker ROADEF'2015 Société Française de Recherche Opérationnelle, Marseille, France, Feb 2015.
- E-G. Talbi, "Solving complex optimization problems", Tutorial IIT'2015 11th Int. Conf. on Innovations in Information Technology, Dubai, UAE, Nov 2015.
- C. Dhaenens, L. Jourdan and M-E. Marmion, "Synergy of knowledge and optimization", KU Leuven KULAK, April 2015

- C. Dhaenens and M-E. Marmion, “Synergy of knowledge and optimization”, Shinshu University, Nagano, Japan, Feb. 2015

### *10.1.5. Leadership within the scientific community*

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

### *10.1.6. Scientific expertise*

- C. Dhaenens: Jury of the contest “les pros de la RO”, organised by the ROADEF society, Nov 2015.
- L. Jourdan: external reviewer for the Luxembourg National Research Fund (FNR).
- L. Jourdan: external reviewer for the FWO (Research Foundation Flanders ).
- L. Jourdan : Jury of the contest "prix Robert Faure" for contribution in the field of Operational research organized by ROADEF Feb. 2015
- E-G. Talbi : Expert for Qatar Foundation QNRF projects, 2015.

### *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.
- F. Dufossé : Member of the Inria “center committee” and “research applications”.
- N. Melab : Member of the steering committee of “Maison de la Simulation” at Université Lille 1.
- L. Jourdan Membre du bureau de la direction des écoles doctorales en Informatique du Nord Pas de Calais.

## 10.2. Teaching - Supervision - Juries

### *10.2.1. 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
- Master: A. Liefooghe, Multi-criteria Decision Aid and Optimization, 25h ETD, M2, Université de Lille 1, France
- A. Liefooghe is supervising the Master 2 MIAGE IPI-NT
- 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 : Responsible of Master MIAGE Formation en Alternance
- Laetitia Jourdan: Co-responsible of Licence 1 Computer Science
- Dimo Brockhoff: Introduction to Optimization, Ecole Centrale Paris, Supelec, ESSEC, MSc in Data Sciences & Business Analytics
- Dimo Brockhoff: Introduction to Optimization, Univ. Paris-Sud, MSc (together with Anne Auger (TAO team)), M2 Apprentissage, Information et Contenu
- Master lecture: N. Melab, Supercomputing, 33h, Master 2, Université Lille 1, France
- Master lecture: N. Melab, Operations Research, 82h, Master 1, Université Lille 1, France
- Master leading: N. Melab, Co-head (with C. Chainais) of the master 2 of advanced scientific computing, U. 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 : 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 (responsible), 60h, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Algorithm and Programming, 44h, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Graphs (responsible), 44h, 1st year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Optimization, 14h, 2nd year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Optimization,8h, 3rd year, Université Lille 1, France
- Polytech Lille : Marie-Eléonore Marmion, Data mining, 10h, 3rd year, Université Lille 1, France

### *10.2.2. Supervision*

PhD defended : Sophie Jacquin, Combining exact method and metaheuristics for production problems, 11/2015, Co-direction : El-Ghazali Talbi et Laetitia Jourdan

Phd defended : Nicolas Dupin, Modélisation et résolution de grands problèmes stochastiques et combinatoires : Application à la gestion de production électrique, Oct 2015, El-Ghazali Talbi

Phd defended : Mathieu Gérard, Contribution à la résolution de problèmes d'optimisation en distribution, Dec 2015, Francois Clautiaux.

PhD defended: Rudi LEROY, Parallel Branch-and-Bound revisited for solving permutation combinatorial optimization problems on multi-core processors and coprocessors, Nouredine Melab and Mohand Mezmaz (UMONS, Belgium), Defended on 19/11/2015

PhD in progress: Maxence Vandromme, Datamining et optimisation combinatoire adaptés à la prévention et à l'orientation de patients, 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 in progress : Thanh-Do Tran, Benchmarking Continuous Multiobjective Optimization Algorithms, since 12/2011, Dimo Brockhoff and El-Ghazali Talbi

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

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

New PhD : Aymeric Blot, Réagir et s'adapter à son environnement : Concevoir des méthodes autonomes pour l'optimisation combinatoire à plusieurs objectifs , ENS Student co-directed Laetitia Jourdan and Marie-Eléonore Marmion

New PhD : AnneLise Bedenel, Classification supervisée et non supervisée en présence de descripteurs évoluant dans le temps. Application à la comparaison d'assurances en ligne, CIFRE with Pixeo co-directed Laetitai Jourdan and Christophe Biernacki (Modal Inria Team)

New PhD : Gautier Vaillant, Parallel combinatorial optimization for molecular sampling and docking on hybrid clusters, Nouredine Melab and Daniel Tuyttens (UMONS, Belgium), Started in 09/2015

### *10.2.3. Juries*

- L. Jourdan: PhD thesis: Pierrick Buret, "Sécurité temporelle des hyperviseurs aérospatiaux", Université de Limoges, Dec 2015.
- L. Jourdan: Phd thesis: CHRAIBI Abdelahad,"A Decision Making System for Operating Theater Design: Application of Facility Layout Problem", Université Américaine de Beyrouth, Liban, Dec 2015.
- L. Jourdan : Optimization of the car relocation operations in one-way carsharing systems, de Rabih ZAKARIA de l'UTBM, December 14th 2015 (L. Jourdan, Rapporteur)
- N. Melab: HDR: Patricia Stolf, "Resource management for green infrastructures through reconfiguration", Université de Toulouse, November 13th, 2015.
- E-G. Talbi: PhD thesis: Charlie Vanaret "Hybridation d'algorithmes évolutionnaires et de méthodes d'intervalles pour l'optimisation de problèmes difficiles», Université de Toulouse, Jan 2015.
- E-G. Talbi: HDR : A. Sbihi "Contributions à la résolution de quelques problèmes d'optimisation combinatoire avec contraintes complexes: Etude et stratégie algorithmique", Université de Cergy-Pontoise, Jan 2015.

- E-G. Talbi: PhD : Simon Thevenin “Metaheuristics for constrained production scheduling problems”, Université Genève, Switzerland, June 2015.
- E-G. Talbi: HDR : D. Duvivier “Contributions au couplage de l’optimisation et de la simulation”, Université de Valenciennes, Sept 2015.
- E-G. Talbi: HDR : A. Nakib “From static to dynamic metaheuristics”, Université de Paris Est, Dec 2015.

## 10.3. Popularization

- D. Brockhoff: Blackbox Optimization talk at 30min of Inria.
- L. Jourdan: Bioinspired computing - talk in undergraduate and graduate schools.
- L. Jourdan: Operational research - for 2nde during integration week (June 2015).
- L Jourdan, C. Dhaenens “Data et Santé”, in "Data for you, data for business", organized by inria Lille (Nov 2015).
- L. Jourdan : Coding gouter for children (Dec. 2015).

# 11. 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$^{o}$ 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$^{o}$ 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$^{o}$ 1, pp. 173-185, http://hal.inria.fr/inria-00638805

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

## Publications of the year

### Doctoral Dissertations and Habilitation Theses

[11] R. LEROY. *Parallel Branch-and-Bound revisited for solving permutation combinatorial optimization problems on multi-core processors and coprocessors*, Université Lille 1, November 2015, https://hal.inria.fr/tel-01248563

### Articles in International Peer-Reviewed Journals

[12] I.-C. BILEGAN, L. BROTCORNE, D. FEILLET, Y. HAYEL. *Revenue management for rail container transportation*, in "EURO Journal on Transportation and Logistics", 2015, vol. 4, n° 2, pp. 261-283, http://hal-emse.ccsd.cnrs.fr/emse-01092226

[13] D. C. CATTARUZZA, N. ABSI, D. FEILLET. *Vehicle routing problems with multiple trips*, in "4OR: A Quarterly Journal of Operations Research", 2016, forthcoming, http://hal-emse.ccsd.cnrs.fr/emse-01250603

[14] I. CHAKROUN, N. MELAB. *Towards a heterogeneous and adaptive parallel Branch-and-Bound algorithm*, in "Journal of Computer and System Sciences", 2015, vol. 81, n° 1, pp. 72-84 [*DOI :* 10.1016/j.jcss.2014.06.012], https://hal.inria.fr/hal-01095425

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[16] F. DUFOSSÉ, K. KAYA, B. UÇAR. *Two approximation algorithms for bipartite matching on multicore architectures*, in "Journal of Parallel and Distributed Computing", 2015, vol. 85, pp. 62-78 [*DOI :* 10.1016/j.jpdc.2015.06.009], https://hal.inria.fr/hal-01242516

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[19] 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(AOR)", October 2015 [*DOI :* 10.1007/s10479-014-1647-x], https://hal.inria.fr/hal-01212016

[20] J. JACQUES, J. TAILLARD, D. DELERUE, C. DHAENENS, L. JOURDAN. *Conception of a dominance-based multi-objective local search in the context of classification rule mining in large and imbalanced data sets*, in "Applied Soft Computing", 2015, vol. 34, pp. 705–720 [*DOI :* 10.1016/J.ASOC.2015.06.002], https://hal.archives-ouvertes.fr/hal-01216483

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