ANR

PROGRAMME JEUNES CHERCHEUSES ET JEUNES CHERCHEURS

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Acronyme COCA

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Acronyme	**COCA**		
Titre du projet en français	Optimisation combinatoire pour agents en situation de compétition		
Titre du projet en anglais	Combinatorial Optimization with Competing Agents		
CSD principale	☒ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9		
CSD secondaire ***(si interdisciplinarité)***	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9		
Aide totale demandée	198848 €	**Durée du projet**	48 mois

SOMMAIRE

1. CONTEXTE ET POSITIONNEMENT DU PROJET / CONTEXT AND POSITIONNING OF THE PROPOSAL

Combinatorial optimization is a very active field in computer science [PS98]. This is certainly due to the numerous real world applications that can be modelled as combinatorial optimization problems. A discrete combinatorial optimization problem is characterized by a finite but possibly huge set of feasible solutions, defined as the power set of a finite set of elementary components. Classical examples are the shortest path problems (finding the shortest path from one point to another in a network), the assignment problems (assigning a set of tasks to a set of agents), the knapsack problems (choosing a subset of items among a set, given a capacity constraint)... Along with the development of information society, combinatorial optimization has become a central issue in many novel applications, including the setting up of mobile or wireless networks, the development of Internet and electronic commerce... New kinds of combinatorial optimization problems requiring new kinds of algorithms are continuously identified. Several streams of research have been developed around combinatorial optimization, such as identifying classes of problems whose computational complexity is equivalent [GJ79], designing exact or approximate solution methods [Vaz02].

Unfortunately the socio-economic context where these problems arise is often put aside. Indeed, most studies assume that a system is fully operated and controlled by a central, hence unique, entity. However many well studied combinatorial problems are embedded in a strategic situation. That is, a context in which an individual's success in making choices depends on the choices of others. This is typically the case when several self-interested agents share a common resource (e.g. a network, a market, etc). This is the primary concern of Game Theory [OR94]. The central entity of Game Theory is the agent (also often called player). Once a set of agents is defined, two types of games can be distinguished: non-cooperative games where one considers actions undertaken by individual agents, and cooperative games where one considers actions undertaken by subsets of agents. We focus here on the former type. The elements characterizing a non-cooperative game are the following: a set of interacting agents, every action undertaken by an agent may have an impact on other gains, every agent has a certain level of information before taking a decision. A solution of a non-cooperative game is often seen as an equilibrium situation, where no one has an incentive to deviate from its current strategy. Game theorists have proposed several concepts of equilibrium (the most well-known is of course the Nash equilibrium), and studied their existence (or non-existence) in many games [OR94]. However they somewhat neglect computational issues: how hard is the computation of an equilibrium, especially when the set of strategies is combinatorial (as in network congestion problems for instance), how the procedure should be implemented... The need for a better understanding of these problems is blatant but this task is as ambitious as the field of application is broad.

Today a growing international community of computer scientists works on these issues at the interface between combinatorial optimization and Game Theory. The interest for this kind of studies is so strong that it gave birth to a new field called Algorithmic Game Theory (AGT) [NRTV07]. For instance AGT was quickly inserted in the list of topics in the call for papers of the best conferences in several fields of Computer Science (STOC, FOCS in Theoretical Computer Science, SODA, ICALP in Combinatorial Optimization, and IJCAI, AAAI in Artificial intelligence). In addition two new conferences mostly dedicated to AGT were recently launched: SAGT (Symposium on AGT, first edition in 2008) and WINE (Workshop on Internet and Network Economics, first edition in 2005). Among conferences where paper submissions in AGT are very numerous, let us also mention ACM-EC (ACM conference in Electronic Commerce, since 1999) and AAMAS (international conference on Autonomous Agents and Multi-Agent Systems, since 2002). Conversely, a significant sign of the interest that the Game Theory community has for work going on in Computer Science is the recent birth (January 2008) of a Prize in Game Theory and Computer Science, promoted by the Game Theory Society. Every four years, it will be awarded to the person (or persons) who have published the best paper at the interface of game theory and computer science.

Algorithmic Game Theory gives rise to novel and challenging research directions which are at the intersection between computer science, social science and economics. Namely, two types of issues are investigated in AGT according to the way a game is represented:

- *Computation in standard form games*: typically, the idea is to revisit usual game theory equilibrium concepts from the perspective of computation, i.e. to investigate the existence of constructive algorithms to compute an equilibrium (when the existence of the equilibrium itself already has been proved by game theorists). This type of problem contributed to launch the AGT field in the early 2000's. The first edition of the above-mentioned prize was incidentally awarded this year to Constantinos Daskalakis, Paul Goldberg and Christos Papadimitriou for their paper « The Complexity of Computing a Nash Equilibrium » [DGP08] (where the authors answer to open questions about the hardness of computing Nash equilibria).
- *Computation in compactly represented games*: the set of potential strategies for each player is here exponential in the size of the representation. This is the case, for instance, in combinatorial auctions [CSS06], where the bidders can bid on combinations of items or packages, and in networking games [ABEAJW06]. Networking games have crucial applications in congestion control and network routing in telecommunications. Combinatorial auctions also have been used in various application domains, among which strategic sourcing, that is, the process by which large companies strike contracts with their suppliers. According to Tuomas Sandholm (Carneggie Mellon University), foundator of CombineNet, Inc., the company have hosted over $40 billion of sourcing since 2000, and created over $5 billion of savings by using combinatorial optimization algorithms [San07].

The goal of the project is to actively contribute to AGT by focusing on the second type of issues. More precisely, we want to study the impact that can have an external entity that tries to lead compactly represented games (frequently encountered in practice) towards a socially optimal equilibrium. Indeed, selfish agents sharing a common resource will often converge towards an equilibrium where the resource is under-exploited. Thanks to appropriate incentives, one can make the system converge towards a more satisfactory equilibrium, and improve social welfare. For this purpose, relevant solution concepts and criteria must first be identified or brought. Then, our main concern will be the design of operational and efficient algorithms.

2. DESCRIPTION SCIENTIFIQUE ET TECHNIQUE / SCIENTIFIC AND TECHNICAL DESCRIPTION

2.1. ÉTAT DE L'ART / BACKGROUND, STATE OF ART

Combinatorial optimization appeared when the planning and the management of operations and the efficient use of resources became crucial. A lot of technical applications are modelled as combinatorial optimization problems: scheduling of production, portfolio selection, facility location, gene sequencing, cost efficient communication networks, etc. Actually a general combinatorial optimization problem Π is described as follows: Given a set Σ of feasible solutions and an objective function $f: \Sigma \rightarrow \Re$, find $S \in \Sigma$ such that $f(S)$ is optimal. Here Σ is a finite set whose cardinality is exponential in the size of Π. The huge number of solutions precludes an exhaustive search of an optimum. Therefore the existence and design of efficient algorithms, i.e. sub-exponential or ideally polynomial in the size of Π, is in the core of combinatorial optimization.

Let us introduce an example that we all face: What route should we take to work tomorrow? Given a transportation network including a source *s* (home) and a destination *d* (office), find the shortest route from *s* to *d*. Here Σ is all paths that link *s* to *d*. An efficient algorithm can solve this combinatorial optimization problem if the time to transit on every portion of the network is known and fixed. However the time required to travel depends crucially on the amount of traffic congestion, i.e. on the number of other commuters who choose interfering routes. Then one should take the choice of the other ones into account in order to reach its office as soon as possible.

As pictured by this example, and beyond the combinatorial aspect (which paths link *s* to *d*, which ones are the shortest), many practical applications are embedded in a strategic situation. That is, several agents share a common resource (the network in the example) and the global solution (the traffic in the example) is not designed by a unique and central entity. Instead, it is composed of each individual's choice. In addition the agents compete for the use of the resource. Since every agent should only, and rationally, be motivated by his own interest (which route from my home to my office is the shortest?), it appears particularly relevant to analyse systems where every agent behaves selfishly.

Recent works in Computer Science resort to Game Theory because this well established field attempts to mathematically capture behaviour in strategic situations, in which an individual's success in making choices depends on the choices of others. Game Theory is a branch of applied mathematics, which has a great impact in economics (several winners of the most prestigious prize in economics, the Nobel Memorial Prize in Economic Sciences, such as Nash and Aumann, have been rewarded for their work in Game Theory). According to Aumann, "game theory is a sort of umbrella or 'unified field' theory for the rational side of social science, where 'social' is interpreted broadly, to include human as well as non-human players". The interest for studies at the interface between Algorithmic and Game Theory is so strong that it gave birth to a new field called *Algorithmic Game Theory* (AGT) [NRTV07].

The most popular solution concept in Game Theory is probably the Nash equilibrium, introduced by John Nash [N51]. A *Nash equilibrium* is a stable situation in which no agent can unilaterally modify his choice and be better off. In the previous example, a Nash equilibrium is a situation in which no user can decrease his travel time by choosing another route. Many works have been devoted to the study of Nash equilibria. In Theoretical Computer Science, many recent works were interested in the complexity of finding a Nash equilibrium. Perhaps the most celebrated result in this area concerns the PPAD-completeness of computing Nash equilibria with two or more agents [CDT08, DGP08]. Many works study, for particular problems, distributed ways to converge towards a Nash equilibrium or approximate Nash equilibrium, and the time needed for this. (see e.g. [CS'07, EKM'07]).

Koutsoupias and Papadimitriou [KP99] introduced the concept *Price of Anarchy* (PoA) which captures the deterioration of the performance of a system due to the selfishness of its agents. Formally the PoA of a system is the largest ratio (over all the instances of the system) between the performance of the system at the worst possible Nash equilibrium ("worst" according to the overall performance of the system) and the optimal performance of the system. Thus, the closer the PoA is to 1, the least the consequences of selfish behaviour. For example the price of anarchy of the "home-to-office" problem may be the average travel time of an agent in the worst Nash equilibrium divided by the minimum possible average travel time. Since 1999, many works have studied the price of anarchy in compactly represented games. General bounds of inefficiency of equilibria were first proved in a model of selfish routing [RT02], where the agents are tasks in a network which choose their paths in order to minimize the arrival at their destination (see [NRTV07] for a survey). In order to minimize the price of anarchy *coordination mechanisms* [CKN04] were introduced in a scheduling setting. A coordination mechanism is a set of rules, one for each resource, which manage the way each resource is used by selfish users. Most work in this field was done for scheduling problems, where the agents are tasks and the resources are machines, each of the machines having a priority rule which gives the order in which the tasks will be scheduled (see e.g. [ILMS05, ABP08]).

The *price of stability* (PoS) is an optimistic vision of the system since it is defined as the ratio between the best Nash equilibrium and the best configuration (not necessarily a Nash equilibrium). It has been introduced in [ADKTWR04], where the authors studied a cost-sharing method in a network, i.e. a method which indicates how to share between several agents the cost of the links they use in the network. Here the set of Nash equilibria depends fundamentally on the choice of the cost sharing method. They studied a particular cost sharing method (Shapley's cost sharing) for which they show that the PoS is much better than the PoA, and that the best-response dynamics, a natural dynamic where users iteratively defect from a good starting solution, leads to a good Nash equilibrium. This establishes that the cost sharing method is in fact a useful mechanism for inducing strategic behavior to form near-optimal equilibria. For the same problem, [CRV08] studied several cost-sharing methods, and show that Shapley's cost sharing method is the best one. Another use of the PoS can consist, not in analysing the system and trying to design it in order to induce equilibria as good as possible, but considering a system in which a central authority propose the best Nash equilibrium to the agents, so that each of them has an incentive to follow the recommendation [PRT07, GMP08].

Another central issue occurs when agents have information that the system does not have. This leads to the field of *Algorithmic Mechanism Design*, started from the seminal paper of Nisan and Ronen [NR99]. The aim is here to design polynomial time algorithms which are truthful, that is with which agents do not have an incentive to lie about their private information. Most of the papers in this field study scheduling problems, and try to design truthful algorithms with the best possible approximation ratio (or to give negative results). A majority of these works use transferable payments in order to encourage the agents to reveal their true values. Note that Archer and Tardos [AT01] give a general property that truthful mechanisms using payments must have. A few works also consider truthful mechanisms in which payments are not allowed (e.g. [ABP06, CGP07] in a scheduling setting). Note that several chapters of the book [NRTV07] are devoted to Algorithmic Mechanism Design.

2.2. OBJECTIFS ET CARACTÈRE AMBITIEUX/NOVATEUR DU PROJET / RATIONALE HIGHLIGHTING THE ORIGINALITY AND NOVELTY OF THE PROPOSAL

As pointed out in the general description of the project and in the state of the art, two main components in Game Theory constitute the heart of the research conducted in this field: the way the game is designed (mechanism design) and, given this mechanism, the way the agents act (selfish agents, cooperative agents,…). In this second topic, the concept of Nash Equilibrium is central and AGT has concentrated a huge effort around this concept (difficulty of finding such an equilibrium, global performance of the system in an equilibrium,…) [NRTV07].

Our aim is to design new models and algorithms that can build solutions which combine performance of the overall system and a notion of stability for the agents involved. Of course, this is already partially captured by several notions mentioned before (PoA, PoS…) but we want to propose new and meaningful ways to deal with such problematic, ways that will enrich both the theoretical comprehension and the practical significance of Game Theory.

The main purpose of this project is to introduce and to study some ways to put reasonable constraints in the way the game works in order to make the global system more efficient. Let us introduce a seminal example due to Pigou [Pig20] in order to illustrate this idea. Consider a population of agents that want to go from one point to one another, with a choice between two routes (home to office). The first route takes one hour, whatever the number of people using it. On the second route, the time equals the proportion of individuals using it. For instance, if 50 percent of the population use this route, the time is half an hour. To minimize the average travel time in the population, half of the people should use the first route (one hour), and the other half the second route (half an hour). It yields an average time of 45 minutes. However, if the agents are selfish, no one will use the first route, and therefore the travel time will be one hour for everybody (Wardrop equilibrium [War52]). Clearly, the global efficiency of the traffic can here be improved by encouraging some people to use the first route (by establishing alternating traffic on the other route for instance). One of the first scopes of this project is to propose formal concepts capturing this kind of concern, and to apply them to discrete combinatorial problems.

More precisely, this can be seen as a way of slightly modifying the mechanism of the game (by compelling the choice of some agents in the previous example) to get a higher social benefit. In practice, we can easily see that several ways are commonly used to modify the situation in order to optimize the global benefit of the solution reached. Let us give again a few basic examples:

- *Trying to impose a strategy – or a small subset of strategies – to a subset of agents (as small as possible).* For instance, several agents may be not very sensitive to the outcome, or we can imagine several kinds of compensations for them. Then, considering that the other agents make their choices freely, an interesting question is to measure the efficiency of such a mechanism: would the society get some benefits from this? From an algorithmic viewpoint, how do we have to fix the strategies of these agents? For illustration, consider n agents who want to connect to a same hub. Each agent faces the following alternatives: either it connects directly to the hub for a given cost C (the same for each agent), or it connects to a "backbone" for a very small cost ε, and then endures an additional cost C/k inversely proportional to the number k of agents using the backbone, for an overall cost $\varepsilon+C/k$. Clearly, in such a situation, if one convinces a few agents to use the backbone, then everybody will use the backbone and it will benefit to everyone.
- *Modifying some of the inputs.* Consider for instance some classical game where each agent has to make a choice among a set of possible resources he can choose. Each resource has an economical cost (that may or may not be shared by the agents who choose it), but also an environmental cost (consider that resources are different types of energies for instance). Then, a public entity might want on the one hand to let the agents choose their own energy but on the other hand to minimize the global environmental impact. To achieve both goals, this entity may put some financial support to some of the resources, in order to make them more interesting for the agents. Then, given some limited budget (capacity of modifying the cost), the government wants to find the way of distributing its financial support in order to minimize the environmental global impact. This basic example can be easily transferred to some more complex games.
- *Introducing a new agent in the game.* Another way of influencing the outcome is to intervene directly as an actor in the game. For instance, when a public entity considers that the solution chosen by selfish agents is not satisfactory, it could enter the game as a

new agent which can participate to some bidding for instance (this is actually the case in many practical situations – city halls pre-empting a house when it considers that the price is too low – state intervening on the market during a financial crisis - …). Introducing this idea in AGT is a novel and promising research direction.

All these examples illustrate the concept of this project, which will be developed in Section 3, which aims at proposing and analysing models and algorithms to find a satisfactory combination of the agents' self-interests and the global performance of the system. This approach is original and deserve to our opinion to be largely investigated.

Combining combinatorial optimization, algorithmic and Game Theory is a recent topic but with great potential [Pap01]. Researches dealing with this topic has been recently conducted by a few members in the team "Combinatorial Optimization and Applications" of LAMSADE, since the arrival two years ago of Laurent Gourvès as a CR-CNRS. Laurent, which did a post-doc on this topic, introduced this problematic in the team and obtained some interesting preliminary results, most of them in collaboration with Jérôme Monnot, CR-CNRS in the same lab [GGMP07, GM08, GMP08]. This project aims at promoting the development of a perennial research activity in AGT in LAMSADE (marginal up to now), by proposing an original approach, and by constituting a "team" of young and dynamic researchers interested in from LAMSADE and LIP6.

3. PROGRAMME SCIENTIFIQUE ET TECHNIQUE, ORGANISATION DU PROJET / SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT MANAGEMENT

3.1. PROGRAMME SCIENTIFIQUE ET STRUCTURATION DU PROJET / SCIENTIFIC PROGRAMME, SPECIFIC AIMS OF THE PROPOSAL

The purpose of this project is to bring operational solutions that can avoid or minimize the inefficient use of a common resource. The long term goal is to constitute a toolbox of improving algorithms and draw a map stating which strategic situation can be improved and to what extent. This cartography would lie on the underlying combinatorial structure of the strategic situation. From now on, a combinatorial problem and its strategic context is called a CO-game. It is a game because we have several interacting and competing agents (at least two) on a common platform/resource (e.g. a network, a market, etc.). Each agent (also called "player") has a set of possible decisions (also called "strategies") and, following his own utility, he has to choose one. The platform being common, every agent is affected by the other's choice. No central entity is supposed to monitor the agent's decision: it is a sort of "anarchy". Then it is unlikely that they reach a configuration that satisfies each individual. The *social welfare*, capturing the overall performance of the system composed of the agents and the common resource, is supposed to be a given function. Typically, it is the average utility or the utility of the least "happy" agent.

The project is divided into four main tasks:

1. building a panel of representative games
2. improving the system's performance
3. generalizations and refinements
4. cartography of CO-games

The members of the COCA project are all involved in every task. Nevertheless, two leaders are assigned to each task. The leaders are responsible for the progress of their task.
We briefly review the content of each task.

Task 1: building a panel of representative games
co-leaders: Laurent Gourvès and Fanny Pascual
The goal is to identify a few paradigmatic combinatorial problems for which the strategic context where they arise is particularly relevant. Thus one has to set a few CO-games to be studied. Then, we will analyse the overall performance of these games when the agents behave selfishly. For example we shall determine the price of anarchy and the price of stability of these games (if not already known in the literature), when no tool is used to help the agents to collaborate, or interact in a way that maximizes the social welfare. This measure will allow us to determine the benefit of the approaches studied to improve the performances of the game.

Task 2: improving the system's performance
co-leaders: Jérôme Monnot and Fanny Pascual
The goal is to minimize the impact of selfish behaviours on the games selected during Task 1. In particular, we propose to investigate two original approaches:

1. the recommendation approach
2. the intervention approach

These approaches, which are the main part of the project's novelty, will be fully described in the sequel. One can see them as algorithms. We also would like to use other approaches but, due to the time limitation of the project, we do not focus on them.

Approaches to alleviate the system's deterioration are positive results. To draw a complete picture, it is also interesting to provide negative results. Another goal of Task 2 is to determine possible thresholds under which improving the system's performance is either impossible, or in contradiction with a desired property like stability.

Task 3: generalizations and refinements
co-leaders: Laurent Gourvès and Olivier Spanjaard
Task 2 is devoted to algorithmic tools to improve the system's performance. One of Task 3's goals is to explore generalizations and/or refinements.
We would like to explore meaningful solutions concepts which are closely related to the Nash equilibrium. In particular, relaxed notions of stability (e.g. ε-approximate Nash equilibria) would certainly help in reaching better performances for the system. Another direction would be to analyse the system if the agents can form coalitions and still behave

selfishly. Finally, issues related to important properties like truthfulness and fairness (which will be explained in the sequel) should be investigated.

Task 4: cartography of CO-games

co-leaders: Jérôme Monnot and Bruno Escoffier

There are maps of combinatorial optimization problems: NP-complete and polynomial problems. There are maps of NP-complete problems: approximable within every constant, approximable within some constants, etc. The aim of Task 4 is to begin the same kind of classification for CO-games. Which technique works well for which kind of CO-game and to what extent? What kind of CO-game is hard to improve? During this task we would like to get a high level vision of combinatorial optimization problems in their strategic context. It would be interesting to use reductions among games to extend our results to problems which were not selected during Task 1.

3.2. COORDINATION DU PROJET / PROJECT MANAGEMENT

The project involves five researchers who hold a permanent position in two different universities:

- University Paris Dauphine, in the laboratory LAMSADE ;
- University Pierre et Marie Curie, in the laboratory LIP6.

As explained in Section 5, these laboratories are close in terms of research as well as geographically. Hence, frequent meetings can be planed in a very simple way, leading to collaborations between members of the team from both laboratories (as a matter of fact, they already collaborated a lot, see Section 5).

Moreover, besides these "working meetings", we plan to organize every two months a one-day meeting for the five members of the team in order to get a global view of the overall development of this project (presentation of new results, new ideas for further research, new collaborations, …). This can be easily done thanks to the reasonably low number of persons involved in the project. A first "kick-off" meeting will be planed at the very beginning of the project.

As explained in Section 4, we also plan to organize two workshops (one after two years, and one at the end of the project). One of them will be held at the University Paris Dauphine, the other one at the University Paris 6.

The project is managed by Laurent Gourvès, who holds a full time researcher position at CNRS (CR), allowing a deep implication in both the scientific part and the coordination part of this project.

3.3. DESCRIPTION DES TRAVAUX PAR TÂCHE / DETAILED DESCRIPTION OF THE WORK ORGANISED BY TASKS

Each member is involved in every task but two leaders are assigned to each task. Let us give a detailed presentation of each task.

3.3.1. TASK 1: BUILDING A PANEL OF REPRESENTATIVE GAMES

co-leaders: Laurent Gourvès and Fanny Pascual
Combinatorial optimization consists of a huge number of problems. It is not possible to enumerate all these problems but one can classify them into categories: graph theory, network design, sets and partitions, sequencing and scheduling, logic, etc. The task is to select a few combinatorial problems, say at least one per category, which are paradigmatic. At this level, it is crucial to select combinatorial optimization problems for which taking the strategic context into account is particularly relevant. For these problems, it is important to know the system's performance if the agents behave selfishly. We now present some examples which could be selected in the panel.

Graph theory

We propose to study games based on *Matching* problems. A matching in a graph is a set of pairwise non adjacent edges. It is an important structure in combinatorial optimization which arises in a lot of practical situations. For example, matchings in bipartite graphs model a market with suppliers on one side and consumers on the other side (an edge represents a transaction). Markets are intrinsically combinatorial and they model highly strategic situations involving competing agents. It is noteworthy that we already started to study this problem in a particular context (cf [GMP08]) but much work must be done. Other graph problems like routing ones (i.e. when the graph represents a transportation network) should be inserted in the panel.

Sets and partitions

It seems judicious to study games based on the *Minimum Set Cover* problem. Given a collection C of subsets of a finite set S, a set cover for S is a subset $C' \subseteq C$ such that every element in S belongs to at least one member of C'. The goal is to minimize the cardinality of C'. The minimum set cover problem models many strategic situations where each element is an agent who wants to be covered by a set of C. Here, being covered means receiving a service. For example it models the energy problem mentioned in section 2.2.. Each element of S is an agent, each subset $E \in C$ is a type of energy and an agent belongs to E if he can receive energy of type E. The system's performance is the number of different types of energy that are used.
Surprisingly, only a few articles on the strategic version of the Minimum Set Cover problem exist and it seems important to pay more attention to it.

Scheduling

The panel would certainly contain games based on scheduling problems. Most of scheduling problems consist in assigning jobs to a pool of processors in order to optimize an objective function (completion time, number of late jobs, etc.). These problems, like many graphs problems, arise in numerous practical situations. Most of them are embedded in a strategic context. For example, jobs can belong to different agents who compete to be executed on the processors. Actually, scheduling problems are extensively studied in AGT due to their applications in networks. Nevertheless future directions of research need to be investigated.

3.3.2. TASK 2: IMPROVING THE SYSTEM'S PERFORMANCE

co-leaders: Jérôme Monnot and Fanny Pascual
Self-interested agents may not spontaneously reach a globally optimal configuration as interfering decisions and conflicting interests often lead to suboptimal performances. Knowing the PoA of the games selected during Task 1, the aim of Task 2 is to design algorithmic approaches to improve the system's performance. Our project is mainly based on two original approaches in AGT: the recommendation approach and the intervention approach. They consist in algorithms which return good Nash equilibria. Other promising approaches are given but these are more prospective directions of research; the project will give priority to the recommendation and intervention approaches.

The recommendation approach

The approach consists in building a global solution, i.e. a choice (or strategy) for each agent involved, and suggests it to the agents. Then, each individual can follow the recommendation or refuse it if not satisfactory. The idea is to construct a stable solution that no agent can reject (as long as all the other agents follow the suggested solution). This solution must also optimize the performance of the system.

Let us explain the concept for the "home-to-office" example: Build a path for each commuter such that:

1. no agent can unilaterally change his route and shorten his travel time (if all the others follow the recommendation)
2. the average transit time is minimized

The recommended solution should be accepted by all the agents. Thus it should be a Nash equilibrium. In addition, it should be as good as possible with respect to the system's performance. Ideally, we would like to determine the best Nash equilibrium but it is often hard from a computational perspective. From an algorithmic point of view, the approach matches the concept of the Price of stability.

Prior to the recommendation approach, there are theoretical questions that need to be investigated. Does the game always admit a (pure) Nash equilibrium? What is the computational complexity of finding such a stable solution?

A natural extension of the recommendation approach is to return a set of solutions instead of a singleton. A distribution of probability over this set is also given (the probability is 100% in case of a singleton). Again the recommended set of solutions should be accepted by each agent (if all the others follow the recommendation and according to the distribution of probability). Actually, this extension corresponds to a well known concept in game theory: *correlated equilibria* [A74]. The challenge is to propose algorithms which can return a good correlated equilibrium for every instance of the game.

Finally, negative results with respect to the approach should be given. Beyond existence issues, it is sometimes computationally hard to determine good (with respect to the system's performance) Nash equilibria. Putting evidence of that kind of phenomenon, together with (ideally matching) positive results, would draw a complete picture of the situation.

The intervention approach

The approach consists in selecting a fraction of the agents and impose a strategy to them. The agents whose strategy is not imposed are free to make their choice selfishly. The idea is to reduce the set of possible outcomes (all Nash equilibria) to a set of *induced equilibria* which show good performance of the overall system. Here, an induced equilibrium is such that each free agent cannot change his strategy and improve his utility.

The goal is to impose a strategy to a minimum number of agents (because it is costly or unpopular) such that a predefined rate of performance for the overall system is guaranteed.

Let us explain the concept for the "home-to-office" example: Build a path for some (as few as possible) commuters such that:

1. an agent whose route was fixed cannot change
2. the average transit time of any induced equilibrium is at most X times the minimum average transit time (X is given)

In fact, we would like to design algorithms which can return a kind of *Stackelberg equilibrium strategy* [S52]. This concept is well established in Game theory but it was not deeply investigated in combinatorial optimization. In Stackelberg games, one player acts as a *leader* (the central authority who impose a strategy to a subset of agents) and the rest as *followers* (those who are free to make their choice selfishly). Up to our knowledge, Stackelberg equilibria have been studied in continuous settings [R04, S07] but not in discrete optimization problems. Studying discrete problems is a very promising direction but the extension to discrete strategies does not seem straightforward.
Prior to the intervention approach, there is a theoretical question that need to be investigated: the goal being to minimize the number of agents whose strategy is fixed, can

we decide in polynomial time whether an instance requires an intervention or not? In other words, if no strategy is imposed, does the PoA equal 1 for this particular instance?
Finally, like for the recommendation approach, negative results should be given. For example, there may be games for which it is computationally hard to impose a strategy to Y times the minimum number of agents and ensure that any induced equilibrium is as good as the best Nash equilibrium (Y is given). Results of that kind would contribute to a draw a complete picture of the situation.

Other approaches

The following approaches are considered as optional.

- A known technique consists in fixing some rules to the system (e.g. fix the rule to share the resources used by selfish agents in a way that the social welfare is as high as possible). This method is usually known as *coordination mechanism* [CKN04, ILMS05], and a few works have studied such mechanisms for scheduling problems. It would be interesting to extend this technique to other CO-games if it is possible.
- Another approach would be to introduce fake agents who regulate the system (see Section 2.2). The idea is that the fake agents' strategy can make the other agents behave in a good way concerning the social welfare. Then many questions arise: how many fake agents do we need? Can these fake agents communicate? Does the game necessarily has a Nash equilibrium?
- Hybrid approaches can be introduced. The idea is to mix two (or more) approaches in order to take advantage of each one.

3.3.3. TASK 3: GENERALIZATIONS AND REFINEMENTS

co-leaders: Laurent Gourvès and Olivier Spanjaard
The aim of this task is to improve, extend or refine the algorithms designed during Task 2. To do so, we consider well established concepts and properties.

Relaxation of stability

In this project, CO-games are studied through their Nash equilibria because they are stable situations. However, pure Nash equilibria do not necessarily exist. Moreover, pure Nash equilibria are not the only state that the agents may reach if they behave rationally. It makes sense to suppose that an agent will not modify his strategy if the expected gain is negligible [LMM03, DMP06]. Then one can study approximate versions of this concept. That is, the agents are in an ε-approximate Nash equilibrium if none of them can change his strategy and improve his utility by a multiplicative factor $1+\varepsilon$. One can also investigate another notion of ε-approximate Nash equilibria: no agent can deviate from his current strategy and get more than ε plus his current utility.
Actually, even if the existence of a pure Nash equilibrium is guaranteed, it may correspond to a configuration which is very poor with respect to the social welfare. Then, relaxing the notion of equilibrium can help to reach higher performances of the system. It would be

interesting to design scalable algorithms which can return different tradeoffs between stability and performance of the system.

Strengthened notions of stability

The proposed direction is complementary to the previous notions of relaxed stability. Nash equilibria are immune to deviations by any single agent. However it is not immune to deviations by coalitions (i.e. sets of agents). Stronger notions of stability, like the *strong equilibrium*, were introduced by Aumann [A74]. Indeed, it often makes sense to suppose that a group of agents can collectively decide on their strategy in order to improve their respective utility. In a strong equilibrium, no subset of agents can deviate in a way where each member of the subset makes a positive profit. Therefore, it would be interesting to extend the approaches of Task 2 to strong equilibria. Interestingly, strengthened notions of stability can help in reaching higher performances since possible collaborations preclude mutual interfering decisions.
Unfortunately, many games do not have strong equilibria. The notion of k-strong equilibrium [AFM07] unifies Nash equilibria and strong equilibria. A k-strong equilibrium is resilient to deviations of coalitions of size at most k. In particular, 1-strong equilibria correspond to Nash equilibria and n-strong equilibria (where n are the number of agents) are the strong equilibria. Then, extending the approaches of Task 2 to k-strong equilibria (with k as big as possible) seems promising.

Fairness

Task 2 is devoted to the design of tools which can improve the system's performance, i.e. the social welfare. It would be interesting to know the agents who most benefit from the gain induced by the improvement. Ideally, we would like this gain to be distributed to the agents in a fair manner. In some strategic situations, being fair is very important if we want the solution to be stable. For the recommendation approach, one can imagine a situation where an agent refuses to follow the recommendation because most of the induced gain goes to his opponents though he cannot do better on his own. Then it would be valuable to refine the recommendation approach and propose a fair version of it.
It is noteworthy that many notions of fairness exist. Investigating several definitions of fairness seems a natural way to extend the tools produced during Task 2. In addition, fairness is a property but it can easily be turned into a criterion. Then it would be interesting to design scalable algorithms which can return different tradeoffs between fairness and performance of the system.

Truthfulness

For the sake of simplicity, we often assume that the input of the problem is completely known. However, in many strategic situations, each agent holds a part of the input, i.e. a private information. For example, in auctions, every bidder has his own valuation for the object auctioned for sale. Then, prior to any processing, one has to design a mechanism that

collects this private data. Each agent behaving selfishly, some of them may lie in order to improve their utility. With incorrect data, any improvement seems impossible and irrelevant. Being *truthful* is a valuable property, it guarantees that no agent has an incentive to lie on his private information. Then it would be interesting to refine the tools produced during Task 2 and propose truthful versions of it.
In Game theory, the main achievement in this direction is the well known Vickrey-Clarke-Groves mechanism [V61, C71, G73]. Truthfulness is also an appreciated property in Algorithmic Game Theory [NR99, CGP07].

3.3.4. TASK 4: CARTOGRAPHY

co-leaders: Jérôme Monnot and Bruno Escoffier
As mentioned above, combinatorial optimization consists of a huge number of problems so it is not possible to enumerate all of them. Fortunately, each time we study one of them, we usually do not have to start from scratch because problems sometimes show similarities. For example two combinatorial optimization problems are similar if their respective proofs of NP-hardness (if they are NP-hard) are based on the same idea. Moreover close problems are often efficiently solved/approximated by close algorithms. The similarity lies on combinatorial arguments. Powerful techniques like *reductions*, which help to transfer the knowledge of a problem to another similar one, greatly contributed to today's understanding of Combinatorial Optimization. Moreover, it is worth noticing that notions of reductions (linked to the difficulty of finding a local optimum, with the famous class of problems PLS) designed initially for combinatorial optimization problems turned out to be a useful tool for analyzing the corresponding CO-games.

The aim of Task 4 is to start a kind of classification for CO-games tackled from the perspective drawn in Task 2 (such a classification exists for combinatorial optimization problems). Which technique works well for which kind of CO-game and to what extent? What kind of game is hard to improve? During this task we would like to get a high level vision of combinatorial problems in their strategic context. It would be interesting to use reductions to extend our results to games which were not selected during Task 1.

The usual hierarchy of hardness for CO-problems will certainly be different when taking into account a strategic setting as in CO-games. Hence, the goal of this task is to find which features of the underlying problems are meaningful when considering the hardness of improving the performance of CO-games. For instance, minimum and maximum weight spanning trees are easy combinatorial problems but one can derive several games from them which have very different PoA from 1 - i.e. no deterioration of the system performance due to the selfish behaviours - to log(n) (where n is the size of the graph) [GM08]. On the other hand, a Sat game proposed in [GGMP07] show similarities between the PoA and polynomial approximation properties of Max Sat from which the game is derived.

3.4. CALENDRIER DES TACHES, LIVRABLES ET JALONS / PLANNING OF TASKS, DELIVERABLES AND MILESTONES

The schedule of the project, together with the beginning and duration of each task, are explained in the following chart.

months	Year 1		Year 2		Year 3		Year 4	
	6	12	18	24	30	36	42	48
Task 1	12 months long							
Task 2		24 months long						
Task 3			24 months long					
Task 4						18 months long		
Events	Kickoff meeting			One day workshop at LAMSADE				One day workshop at LIP6

4. STRATEGIE DE VALORISATION DES RESULTATS ET MODE DE PROTECTION ET D'EXPLOITATION DES RESULTATS / DATA MANAGEMENT, DATA SHARING, INTELLECTUAL PROPERTY AND RESULTS EXPLOITATION

Présenter les grandes lignes des modes de protection et d'exploitation des résultats.

The obtained results will be submitted for publication in top-rated international conferences and journals including AGT in their topics of interest, mainly in operations research and theoretical computer science (e.g. SAGT, EC, WINE, COCOON, SPAA for conferences, TCS, JACM for journals), but also in artificial intelligence (e.g. AAAI, IJCAI, AAMAS, ECAI for conferences). To promote an international recognition, we plan to organize two one day workshops on AGT in Paris, one in LAMSADE at mid-project and one in LIP6 at the end of the project.

5. ORGANISATION DU PROJET / CONSORTIUM ORGANISATION AND DESCRIPTION

5.1. DESCRIPTION, ADÉQUATION ET COMPLÉMENTARITÉ DES PARTICIPANTS / RELEVANCE AND COMPLEMENTARITY OF THE PARTNERS WITHIN THE CONSORTIUM

5.1.1 POSITIONS OF THE MEMBERS

Laurent Gourvès, Jérôme Monnot and Bruno Escoffier are permanent members of the "Combinatorial Optimization and Applications" pole of the LAMSADE. The LAMSADE is a research lab in computer science co-funded by CNRS and University Paris Dauphine (Paris 9). The "Combinatorial Optimization and Applications" pole focuses on approximation algorithms for hard problems, mathematical programming and management. Laurent, which did a post-doc on AGT, introduced this problematic in the pole when he integrated it as CR-CNRS (Senior researcher), and obtained some interesting preliminary results, most of them in collaboration with Jerôme, CR-CNRS in the same lab [GGMP07, GM08, GMP08]. Jérôme is an expert in theoretical computer science, and more specifically in computational complexity and approximation algorithms (54 international publications). Bruno is Maître de conference (Assistant professor) in the same team since September 2006, and he co-signed 6 papers with Jérôme in international journals or conferences, in the field of computational complexity and approximation algorithms.

Fanny Pascual and Olivier Spanjaard are permanent members of the DESIR department ("Decision making, Intelligent Systems and Operations Research") of the LIP6. The LIP6 is a research lab in computer science co-funded by CNRS and University Pierre and Marie Curie (Paris 6). Fanny integrated team "Operations Research" of department DESIR as Maître de conférence in September 2007. She holds a PhD in Algorithmic Game Theory (defended in October 2006), and already collaborated several times with Laurent on this topic (see 5.1.2). She is also co-author of a chapter dealing with AGT and Scheduling in a handbook of approximation algorithms and metaheuristics [Gon07]. Olivier belongs to team « Decision making » of department DESIR since 2004. His expertise area is algorithmic decision theory in general, and more particularly multiobjective combinatorial optimization. For six months, he has been responsible of a LIP6 project on decision with multiple agents on combinatorial domains, which has therefore strengthened his already existing interest in AGT.

As specialists of AGT, Laurent and Fanny will lead Task 1, whose results will influence the conduct of the whole project. Then, Fanny and Jérôme will lead Task 2, since they already obtained preliminary results in the research direction we are planning to follow. Task 3, which includes concerns of fairness and truthfulness, will be animated by Olivier and Laurent (the former already published on the subject of fairness [GS07]). Finally, the leadership of Task 4 is naturally given to Bruno and Jérôme, given their expertise in the study of complexity classes.

The proximity of the members, geographically as well as in their research interests, should lead to a fruitful and sustainable cooperation.

5.1.2. PAST COLLABORATIONS BETWEEN THE MEMBERS

The five members of the project are active in several research domains, in particular in combinatorial optimization, in game theory and in algorithmic decision aiding. Beside their current collaborations, they had, for several years, many opportunities to work together.

Indeed, Fanny Pascual and Laurent Gourvès did their PhD within the same team of the research lab in computer science of the university of Evry, they spent six months together at the university of Athens where they worked on Algorithmic Game Theory with Greek researchers.
Bruno Escoffier, Olivier Spanjaard and Jérôme Monnot did their PhD in the LAMSADE. Olivier was in the decision aiding team while Bruno and Jérôme were in (and still belong to) the Combinatorial optimization team. Both Olivier, Bruno and Laurent collaborated with Jérôme during their PhD.

As a matter of fact, the five members of the project already produced many articles published in highly selective international journals and conferences:

- Combinatorial optimization, and especially devising approximation algorithms for solving hard combinatorial optimization problems, has been an intense research topic for Bruno Escoffier, Jérôme Monnot and Laurent Gourvès. In combinatorial optimization, joint works has lead to several articles [GLMM09, CGMT08, EGM07, DDEMP08, EM08, EMP06, EMP06b]. They also wrote together several book chapters [ES05, DEMPW08, DELMPW08] (the first one with Olivier Spanjaard).
- In AGT, Laurent Gourvès, Fanny Pascual and Jérôme Monnot are in active collaboration. They already published in this field several joint articles in international journals and conferences [GM08, GMP08, CGP07, GGMP07].
- Algorithmic decision aiding include several topics (robust analysis, multicriteria decision aiding, preference modelling,…) that are in the heart of the research of Olivier Spanjaard, and in which Jérôme Monnot, Laurent Gourvès and Bruno Escoffier are also interested. Collaborations between them produced several articles [MS03, ABGM05, EMS08], as well as a book chapter [ABGM08].

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[DELMPW08] Weighted Edge Coloring. M. Demange, B. Escoffier, G. Lucarelli, J. Monnot, V. Th. Paschos and D. de Werra, Chapter 11 of the book *Combinatorial optimization - Theoretical Computer Science: Interfaces and Perspectives,* Iste - Wiley and Sons, pages 291-318, John Wiley Publisher, 2008
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Collaborations in Games

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5.2. QUALIFICATION DU PORTEUR DU PROJET / QUALIFICATION OF THE PRINCIPAL INVESTIGATOR

Laurent Gourvès did his PhD thesis under the supervision of Pr. Evripidis Bampis and Pr. Eric Angel (University of Evry). The topic was Multiple objective combinatorial optimization. He was involved in a France-Berkeley project named *"MULT-APPROX: Multiobjective Optimization and Approximation"* (Pr. Christos H. Papadimitriou for Berkeley and Pr. Bampis for France) and in the European thematic network APPOL II (IST-2001-32007) on Approximation and on-line algorithms. He defended in november 2005.

During the year 2006 Laurent Gourvès did a post-doc at the university of Athens. The topic was on Algorithmic Game Theory. During his stay he collaborated with Professor Elias Koutsoupias and George Christodoulou.

Laurent Gourvès holds a permanent position at CNRS (Chargé de recherche) since November 2006. He conducts his research within the "Combinatorial optimization and applications" pole of the LAMSADE. As soon as he joined the LAMSADE, Laurent Gourvès contributed to introduce AGT as a promising topic of research of his pole. He collaborated with Vangelis Paschos (Chair of the LAMSADE), Jérôme Monnot (Chargé de recherche CNRS at LAMSADE) and Aristotelis Giannakos (Associate Researcher at LAMSADE). He is currently conducting other collaborations with Bruno Escoffier (Assistant Professor at LAMSADE), Jérôme Monnot, Fanny Pascual (Assistant Professor at the university Pierre & Marie Curie), Eric Angel and Evripidis Bampis.

Laurent Gourvès is fully involved in his research project since he also teaches Combinatorial Optimization at ENSTA (Ecole Normale supérieure des Techniques avancées) since 2007 and AGT at the University of Paris Dauphine since 2006 (Master 2 research).

Until now he has collaborated with 14 researchers (four of them are foreigners and work abroad, the others hold a position in France). He is the author of 12 international conference papers, 5 international journal papers and 4 book chapters.

Since November 2006 Laurent Gourvès is one of the four members of the JFRO board ("journées franciliennes de la recherche opérationelle"). The JFRO board organizes 3 one day research seminars per year around Paris. Each seminar is dedicated to a sub-field of Operations Research or to a fruitful methodology in Operations Research.

5.3. QUALIFICATION, ROLE ET IMPLICATION DES PARTICIPANTS / CONTRIBUTION AND QUALIFICATION OF EACH PROJECT PARTICIPANT

	Nom	Prénom	Emploi actuel	Unité de rattachement et Lieu	Discipline*	Personne.Mois (par an)	Rôle/Responsabilité dans le projet
Coordinateur	Gourvès	Laurent	CR2-CNRS	LAMSADE – CNRS et Université Paris 9		9.6	Co-leader of Task 1 and Task 3

Autres membres	Monnot	Jérôme	CR1-CNRS	LAMSADE – CNRS et Université Paris 9		5	Co-leader of Task 2 and Task 4
	Escoffier	Bruno	MCF	LAMSADE – CNRS et Université Paris 9		3.6	Co-leader of Task 4
	Pascual	Fanny	MCF	LIP6 - CNRS et Université Paris 6		3.6	Co-leader of Task 1 and Task 2
	Spanjaard	Olivier	MCF	LIP6 - CNRS et Université Paris 6		4.2	Co-leader of Task 3

* à renseigner uniquement pour les Sciences Humaines et Sociales

6. JUSTIFICATION SCIENTIFIQUE DES MOYENS DEMANDES / SCIENTIFIC JUSTIFICATION OF REQUESTED BUDGET

6.1. ÉQUIPEMENT / EQUIPMENT

The project does not need any specific high cost equipment. We ask for 4 laptops, of an estimated cost of 1 500 euros each, leading to a global cost of 6 000 euros.
In the "document de soumission A", this amount is taken into account in the column "autres dépenses de charge externe".

6.2. PERSONNEL / STAFF

The team of the project is constituted by five permanent researchers: Laurent Gourvès (CR-CNRS, holder of the project), Jérôme Monnot (CR-CNRS) and Bruno Escoffier (MCF) from LAMSADE, Université Paris Dauphine, Fanny Pascual (MCF) and Olivier Spanjaard from LIP6, Université Pierre et Marie Curie.
In the following tabular we give the implication (in percentage and in person.months) of each member of the team and the corresponding salary costs (part of the salary devoted to the project).

Team members	Affiliation	Status	%	P.M./year	Cost/year	P.M total	Total cost
Laurent Gourvès	LAMSADE	CR2	0,8	9,6	40 800	38,4	163 200
Jérôme Monnot	LAMSADE	CR1	0,42	5	27 500	20	110 000
Bruno Escoffier	LAMSADE	MCF	0,3	3,6	4 800	14,4	19 200
Fanny Pascual	LIP6	MCF	0,3	3,6	4 800	14,4	19 200
Olivier Spanjaard	LIP6	MCF	0,35	4,2	7 875	16,8	31 500
Total			**2,17**	**26**	**85 775**	**104**	**343 100**

In order to improve the amount of time and effort devoted to the project, we apply for a Post-Doctorate student for a period of 2 years. The corresponding cost is 49 000*2=98 000 euros. This Post-Doc student will be chosen after an international announcement.

Moreover, both LAMSADE and LIP6 manage a Master of research dealing with combinatorial optimization. We apply for 4 master fellowships of 4 months each. The full cost is 8400/12*4*4=11 200 euros.

Finally, to allow a deeper implication of the Maîtres de Conférences involved in the project, we apply for a reduction of their teaching duties ("compensation des services d'enseignements"): 96 hours for each of the three MCF (for the whole project), equivalent to one semester without teaching. The corresponding cost is 3*10 000= 30 000 euros.

6.3. PRESTATION DE SERVICE EXTERNE / SUBCONTRACTING

No expense

6.4. MISSIONS / MISSIONS

In order to highlight the results obtained in this project, the members will participate to international workshops and conferences. We ask for an average of one mission per year and per person (including the post-doc student). Considering a total cost of 1 500 euros per mission, the global cost asked is: 1 500*22 = 33 000 euros.

6.5. DEPENSES JUSTIFIEES SUR UNE PROCEDURE DE FACTURATION INTERNE / INTERNAL EXPENSES

No expense for inward billing.

6.6. AUTRES DEPENSES DE FONCTIONNEMENT / OTHER EXPENSES

As mentioned in the description of the project, we plan to organize two workshops during this project: one after two years, and one after four years. Each of them will take place in Paris, during one day. We estimate the cost of each workshop (including travel expenses of invited researchers) at 5 000 euros. Hence, the estimated global cost is 10 000 euros.
In the "document de soumission A", this amount is taken into account in the column "autres dépenses de charge externe".

7. ANNEXES

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7.2. BIOGRAPHIES / CV, RESUME

Laurent GOURVÈS

Current position: CNRS researcher (Chargé de recherche 2eme classe)

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Short bio: Laurent Gourvès received the Ph.D. degree in Computer Science in november 2005 from Université d'Evry Val d'Essonne. He made a post-doc in Athens University and became CNRS researcher (permanent position) in november 2006.

Research interests: Laurent Gourvès is mainly interested in Combinatorial Optimization, Algorithmic Game Theory, Approximation Algorithms and Multiple Criteria problems.

Main responsibilities and activities:

- Member of the organizing board of JFRO (journées franciliennes de la recherche opérationnelle)
- Referee for WAOA, WEA, STACS, ISAAC, Journal of scheduling, Revue d'Intelligence Artificielle

Selected publications: He is author of 17 research publications including 5 refereed international journals and 12 refereed international conferences proceedings. He is also author of 4 book chapters.

Here are five important publications during the last five years.

[1] B. Escoffier, L. Gourvès, J. Monnot, "Complexity and approximation results for the connected vertex cover problem", Proceedings of WG 2007, LNCS 4769, Springer, 2007. Extended version accepted for publication in Journal of Discrete Algorithms.

[2] L. Gourvès, J. Monnot, F. Pascual, Cooperation in multiorganization matching, to appear in the proceedings of WAOA'08, LNCS, Springer, 2008.

[3] L. Gourvès and J. Monnot, Three selfish spanning tree games, to appear in the proceedings of WINE'08, LNCS, Springer, 2008.

[4] A. Giannakos, L. Gourvès, J. Monnot, V. Th Paschos, On the performance of congestion games for optimum satisfiability, In Proc. of WINE 2007, LNCS 4858, Springer, 2007.

[5] G. Christodoulou, L. Gourvès and F. Pascual, Scheduling Selfish Tasks: About the Performance of Truthful Algorithms, In Proc. of COCOON'07, LNCS 4598, 187–197, 2007.

Jérôme MONNOT

Current position: Senior researcher (chargé de recherche) (1st class) at CNRS (Centre National de la Recherche Scientifique) and Université Paris-Dauphine

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Short bio: Jérôme Monnot received the Ph.D. degree in Computer Science and Operations Research in 1998 and Habilitation thesis in 2003 from Université Paris-Dauphine. He became chargé de recherche at CNRS in 2001.

Research interests: Jérôme Monnot is interested in Complexity Theory, Approximation of hard problems, Combinatorial Optimization, Multicriteria optimization, Robust problems, Reoptimization, Game Theory and more generally in Operations Research.
Main responsibilities and activities:

- Organiser of the Working Group on "Algorithmique à garanties de performances (AGAPE) ", GDR RO 3002 CNRS.
- Referee for the Mathematical Reviews database.
- Referee for WAOA, WEA, STACS, ISAAC, SODA, CPM, Journal of scheduling, EJOR, DM, DAM, ORL, IPL, JOCO, OR, TCS, Annals of OR, Ars Combinatoria, Discussiones Mathematicae Graph Theory, Optimization Methods and Software.

Selected publications: He is author of 54 research publications including 32 refereed international journals and 22 refereed international conferences proceedings. He is also author of 1 book and 8 chapter books.

Here are five important publications during the last five years.

[1] B. Escoffier, J. Monnot, et O. Spanjaard, « Some tractable instances of interval data minmax regret problems », *Operations Research Letters,* 36, p : 424-429, 2008.

[2] L. Gourvès, J. Monnot, et F. Pascual « Cooperation in multiorganization matching » Proc. WAOA. 08, LNCS, 2008. (to appear).

[3] B. Couetoux, L. Gourvès, J. Monnot, et O. Telelis « On Labeled Traveling Salesman Problems » Proc. ISAAC. 08, LNCS, 2008. (to appear).

[4] R. Hassin J. Monnot, et D. Segev « The Complexity of bottleneck Labeled graph problems » Algoritmica, 2008 (to appear).

[5] L. Gourvès, A. Lyra, C. Martinhon, et J. Monnot « The minimum reload s - t path/trail/walk problems » Proc.SOFSEM. 09, LNCS , p: , 2009. (to appear).

Bruno ESCOFFIER

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Short bio: Bruno Escoffier holds master diplomas in Computer Science from the Université Paris 6 and in Science and Executive Engineering from the Ecole des Mines de Paris; he received its Ph.D. in Computer Science in November 2005 from the Université Paris Dauphine. He is since September 2006 Maître de Conférences (Assistant Professor, permanent position) in the team “Combinatorial Optimization and applications” of Lamsade, Université Paris Dauphine.

Research interests: Bruno Escoffier is mainly interested in Combinatorial Optimization and Operations Research, more precisely in algorithmic complexity, in the development of exact or approximate algorithms for solving hard combinatorial problems, in dynamic and on-line computation, as well as in several aspects of algorithmic decision aiding.

Main responsibilities and activities:

- Member of program committee of two French conferences (Majecstic 04 and 05),
- Member of the organizing committee of two international workshops (Computer Science and Decision Theory, 2004, and Voting Theory and Preference Modelling, 2006, both at Université Paris Dauphine).
- Member of the organizing board of JFRO (journées franciliennes de la recherche opérationnelle) since 2006.
- Referee for international journals (ACM TALG, Algorithmica, TCS, DAM,…) and conferences (ESA, ISAAC, MFCS, WEA,...).

Selected publications: Bruno Escoffier is the author of 1 book, 5 book chapters, 13 articles in International Journals and 11 refereed international conferences proceedings.

Here are five important publications during the last five years.

[1] B. Escoffier, L. Gourvès, J. Monnot, “Complexity and approximation results for the connected vertex cover problem”, *Proceedings of WG 2007*, LNCS 4769, Springer, 2007. Extended version accepted for publication in *Journal of Discrete Algorithms*.

[2] B. Escoffier, J. Monnot and O. Spanjaard. Some tractable instances of interval data minmax regret problems. *Operations Research Letters* 36 : 424-429, 2008.

[3] B. Escoffier and J. Monnot. A better differential approximation ratio for symmetric TSP. *Theoretical Computer Science* 396(1-3) : 63-70, 2008.

[4] D. de Werra, M. Demange, B. Escoffier J. Monnot and V. Th. Paschos.Weighted coloring on planar, bipartite and split graphs : complexity and approximation. *Proc. ISAAC’04*, LNCS 3341, 896-907, 2004. Extended version accepted for publication in *Discrete Applied Mathematics.*

[5] G. Ausiello, B. Escoffier, J. Monnot and V. Th. Paschos. Reoptimization of minimum and maximum travelling salesman’s tour. *Proc. SWAT’06*, LNCS 4059, 196-207, 2006.

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Short bio : Fanny Pascual received a Ph. D. in Computer Science in october 2006 from Université d'Evry. She spent one semester in Athens University in spring 2006, and she has been an INRIA post-doc in Grenoble in 2006-2007. She became Maître de Conférences in Université Pierre et Marie Curie (Paris 6) in 2007.

Research interests: Combinatorial Optimization, Algorithmic Game Theory, Operations Research.

Main responsibilities and activities:

- Organization of the meetings of the research group GoTHA (Groupe de recherche en Ordonnancement Théorique et Appliqué) of the GDR RO
- Referee for Euro-Par, WAOA, WEA, Fun with algorithms, Computers & Operations Research, RAIRO.RO, IEEE Transactions on Parallel and Distributed Systems (TPDS), IEEE Transactions on Mobile Computing (TMC).

Selected publications: She is author of 6 refereed international journals, 9 refereed international conferences proceedings, and one chapter book.

Here are five important publications during the last five years.

[1] F. Diedrich, K. Jansen, F. Pascual, D. Trystram, “Approximation algorithms for scheduling with reservations”**,** to appear in *Algorithmica,* 2008.

[2] L. Gourvès, J. Monnot, F. Pascual, “Cooperation in Multi-Organization Matching”**,** *6th Workshop on Approximation and Online Algorithms (WAOA 2008),* LNCS, 2008.

[3] G. Christodoulou, L. Gourvès and F. Pascual, “Scheduling Selfish Tasks: About the Performance of Truthful Algorithms”, In Proc. of *Computing and Combinatorics, 13th Annual International Conference (COCOON 2007)*, LNCS 4598, 187–197, 2007.

[4] F. Pascual, K. Rzadca, D. Trystram. “Cooperation in Multi-Organization Scheduling”, *Concurrency and Computation: Practice and Experience (Special issue of Euro-Par’07, LNCS 4641, 224-233),* to appear.

[5] E. Angel, E. Bampis, F. Pascual, “Truthful algorithms for scheduling selfish tasks on parallel machines”, *Theoretical Computer Science*, Vol. 369, 157-168, 2006.

Olivier SPANJAARD

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Short bio: Olivier Spanjaard received the Ph.D. degree in Computer Science in 2003 from Université Paris-Dauphine. He became Maître de Conférences in 2004 in Université Pierre et Marie Curie.

Research interests: Olivier Spanjaard is mainly interested in Operations Research, Artificial Intelligence, Multiobjective Optimization and Optimization with multiple scenarios or agents. He is interested in theoretical and practical aspects of these fields.

Selected publications: He is author of 17 international publications including 5 refereed international journals and 12 refereed international conferences proceedings. He is also author of 1 book chapter.

Here are five important publications during the last five years.

[1] F. Sourd and O. Spanjaard, "A multi-objective branch-and-bound framework. Application to the bi-objective spanning tree problem", *INFORMS Journal on Computing*, 20(3), 472-484, 2008.

[2] B. Escoffier, J. Monnot and O. Spanjaard, "Some tractable instances of interval data minmax regret problems", *Operations Research Letters*, 36, 424-429, 2008.

[3] P. Perny and O. Spanjaard, "Near Admissible Algorithms for Multiobjective Search", *18th European Conference on Artificial Intelligence (ECAI 2008)*, 490-494, 2008.

[4] P. Perny, O. Spanjaard et L.-X. Storme, "State Space Search for Risk-averse Agents", *20th International Joint Conference on Artificial Intelligence (IJCAI 2007)*, 2353-2358, 2007.

[5] P. Perny, O. Spanjaard and L.-X. Storme, "A decision-theoretic approach to robust optimization in multivalued graphs", *Annals of operations Research*, 147(1), 317-341, 2006.

7.3. IMPLICATION DES PERSONNES DANS D'AUTRES CONTRATS / INVOLVEMENT OF PROJECT PARTICPANTS TO OTHER GRANTS, CONTRACTS, ETC...

The members of the COCA project are involved in other projects which are ongoing, under evaluation or almost finished. The name of these projects are:

- PHAC : Preference Handling and Aggregation on combinatorial domains
- GUEPARD : GUaranteed Efficiency for PAReto optimal solutions Determination in multiobjective combinatorial optimization problems
- ComSoc : Computational social choice
- TODO : Time versus optimality in discrete optimization
- DOCCA : Design and Optimization of Collaborative Computing Architecture

The PHAC project will end this year (in orange in the following table). The DOCCA project is ongoing (in blue in the following table). Finally, GUEPARD, TODO and ComSoc are submitted this year (in grey in the following table).

Part.	Nom de la personne participant au projet	Personne . mois	Intitulé de l'appel à projets Source de financement Montant attribué	Titre du projet	Nom du coordinateur	Date début & Date fin
N°1	Gourvès Laurent	9	ANR, Programme Blanc 390k€, Under evaluation	GUEPARD	Patrice Perny	2009-2012
N°1	Escoffier Bruno	26.4	ANR, Programme Blanc 692k€, Under evaluation	TODO	Vangelis Th. Paschos	2009-2012
N°1	Escoffier Bruno	5.4	ANR, Programme Blanc 338k€, Under evaluation	ComSoc	Denis Bouyssou	2009-2011
N°1	Jérôme Monnot	12	ANR, Programme Blanc 692k€, Under evaluation	TODO	Vangelis Th. Paschos	2009-2012
N°1	Jérôme Monnot	15	ANR, Programme Blanc 390k€, Under evaluation	GUEPARD	Patrice Perny	2009-2012
N°2	Olivier Spanjaard	19	ANR, Programme Blanc 390k€, Under evaluation	GUEPARD	Patrice Perny	2009-2012
N°2	Olivier Spanjaard	12	ANR, Programme Blanc 155k€	PHAC	Jérôme Lang	2006-2008
N°2	Olivier Spanjaard	5.4	ANR, Programme Blanc 338k€, Under evaluation	ComSoc	Denis Bouyssou	2009-2011
N°2	Fanny Pascual	9	ANR, Programme Blanc 390k€, Under evaluation	GUEPARD	Patrice Perny	2009-2012
N°2	Fanny Pascual	24	ANR, Jeune chercheurs 150 k€	DOCCA	Florence Perronnin	2007-2010