Programme BLANC
Document de Soumission B

Edition 2009

November 17, 2008

Acronyme	*JEDY&CO*
Titre du projet en français	**JE**ux **D**ans les s**Y**stèmes dymaniques et **CO**nvergences
Titre du projet en anglais	Games in dynamic systems and Convergences
CSD principale	[x] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9
CSD secondaire (*si interdisplinarité*)	[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

Contents

1 Contexte et positionnement du projet / context and positionning of the proposal

More and more distributed systems include agents that interact in various and varying degrees of collaboration and competition. For example, in telecommunication protocols, inter-domain routing often involves routes that belongs to commercial companies whose benefits are function of the involved traffics, and hence function of a global competition. As another example, in the computational grid tasks must often be scheduled on machines, that may belong to several organizations that have their own objectives. This may lead to globally sub-optimal load balancing situations resulting of the competition between organizations that have to optimize their own objectives.

Most of solutions in distributed systems have been conceived with the classical tools of distributed algorithms. Classical distributed algorithms consider that agents may be faulty, but that non-faulty agents are all contributing to a common social objective. In the last ten years, many works were devoted to reconsider several algorithms or constructions with more realistic hypotheses upon agents, taking into considerations that they may be independent agents with economic or own profits, using Game theory.

Game theory is indeed a natural tool to study theses systems, as it is a branch of mathematics that aims at predicting toward which situation(s) should be a set of rational partners will converge in a competition [**?**].

Game theory introduces several notions of equilibria, that aims at modeling situations where all individual players act in accordance with their selfish interest. In particular, a Nash Equilibrium is a configuration in which no rational partner has some unilateral incentive to depart: if the choices (called strategies in this theory) made by its opponents are kept fixed, no player has a benefit in changing unilaterally his/her own strategy. Since the introduction of this concept by Nash in [**?**], many variants of this notion of equilibrium have been proposed and studied: see for e.g. perfect equilibria [**?**], proper equilibria [**?**], sequential equilibria [**?**], stable equilibria [**?**] ...etc): see *e.g.* [**?**].

Game theory, that comes originally from Mathematics and Economics, is distinguished from Algorithmic Game Theory. Indeed, most historical developments of classical theory have been obtained without any consideration of effectiveness. Algorithmic Game Theory, which is mainly less than 10 years old, aims at revisiting constructions from a complexity and distributed algorithmic point of view. For example, while Nash theorem establishes that a mixed equilibrium always exist using Brouwer fix point theorem, there is no guarantee that it can be computed, and even if it is computable, that it may be computed efficiently or piratically by players.

Given the description of a system, the problem of **computing its equilibria** is the problem of determining the situations that should be reached if all partners were rational. A lot of attention has been put recently to this problem, by considering several situations and several constraints, for example in the fields of networks or scheduling [**?**]. The problem of computing equilibria from a theoretical complexity point of view has also received much attention in the last five years: see e.g. surveys [**?**, **?**]. However, most of these studies *require a full description of the system* in order to compute the equilibria, and consider mostly *centralized (i.e. non-distributed) algorithms.*

Now, a system may have several equilibria, but all of them are often not equivalent for the global efficiency.

Given the description of a system, **the evaluation of equilibria** is the hard problem of comparing equilibria. If an equilibrium is not Pareto optimal, meaning that the players' payoffs can all be increased, this is clear that the equilibrium is not desirable. But, a system may have many Pareto optimal situations - situations that cannot be improved upon without hurting at least one player- but with non equivalent individual or social outcomes. Equilibria can be compared for instance according to the fairness between partners, using measures like the Jain index [**?**], or variants of price of anarchy or of stability that are ratio introduced to quantify the lost induced by competition with respect to an ideal cooperation. See *e.g.* [**?**, **?**] [1]for surveys with numerous references on the subject. These notions are often *global notions*, that *cannot be computed locally, and hence used locally in a implementation of a distributed system.*

The design of distributed algorithms is classically done in order to guarantee that the final state reached by agents is the expected one, i.e. is correct. As we said, it has been observed in the last decade that several applications coming from distributed systems involve naturally competitions between agents, and hence can be modeled by game theory. Several distributed problems have been revisited under this aspect. But most of the attention have been put up to this day to guarantee that final states correspond to equilibria, and hence to rational situations, but *ignoring if these situations of equilibria can be reached by the distributed system*, i.e. *can be reached by agents using only local information.* Indeed, in distributed systems, players generally correspond to agents, that do not have or cannot have a global view of the system. This means that the equilibria, and possibly the best equilibrium, must be computed in a distributed fashion, without information that are non-local to agents.

Since some/most notions of equilibria from game theory are global notions, and hence can not be computed exactly with only local information, this forces to relax the considered notion of equilibria to more approximate notions. For example, whereas it may be difficult to guarantee that a system is globally in an Nash equilibrium, it may be possible to guarantee that the situation reached is such that any agent is locally in an equilibrium with all its neighbors. [2]

This project proposes to give answers to the following problems:

- In applications coming from distributed systems, chosen in the context of situations where some agents compete for common resources, determine whether some equilibrium be computed in a distributed fashion. This means: determine whether the agents can be designed such that the system evolves globally to states that correspond to some notion of equilibria. Describe the notions of equilibria that can be computed in such a way.

- Determine whether good/expected equilibria can be computed in a distributed fashion. That is to say, determine whether there is a way to guarantee the evolution towards efficient equilibria, for various notions of efficiency considered in literature.

- Discuss the quality of the obtained solutions. First, understand what is the complexity of solutions from a complexity point of view: characterize when this is possible to some polynomial time algorithms. Determine bounds on the time required before reaching some equilibria, or a situation close to equilibria. Second, understand what are the guarantees given by the proposed algorithms: explicit the relations between reached situations, and the ones that would have been obtained using exact notion of equilibria and centralized algorithms.

Considered applications will be chosen among problems coming from scheduling applications in the computational grid and from interdomain routing, using the fields of expertise of involved partners.

[1] better/morerecent ref?
[2] ok? citer graphical games?

2 Description scientifique et technique / scientific and technical description

2.1 Etat de l'art / Background, state of the art

(2 pages maximum)

*Presenter un **etat de lart national et international** dressant letat des connaissances sur le sujet et decrivant le **contexte et les enjeux scientifiques**dans lequel se situe le projet.Faire apparaitre deventuels resultats preliminaires.*

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This context of game with local view (local in the sense of a distributed system) is not so standard in literature.

Other game theoretic models These fields of applications have already been considered in game theoretic settings for several other applications.

In particular, a general and now classical theoretical setting for load balancing has been introduced in [**?**]. Tasks or jobs (players) whose objective is to minimize their own cost must be mapped to servers. Such games are sometimes called the *KP model* [**?**, **?**]. This model can also be formally defined as a routing problem between two nodes connected by parallel edges with possibly different speeds. Each agent has an amount of traffic to map to one of the edges such that the load on this edge is as small as possible [**?**]. Wardrop network[**?**][3]can be considered as a generalization of this model.

These models have essentially been studied from a general complexity theoretic point of view, sometimes as toy examples.

Some authors involved in this proposal have already considered more specific applications related to the fields of applications proposed here. Works [**?**, **?**] consider the dual settings where players correspond to resources (like servers, routers) in the context of some network or computational grid applications. In [**?**] players correspond to servers and not to tasks in a load balancing problem. In [**?**] the problem is to concurrently schedule multiple applications on an heterogeneous network of computers in a computational grid. In [**?**], nodes are considered as players and aim at making profits from their incoming traffic.

[3] ref?

More generally, many game theoretic settings have been discussed in the context of wireless networks[4], or in network contexts. In most of these studies, in the spirit of classical game theory, the problem is often to model a situation as a game, and then use the concepts of equilibria from game theory to derive what will be the rational situations. [5]

From an abstract complexity point of view, the hardness of computing the equilibria of a game is now rather well understood[**?**], and one can say that most of the work done so far using game theory in these application domains is about computations of equilibria of particular games, with constraints specific to considered applications.

Measuring quality of equilibria Various quantities have been introduced to quantify efficiency of equilibria. For example, Price of anarchy, introduced by [**?**], comparing cost of Nash equilibria to cost of the optimal (social cost) has been intensively studied on the KP model: see e.g. [**?**] for a reference introduction. This has been extended to Wardrop network games [6], or to above mentioned extensions of the KP model [7]. [8]

Computing equilibria in a distributed fashion? However, in all above works, equilibria are not assumed to be computed locally: from a global description of the system, using the considered (usually global) notion of equilibria, one analytically derives what should be the situation(s) assuming that agents are rational. In the spirit of most classical game theory, one does not really discuss how agents can evolve in order to reach such a situation.

In that sense, when we said that the hardness of computing the equilibria of a game is now rather well understood[**?**], the notion of computation involved is the notion of centralized algorithm: that is to say, about (non-distributed) algorithms which are intended to take a description of the system and output a description of its equilibria.

When designing a distributed system, an important problem is to understand if distributed agents can be programmed such that the system evolves towards equilibria. Only a few works have been devoted to this problem.

Computing equilibria by learning A first way to compute equilibria is to use the theory of the learning of equilibria in classical game theory. In classical *game theory*, various algorithms for learning equilibrium states have been proposed: games with perfect, complete or incomplete information, with a restricted number of players, etc... See e.g. [**?**] for an introduction to the learning automata model, and the general references in [**?**] for specific studies for zero-sum games, N-person games with common payoff, non-cooperative games, etc...

However, most of the previous approaches cannot be implemented in a distributed system: for example, *dummy player approaches* require to maintain a global view of the system, as well as an full history of the system.

In the KP model, it has been observed that the proof of existence of a pure Nash equilibria can be turned into a dynamic: players play in turn, and move to machines with a lower load. Such a strategy can be proved to lead to a pure Nash equilibrium by use of a potential argument. Bounds on the convergence time have

[4]ref?
[5]ref?
[6]ref?
[7]ref?
[8] ***Indices de Jains? Other things a deevelopper ici?***

been investigated in [?, ?]. Considered algorithms are centralized and require complete information games. Bounds are mostly obtained by bounding the possible variations of suitable potential functions. Since players play in turns, this is often called the *Elementary Step System*. Other results of convergence in this model, have been investigated in [?, ?, ?].

Concerning models that allow concurrent decisions, we can mention the followings works. In [?], tasks are allowed to migrate in parallel from overloaded to underloaded resources. The process is proved to terminate in expected $O(\log \log n + \log m)$ rounds. The analysis is restricted to the case of unitary weights, and with identical machines. The considered process requires a global knowledge: one must determine whether one load is above or under average.

In [?] is considered a distributed process that avoids that latter problem: only local knowledge is required. The process is proved to terminate in expected $O(\log \log n + m^4)$ rounds. The analysis is also done only for unitary weights, and for identical machines. Techniques involved in the proof, relying on martingale techniques, are somehow related to techniques for studying the classical problem of allocating balls into bins games as evenly as possible.

Some authors of this proposal considered in[?] a particular learning scenario for tasks in the KP model. This learning algorithm, already considered in [?] for general games, is proved to be convergent on these allocation games, with provable error bounds on the convergence time [9].

Computing equilibria by other means Alternatives to the theory of the learning of equilibria can also be used to compute equilibria.

For example, some authors involved in this proposal in [?] a technique to compute in a distributed system its Nash bargaining situations (NBS). The considered technique is based on a gradient descent method, using the fact that NBS' corresponds to the extrema of some function, not correlated to the game.

For some other games, it is sometimes possible to use learning equilibria techniques but working on different games, in order to guarantee convergence towards some equilibria. For example, [?] proposes a way to compute pure equilibria using such an approach.

Complexity point of view Observe that some, but only few, of the previous studies lead to bounds on the convergence time: for example, [?] proves a convergence in expected $O(\log \log n + \log m)$ rounds for the KP model.

Notice also that distributed systems contexts sometimes lead to not fully specified games in the spirit of game theory. For example, it is not easy to define precise player utilities for multicriteria scheduling. Equilibria like Pareto optimal situations can however sometimes be computed. Discussing the complexity of these distributed algorithms hence yields to discuss relations between optimal situations and equilibria situations.

More generally, only a few things are also known about the relations between the effectively computed solutions and true equilibria. For example, when working on gradient descent based methods, what is the relation between a situation close to a minimum and the true equilibria corresponding to the exact minimum.

Our application context We propose to consider applications coming from scheduling problems in the context of the computational grid and from interdomain routing, using the fields of expertise of involved partners. In particular, some partners have been working on multi-objective scheduling problems [10]. One

[9] ref?
[10] ref?

considers a set of machines (heterogeneous processor or group of homogeneous processors) that are independent with their own control. Some tasks are submitted locally in each organization, but can be executed on some other organizations, as soon as local efficiency of locally submitted tasks are not too much penalized. We also have been working on interdomain routing, in the presence of routers that belong to several companies whose aim at making profits from incoming traffic [11].

In these applications, the common problem is to allocate some resources to some agents corresponding to players. These agents are in a situation of competition, and are agents in a distributed system. As such, they can not have easily a full description of the game, but have only a local view of the system.

2.2 Objectifs et caractere ambitieux/novateur du projet / Rationale highlighting the originality and novelty of the proposal

(2 pages maximum)

*Decrire les **objectifs scientifiques/techniques**du projet.*

This project proposes to give answers to the following problems:

- In applications coming from distributed systems, chosen in the context of situations where some agents compete for common resources, determine whether some equilibrium be computed in a distributed fashion. This means: determine whether the agents can be designed such that the system evolves globally to states that correspond to some notion of equilibria. Describe the notions of equilibria that can be computed in such a way.
- Determine whether good/expected equilibria can be computed in a distributed fashion. That is to say, determine whether there is a way to guarantee the evolution towards efficient equilibria, for various notions of efficiency considered in literature.
- Discuss the quality of the obtained solutions. First, understand what is the complexity of solutions from a complexity point of view: characterize when this is possible to some polynomial time algorithms. Determine bounds on the time required before reaching some equilibria, or a situation close to equilibria. Second, understand what are the guarantees given by the proposed algorithms: explicit the relations between reached situations, and the ones that would have been obtained using exact notion of equilibria and centralized algorithms.

Considered applications will be chosen among problems coming from scheduling of applications in the computational grid and from interdomain routing, using the fields of expertise of involved partners.

*Presenter **les avancees scientifiques**attendues. Preciser loriginalite et le caractere ambitieux du projet.*

*Detailler les **verrous scientifiques et techniques**a lever par la realisation du projet.*

Among clear difficulties to reach these objectives are the following:

- Notions of equilibria from game theory are mainly global, and hence non-distributed notions, in the sense that they involve all agents. For example, in a Nash equilibrium, *all* agents must be in a situation such that unilaterally they can not improve their payoff, fixing the strategies of *all* other agents. When considering distributed algorithms, one need to replace these global notions by local criteria. This may lead to change the notions of equilibria considered into approximations, or approximated notions, that needs to be understood, and that are not classical.

[11]ref?

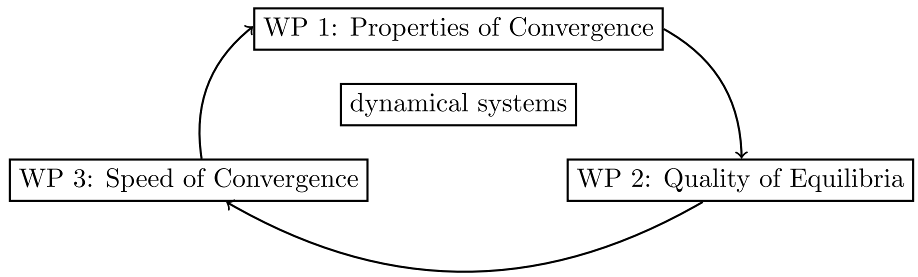

Figure 1: Relations between workpackages in the JEDY&CO project.

- Solutions from the theory of equilibria learning in games, or dynamic learning scenarios that we expect to use, often involve stochastic behaviors. This introduces clearly some difficulties. Classical notions of convergence or of termination for distributed systems need to be replaced by probabilistic notions. This involves all the subtleties behind the various notions of convergence for stochastic processes, like weak convergence, convergence in law, almost sure convergence, etc, and also behind their algorithmic study.
- Solutions from the theory of equilibria learning in games, or dynamic learning scenarios that we expect to use, are often analyzed using continuous tools, like ordinary differential equations. These tools are used to discuss processes that are actually purely discrete. This involves all the discussions and problems behind analyzing discrete processes by continuous abstractions.

*Decrire eventuellement **le ou les produits finaux developpes**a lissue du projet montrant **le caractere innovant**du projet.*

*Presenter les **resultats escomptes**en proposant si possible des criteres de reussite et devaluation adaptes au type de projet, permettant devaluer les resultats en fin de projet.*

*Le cas echeant, demontrer **l'articulation entre les disciplines scientifiques** et le**caractere interdisciplinaire** du projet.*

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

(2 pages maximum)

Presentez le programme scientifique, la methodologie et la structuration du projet.

Justifiez la decomposition en taches du programme de travail en coherence avec les objectifs poursuivis.

*Les taches representent les grandes phases du projet. Elles sont en **nombre limite**.*

Presenter les liens entre les differentes taches (si possible, utilisez un diagramme ou un organigramme technique).

The JEDY&CO project is divided into three work packages subdivided into three tasks. Each task is assigned a leader that is responsible for the on-time submission of the associated deliverables. More details about the organization of the JEDY&CO project are provided in Section 3.4

1. Work package 0: **Management** (Leader: Johanne Cohen, PRiSM)
2. Work package 1: **Property of a dynamical system convergence for distributed and interactive Algorithms.**
   (a) Task 1.1: *Distributed system with players having local and partial information* (Leader: Denis Trystram, LIG)
   (b) Task 1.2: *Distributed hierarchical system with different types of players* (Leader: Corinne Touati, LIG)
   (c) Task 1.3: *Distributed system with dynamical interactions* (Leader: Dominique Barth, PRiSM)
3. Work package 2: **Qualitative and Quantitative properties of Equilibrium points**
   (a) Task 2.1: *Optimality and fairness and correlation of equilibria* (Leader: Corinne Touati, LIG)
   (b) Task 2.2: *Stability and Purity property* (Leader: Corinne Touati, LIG)
   (c) Task 2.3: *Reputation, truthful property, and robustness* (Leader: Johanne Cohen, PRiSM)
   (d) Task 2.4: *Approximation, equity , Pareto approximation* (Leader: Denis Trystram, LIG)
4. Work package 3: **Speed of convergence, number of iterations, and synchronization issues**
   (a) Task 3.1: *Step size adaptation of stochastic system.* (Leader: Johanne Cohen, PRiSM)
   (b) Task 3.2: *Speed of convergence of learning scenarios* (Leader: Olivier Bournez, LIX)
   (c) Task 3.3: *Study of improvement given by asynchronous behavior on theoretical and heuristic point of view* (Leader: Bruno Gaujal, LIG)

The expected schedule of the whole project (excluding the "Management" workpackage) over the three years life span is shown in the Figure 3.1.

The expected participation of the various funded partners in the various tasks is described in Figure 3. The unit used in Figure 3 is the *person-month* (abbreviated *pm*).

3.2 Coordination du projet / project management

(2 pages maximum)

Preciser les aspects organisationnels du projet et les modalites de coordination (si possible individualisation dune tache coordination : cf. tache 0 du document de soumission A).

Work package 0 is devoted to management of the project.

Workpackage leader Johanne Cohen, *PRiSM*

Participants *all*

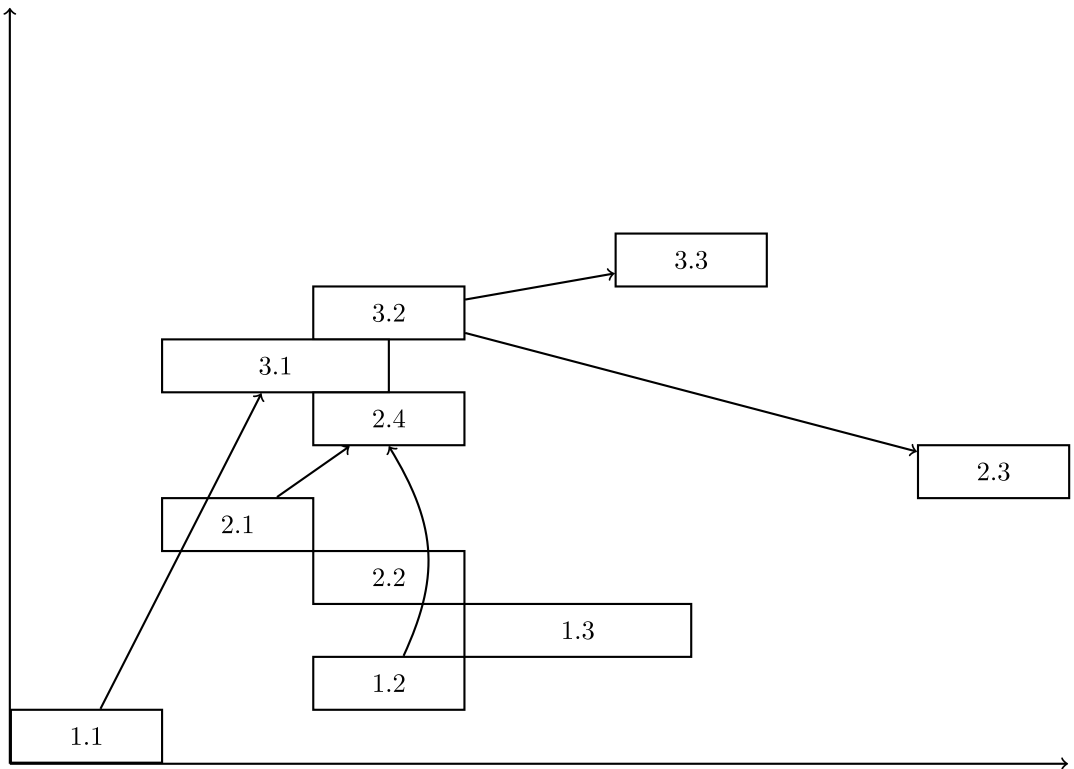

Figure 2: Temporal organization of the **JEDY&CO** project.

Task	**PRiSM**	**LIG**	**LIX**		
Management	*pm*				
Task 1.1	pm	pm	pm	5.4pm	4pm
Task 1.2	4.14pm	5.45pm	0.9pm		
Task 1.3	4.14pm	8.18pm	1.8pm		
Task 1.4	8.28pm	2.73pm	1.8pm		
Task 1.5		5.45pm			7pm
Workpackage 1	*26.9pm*	*17.73pm*	*6.3pm*	*5.4pm*	*11pm*
Task 2.1	8.28pm	2.73pm			4pm
Task 2.2	8.28pm		3.6pm		
Task 2.3	2.07pm	2.73pm	3.6pm	2.7pm	2pm
Task 2.4	2.07pm		1.8pm	5.4pm	
Workpackage 2	*20.69pm*	*5.45pm*	*9pm*	*8.1pm*	*6pm*
Task 3.1	8.28pm		2.7pm	1.35pm	1pm
Task 3.2		1.36pm	3.6pm	1.35pm	4pm
Task 3.3	4.14pm		0.9pm	5.4pm	
Workpackage 3	*12.41pm*	*1.36pm*	*7.2pm*	*8.1pm*	*5pm*
Total	**60pm**	**30pm**	**22.5pm**	**21.6pm**	**22pm**
Total (%)	**38.44%**	**19.22%**	**14.41%**	**13.84%**	**14.09%**

Figure 3: Funded partners commitments to tasks (excluding resources provided by the **SHAMAN** project)

Deliverables At $t+2$ a a web site for the project will be provided, and scientific results and deliverables will be posted on the web site as they become available. At $t+3$ a SVN server will be set up for source file sharing among partners. At $t+3$, $t+6$, $t+9$, $t+12$, $t+15$, $t+18$, $t+21$, $t+24$, $t+27$, $t+30$, $t+33$, and $t+36$ plenary meetings will be organized. It is expected that at $t+18$ and $t+30$ those plenary meetings will be organized concurrently with an international workshop or conference on related topics. At $t+36$ a final report stating the main achievements of the project will be compiled.

Structure and flow Figure 3 summaries the logical dependencies between the various workpackages of the JEDY&CO project. There is a natural flow from Workpackage 1 to Workpackage 2: whenever a convergence is observed or proved, this is necessary to understand the quality of the involved equilibria. There is a natural flow from Workpackage 2 to Workpackage 3: whenever the quality of involved equilibria is attested, this is necessary to evaluate whether this equilibria is attained in a reasonable time. There is also a natural flow from Workpackage 3 to Workpackage 1: whenever speed of convergence is low, this is often required to reconsider the strategy that lead to convergence.

The chronogram for the JEDY&CO project is depicted in Figure 4.

The summary for the list of deliverables for the JEDY&CO project is presented in Figure **??**.

3.3 Description des travaux par tache / detailed description of the work organised by tasks

(idealement 1 ou 2 pages par tache)

Pour chacune dentre elle, decrire :

son responsable et les partenaires impliques (si possible, sous forme graphique),

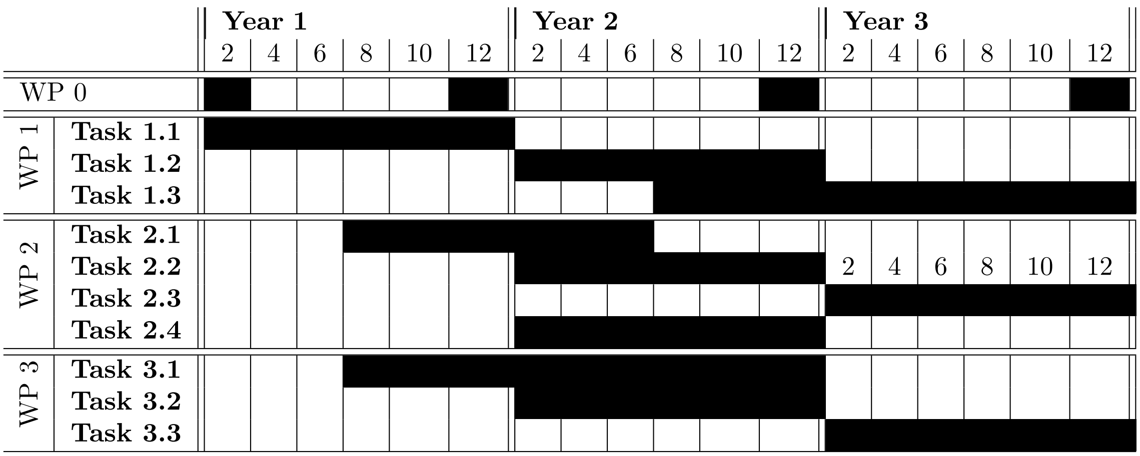

Figure 4: Task chronogram summary

Figure 5: Deliverables summary

ses objectifs,

le programme detaille des travaux[12] *,*

la description des methodes, des choix techniques et des solutions envisages,

les risques et les solutions de repli envisagees, les indicateurs de succes associes aux objectifs et les livrables,

les contributions des partenaires (le qui fait quoi)

3.3.1 WP1: Property of a dynamical system convergence for distributed and interactive Algorithms.

Task 1.1: ***Property of convergence with partial information***

Workpackage Leader: Denis Trystram, *LIG.*

Participants : PRiSM, LIG, LIX

Description The project JEDI&Co targets on distributed systems (namely, computational grids, telecommunication network). We are looking for solutions that are "good" equilibria or that optimize one (or more) objective(s). Such distributed systems are characterized by "agents" that have only local information and it is hard to obtain and keep a global view of the system. In this sense, the information are only partial ones. Using classical optimization, most efficient solutions of combinatorial optimization problems (like multi-organization scheduling or routing) are centralized. Obtaining a good solution (an optimal one or guaranteed

[12] Les projets de recherche sappuyant sur les donnees reunies, par exemple, dans le cadre de la constitution dun corpus, dun suivi de cohorte, dune approche longitudinale, dun panel, doivent expliciter precisement la nouveaute du recueil de donnees envisage, la nouveaute des traitements ou des analyses proposees par rapport a ceux deja engages.

a solution with a performance guaranty) needs to have a global state. Usually, good local solutions (optimized locally or for selfish purpose) are not good global solutions.

This distributed character of the systems originates from two situations. Firstly, the agents do not want to give or share their local information. Obtaining a global state in this case may be prohibitive, and thus, it is impossible to include it into a dynamic process. Secondly, local information are available. Each agent has its own wishes or constraints, and it aims at optimizing its selfish objective. Thus, it is theoretically possible to construct the global view, however, it is not tractable for realistic instances (because of the too large number of local strategies). In both cases, we need to construct equilibria using iterative algorithms involving only partial distributed information. The purpose of Task T11 is to study the convergence of such processes.

This task is a basic one, because it is important that all participants study the literature related to the construction and the analysis of global state (distributed algorithms, approximation solutions, variants of Nash equilibria, etc.). The goal of this task is to master the existing methods and results for constructing a global solutions from local partial solutions. Such techniques are known in the different disciplines (algorithms, operational research, complexity), and should be shared and learned by all the participants of different disciplines. The output of this task will be first to share this basic background and knowledge. Moreover, another output is to derive new results for the target problems: new approximation algorithms for the multi-organization scheduling problem and new convergence conditions for the routing problem.

Task 1.2: ***Distributed hierarchical system with different types of players***

Workpackage Leader: Corinne Touati, *LIG*.

Participants : PRiSM, LIG

Description With the increasing level of interconnection and heterogeneity between systems, different levels of optimization are generally needed. A typical example is MPLS (Multi Protocol Label Switching) where users optimize their individual route so as to minimize some cost function without knowledge of the type of network their packets are actually going through, would it be wireless, optical or Ethernet. The routes they are aware of consists of hops between virtual nodes that do not even necessarily coincides with physical ones. Meanwhile, the system aims at leveraging the physical paths followed by packets so as to guarantee good utilization of the system.

Another example can be found in wireless systems, where contention is addressed both at the network layer (TCP window) and at the physical layer (backoff timer of IEEE 802.11 protocol). As there is no coordination between the two network layers, inefficiencies occur.

An even different system was studied by Legrand and al. [38] where schedulers compete in an non-cooperative way to access the grid, while the system ensures fair access to individual resources. They observed that even though one can guarantee fairness and efficiency at each local resource, this does not lead to fairness in the global system, hence comforting the fact that optimizations achieved at independent levels do not lead to efficient use of the global system.

In hierarchical systems, some piece of information should hence be transferred between the different levels of optimization so as to obtain efficient equilibria. In this task, we seek efficient algorithms in hierarchical systems with minimal information exchange between the layers.

Task 1.3: ***Distributed system with dynamical interactions***

Workpackage Leader: Dominique Barth, *PRiSM*.

Participants : PRiSM, LIX

3.3.2 WP2: Qualitative and Quantitative properties of Equilibrium points

Task 2.1: ***Optimality and fairness and correlation of equilibria***

Workpackage Leader: Corinne Touati, *LIG*.

Participants : LIG, LIX

Description Optimality is usually defined based on the definition of Pareto optimality. Yet, if a point is not Pareto optimal, one needs a measure of its inefficiency. The price of anarchy and price of stability are measures of distance between the non cooperative equilibria and a particular point of the Pareto border, namely the social optimum. The more recent SDF (Selfish Degradation Factor) is the distance between a Nash equilibrium and the Pareto border. Analogously, the Jain Index measure the distance of an equilibrium point to the (Pareto optimal) Max-Min fair point.

This task is two-folds. First, we aim at developing tight bounds on the efficiency of the equilibria, using one of the already defined efficiency metrics. Indeed, as previously mentioned, these performance measures are based on global considerations and thus can often only be approximated in a distributed environment. Second, we aim at developing algorithms that converge towards efficient equilibria, relatively to these performance measures. Toward this goal, different techniques can be used. One of them is to consider a non-cooperative game on a modified system, for which the equilibrium is known to be optimal [?]. Another option is to consider a wider class of equilibria, known as Correlated Equilibria [?]. In such games, an independent agent provides some additional piece of information. It has been shown that, appropriate choice of this information can, in a totally non-cooperative system, increase the efficiency of the reached equilibrium. The underlying concept is that this data acts correlates the different agents. Further, it has been shown that this data does not need to be connected to the system state to have an effective impact on the system's performance [?].

Task 2.2: ***Stability and Purity property***

Workpackage Leader: Corinne Touati, *LIG*.

Participants : PRiSM, LIG

Task 2.3: ***Reputation, truthful property, and robustness***

Workpackage Leader: Johanne Cohen, *PRiSM*.

Participants : PRiSM, LIG

Task 2.4: ***Approximation, equity , Pareto approximation***

Workpackage Leader: Denis Trystram, *LIG*.

Participants : PRiSM, LIG, LIX

Description Nash equilibria correspond to the best possible situation when no cooperation is allowed. There are many interesting variants of this concept (that will be studied in other tasks). Allowing cooperation among agents often leads to form coalitions: two or more agents can agree on some common strategies for improving their own objectives, the counter-part is that the objectives of other agents are usually worsened. In order to avoid such bad effects, we propose to add an extra global (centralized) mechanism for controlling or optimizing the global behavior of the system. The main difference with other existing classical approaches is that this global solution is obtained from local partial solutions. For instance, the multi-organization scheduling problem, this corresponds to construct a approximation of the global optimum without deteriorating the local solutions. ADD HERE FEW WORDS ABOUT APPROXIMATION FOR THE OTHER PROBLEM (ROUTING).

Pareto optimal solutions are defined as the best possible compromise solutions among all the agents. The users of such distributed systems are interested in determining the whole set of Pareto points, one user would put emphasize of specific compromises which are generally different than the other users. This usually leads to a problem for enumerating all the Pareto set (whose cardinality may be exponential in the size of the problem). Thus, approximations are needed to reduce the search space to a polynomial number of solutions (these solutions will not be optimal, but only approximated solutions).

This task aims at determining a framework for the study of multi-objective optimization using the concepts of game theory. The classical approach in combinatorial optimization can only handle efficiently few objectives. We target here on many objectives (typically, each user would have his-her own objective). The output of this task is to establish new approximation bounds for specific objectives in the multi-organization scheduling problem (for instance, the best existing absolute bound for obtaining the global makespan using greedy algorithms is 3 and the lower bound is 2. We believe that it is possible to improve this bound, and to propose better bounds using more sophisticated algorithms).

3.3.3 WP3: Speed of convergence, number of iterations, and synchronization issues

Task 3.1: ***Step size adaptation of stochastic system.***

Workpackage Leader: Johanne Cohen, *PRiSM*.

Participants : PRiSM, LIG, LIX

Task 3.2: ***Speed of convergence of learning scenarios***

Workpackage Leader: Olivier Bournez, *LIX*.

Participants : PRiSM, LIX

Task 3.3: ***Study of improvement given by asynchronous behavior on theoretical and heuristic point of view***

Workpackage Leader: Bruno Gaujal, *LIG*.

Participants : LIG, LIX

3.4 Calendrier des taches, livrables et jalons / planning of tasks, deliverables and milestones

(2 pages maximum)

Presenter sous forme graphique un echeancier des differentes taches et leurs dependances (par exemple, utiliser un diagramme de Gantt).

Presenter un tableau synthetique de l'ensemble des livrables du projet (numero de tache, date, intitule, responsable).

Preciser de facon synthetique les jalons scientifiques et/ou techniques, les points bloquants ou aleas qui risquent de remettre en cause l'aboutissement du projet ainsi que les reunions de projet prevues.

The chronogram for the JEDY&CO project is depicted in Figure 4.

The summary for the list of deliverables for the JEDY&CO project is presented in Figure **??**.

4 Strategie de valorisation des resultats et mode de protection et dexploitation des resultats / data management, data sharing, intellectual property and results exploitation

(1 a 2 pages)

Presenter les strategies de valorisation des resultats :

la communication scientifique;

la communication aupres du grand public, le cas echeant;

la valorisation des resultats attendus; les retombees scientifiques et techniques, eventuellement les retombees industrielles, economiques la place du projet dans la strategie industrielle des entreprises partenaires du projet autres retombees (normalisation, information des pouvoirs publics, ...) pour les bases de donnees, indiquer les modes de stockage et de maintenance ainsi que les communautes beneficiaires Presenter les grandes lignes des modes de protection et dexploitation des resultats. Pour les projets partenariaux organismes de recherche/entreprises, les partenaires devront conclure, sous legide du coordinateur du projet, un accord de consortium dans un delai de un an si le projet est retenu pour financement. Pour les projets academiques, laccord de consortium nest pas obligatoire mais fortement conseille.

Results sharing Obtained results will be submitted to high level public computer science conferences, or to public computer science journals.

All meetings from the JEDY&CO project will be open. Scientists interested by the subjects of the meetings will have the opportunity to present their results, if related, or to listen from the talks from members of the JEDY&CO project.

We intend to organize at $t+18$ and $t+30$ the plenary meetings concurrently with an international workshop or conference on related topics. This particular plenary meetings will be special occasions to communicate wisely on the JEDY&CO project, its thematics and results. We will in particular invite first level speakers to present talks at these meetings.

Some members of the JEDY&CO project have some relationships with industrial partners (see e.g. past projects ACTRICE, ANR CHOC). Even if the problematics of the JEDY&CO projects are currently at a theoretical level, we will encourage migration of our theoretical results towards concrete industrial problems.

Intellectual property and results exploitation Each partner keeps complete property of its previous background. No stipulation can be interpreted as giving any property transfer. Neither disclosure from a partner to another, nor possible use, in the context of this project, can give the other partner the right to make commercial usage of it without the preliminary agreement of the owner, except for disposals from article.

5 Organisation du partenariat / consortium organisation and description

5.1 Description, adequation et complementarite des partenaires / relevance and complementarity of the partners within the consortium

(maximum une demi page par partenaire)

Decrire brievement chaque partenaire et fournir ici les elements permettant dapprecier la qualification des partenaires dans le projet (le 'pourquoi qui fait quoi). Il peut sagir de realisations passees, dindicateurs (publications, brevets), de linteret du partenaire pour le projet (il ne sagit pas de fournir ici le C.V. du responsable scientifique de chaque partenaire).

Fournir en annexe 7.2 une presentation plus detaillee des partenaires, de leur savoir- faire et de leurs apports et attentes dans le projet.

Montrer la complementarite et la valeur ajoutee des cooperations entre les differents partenaires. Linterdisciplinarite et louverture a diverses collaborations seront a justifier en accord avec les orientations du projet. ***(une page maximum)***

PRiSM Partner PRiSM is a French laboratory in computer science of the University of Versailles St-Quentin created in 1994 and associated to the French CNRS since this date. This laboratory is composed of seven research teams in various scientific domains with 50 researchers and about 80 PhD students:

- Algorithmic, Combinatorics and Applications
- Computer architectures and Parallelism
- Network architectures and services
- Evaluation of Performance of networks
- Cryptography
- Distributed computing and optimization
- Data Base systems
- information Systems and Software architectures

PRiSM is involved in RTRA DIGITEO, in the "pôles de compétitivité" SYSTEM@TIC and MOVEO and in different European networks of excellence. The research teams participating to the JEDY&CO project are the team "Algorithms, Combinatorics and Applications" (ALCAP) and the team "Distributed computing and optimization" (CARO). The competences of these teams brought to the project related to distributed algorithms for networks (in particular about routing, resource provisioning for QoS and pricing), combinatorial optimization, graph algorithms and algorithmic theoretical game theory. These teams are jointly implied in various French and European research projects in the field of telecommunications networks. They are also involved in academic and industrial research projects in France, with telecommunication industrial partners.

LIG Partner

LIX Partner LIX is a French laboratory in computer science at the Ecole Polytechnique. It is a mixed laboratory with the CNRS, and hosts several INRIA projects. The researchers O. Bournez and C. Dürr from LIX have recently started working on algorithmic game theory. More precisely on the question of existance of Nash equilibria, the price of anarchy and learning aspects of games. The network of this project, would able them to integrate techniques from the other groups which they do not master yet.

5.2 Qualification du coordinateur du projet / qualification of the project coordinator

(une demi page maximum)

Fournir les elements permettant de juger la capacite du coordinateur a coordonner le projet.

5.3 Qualification, role et implication des participants/ contribution and qualification of each project particpant

Pour chaque partenaire, remplir le tableau ci-dessous qui precisera la qualification, les activites principales et les competences propres de chaque participant :

* a renseigner uniquement pour les Sciences Humaines et Sociales

Pour chacune des personnes dont limplication dans le projet est superieure a 25% de son temps sur la totalite du projet, une biographie dune page ***maximum****sera placee en annexe 7.2 du present document qui comportera :*

Nom, prenom, age, cursus, situation actuelle

Autres experiences professionnelles

Liste des cinq publications (ou brevets) les plus significatives des cinq dernieres annees, nombre de publications dans les revues internationales ou actes de congres a comite de lecture.

Prix, distinctions

Si besoin, pour chacune des personnes, leur implication dans d'autres projets (Contrats publics et prives effectues ou en cours sur les trois dernieres annees) sera presentee selon le modele fourni en annexe 7.3. On precisera l'implication dans des projets europeens ou dans dautres types de projets nationaux ou internationaux. Expliciter larticulation entre les travaux proposes et les travaux anterieurs ou deja en cours.

6 Justification scientifique des moyens demandes / scientific justification of requested budget

On presentera ici pour chaque partenaire, la justification scientifique et technique des moyens demandes dans le document de soumission A. Ces moyens sont synthetises a lechelle du projet dans la fiche Tableaux recapitulatifs dans ce document de soumission A.

Chaque partenaire justifiera les moyens quil demande en distinguant les differents postes de depenses selon le canevas suivant :.

6.1 Partenaire 1 / partner 1 : PRiSM

Equipement / Equipment

Preciser la nature des equipements et justifier le choix des equipements Si necessaire, preciser la part de financement demande sur le projet et si les achats envisages doivent etre completes par dautres sources de financement. Si tel est le cas,* *indiquer le montant et lorigine de ces financements complementaires. *Un devis sera demande si le projet est retenu pour financement.*

Personnel / Staff

Le personnel non permanent (theses, post- doctorants,CDD..) finance sur le projet devra etre justifie.

Fournir les profils des postes a pourvoir pour les personnels a recruter (une demi page maximum par type de poste) Pour les theses (ne concerne ni la biologie-sante, ni les sciences humaines et sociales), preciser si des demandes de bourse de these sont prevues ou en cours, en preciser la nature et la part de financement imputable au projet.

-

Prestation de service externe / Subcontracting

Preciser : la nature des prestations le type de prestataire.

Missions / Missions

Preciser : les missions liees aux travaux dacquisition sur le terrain (campagnes de mesures) les missions relevant de colloques, congres

Depenses justifiees sur une procedure de facturation interne / Internal expenses

Preciser la nature des prestations

Autres depenses de fonctionnement / Other expenses

Toute depense significative relevant de ce poste devra etre justifiee.

6.2 Partenaire 2 / partner 2 : LIG

Equipement / Equipment

Preciser la nature des equipements et justifier le choix des equipements Si necessaire, preciser la part de financement demande sur le projet et si les achats envisages doivent etre completes par dautres sources de financement. Si tel est le cas, indiquer le montant et lorigine de ces financements complementaires. *Un devis sera demande si le projet est retenu pour financement.*

Personnel / Staff

- A postdoctoral fellow will participate to Task 3.3 and then to tasks of the WP4. This postdoc will be recruited for 18 months for a total amount of €??.

Prestation de service externe / Subcontracting

Preciser : la nature des prestations le type de prestataire.

Missions / Missions

Preciser : les missions liees aux travaux dacquisition sur le terrain (campagnes de mesures) les missions relevant de colloques, congres

Depenses justifiees sur une procedure de facturation interne / Internal expenses

Preciser la nature des prestations

Autres depenses de fonctionnement / Other expenses

Toute depense significative relevant de ce poste devra etre justifiee.

6.3 Partenaire 3 / partner 3 : LIX

Equipement / Equipment

Preciser la nature des equipements et justifier le choix des equipements Si necessaire, preciser la part de financement demande sur le projet et si les achats envisages doivent etre completes par dautres sources de financement. Si tel est le cas, indiquer le montant et lorigine de ces financements complementaires. *Un devis sera demande si le projet est retenu pour financement.*

Personnel / Staff

Le personnel non permanent (theses, post- doctorants,CDD..) finance sur le projet devra etre justifie.

Fournir les profils des postes a pourvoir pour les personnels a recruter (une demi page maximum par type de poste) Pour les theses (ne concerne ni la biologie-sante, ni les sciences humaines et sociales), preciser si des demandes de bourse de these sont prevues ou en cours, en preciser la nature et la part de financement imputable au projet.

Prestation de service externe / Subcontracting

Preciser : la nature des prestations le type de prestataire.

Missions / Missions

Preciser : les missions liees aux travaux dacquisition sur le terrain (campagnes de mesures) les missions relevant de colloques, congres

Depenses justifiees sur une procedure de facturation interne / Internal expenses

Preciser la nature des prestations

Autres depenses de fonctionnement / Other expenses

Toute depense significative relevant de ce poste devra etre justifiee.

7 Annexes

7.1 References bibliographiques / references

Inclure la liste des references bibliographiques utilisees dans ce document et les references bibliographiques des partenaires ayant trait au projet.

7.2 Biographies / CV, Resume

(une page maximum par personne)

The project partners are: three French academic partners (PRiSM, LIG, LIX). The partners credentials are described in more detail below. The project is to employ (in terms of percentage of research time) of each French permanent academic partners involved in the project. Note that PhD students and post doctoral researches are to be employed but are not listed.

The PRiSM partner has a strong background in distributed and graph algorithms, with emphasis on optimization algorithms for telecommunication network. The PRiSM partner includes the following people:

- Dominique Barth (20%) professor of Université de Versailles St Quentin [?, ?, ?, ?, ?, ?]. 41ans http://www.prism.uvsq.fr/ barth Dominique Barth defended a PhD thesis in Computer Science (1994) in Bordeaux and defended a HDR (1999) in Orsay. He has been with Université Paris-Sud 11 at Orsay between 1994 and 1999, and currently is Professor in the PRiSM laboratory with Univeristé de Versailles St Quentin since 1999. He has created and leaded the Algortihmic, Combinatoric and Application team of PRiSM. His main research interests concern graph theory and gaph algorithms with two application domains, telecommunication network and Computational Biology. Concerning telecommunication networks, he mainly focuses on distributed algorithms to manage QoS in a selfish interdomain network, using game theory concepts. He is and has been the head of the participation of his team two many european and national research projects.

- Johanne Cohen, (60%) Chargée de Recherche CNRS [?, ?, ?, ?]. Johanne Cohen is the principal investigator of the JEDY&CO project. Her CV can be found in Section **??**. She is chargée de recherche CNRS since 2001. She was an assistant professor at Nancy I university from 2000 to 2001, after a PhD defensed in Paris XI Orsay University in 1998, and a Magistere from ENS Lyon. Her research interests include algorithmics for telecommunication, graph theory, algorithmic game theory, distributed algorithmics, complexity and approximation theory.

- Thierry Mautor (20%) [?, ?, ?, ?, ?] is assistant professor in the PRiSM laboratory of the University of Versailles-Saint Quentin en Yvelines since 1994. He defended a PhD thesis in 1993 and a HDR in 2001. His main research field is the Combinatorial Optimization and the determination for several optimization problems of efficient solution methods as well exact as heuristic. Especially, he works on the Quadratic Assignment Problem and the Vehicle Routing Problems. But, he has worked also on Parallel and Distributed Algorithms, on Graph Algorithms and Game Theory, specially for telecommunication network problems.

The LIG partner has a strong background in complexity and scheduling algorithms, with emphasis on network. The LIG partner includes the following people:

- Bruno Gaujal (20%) [?, ?, ?, ?, ?] is a former student of École Normale Supérieure in Lyon. He received his PhD from the University of Nice in 1994. He has held several positions in AT&T Bell Labs (USA), INRIA Sophia-Antipolis, Loria (Nancy) and ENS-Lyon. Currently, he is a Research Director with INRIA Rhones-Alpes. Since 2005, he is the leader of the large-scale computing group, MESCAL (30 members) (INRIA project team, member of the LIG laboratory). He joins the INRIA-Alcatel Lucent common Laboratory in 2008 where he leads the research action on self optimizing networks (SelfNets, 40 members). His main interests are in performance evaluation, optimization and control of discrete event dynamic systems in a deterministic as well as a stochastic context.

- Corinne Touati (20%) [**?**, **?**, **?**, **?**, **?**, **?**]. She is chargée de recherche INRIA and she is a member of INRIA projet MESCAL (Middleware Efficiently SCALable). She held a post-doctoral position in the OSDP (Operating Systems and Distributed Programming) laboratory of Tsukuba University (Japan) lead by Professeur Kameda from November 2003 to May 2006. She did her PhD studies at the University of Nice and the INRIA Sophia-Antipolis, under the joint supervision of Eitan Altman and of Jérôme Galtier (from October 2000 to September 2003). She studies optimization and performance evaluation problems in communication networks and distributed systems, using in particular tools issued from game theory. Corinne Toauti takes part in the Program Committee of international conferences in game theory and in communication networks (IEEE WCNC 2008, ValueTools 2008, NET-COOP 2008).

- Denis Trystram (40%) [**?**, **?**, **?**, **?**]. He was born in 1958 in Paris, France. He obtained a PhD in Applied Mathematics at INPG (Institut National Polytechnique de Grenoble) in 1984 and a second one in Computer Science in 1988 from the same institute. He is Professor since 1991 at INP Grenoble and is now distingued professor in this Institute. He is leading a research team on Scheduling and Combinatorial Optimization within the MOAIS team at LIG laboratory. He is currently Regional Editor for Europe for the Parallel Computing Journal and serve in the board of IEEE TPDS and other journals. Denis Trystram participates regularly to the Program Committee of major conferences of the field (EUROPAR, IPDPS, HiPC, PARCO, SPAA, ...).

  The main research activities of professor Trystram concern the design of efficient approximation algorithms for multi-objective scheduling problems. He has published several books and more than 80 articles in international journals and as many international conferences.

The LIX partner has a strong background in complexity and scheduling algorithms, with emphasis on and computational aspect of dynamical system. The LIX partner includes the following people:

- Olivier Bournez (40%) [**?**, **?**, **?**]

  Christoph Dürr (50%) [**?**, **?**, **?**] studied computer science at the Akademie für Datenverarbeitung in Böblingen, worked in the industry during 2 years, and continued studying at the Université Paris-Sud, where he did his PhD in 1997. After two years of postdoc at ICSI Berkeley, and later the Hebrew University of Jerusalem, we worked as a teaching assistant at the IUT d'Orsay, and is now a CNRS researcher at LIX, Ecole Polytechnique. He recieved his habilitation in 2005. Rather than being a specialist in a particular domain, he constributed to quite different areas of computer science, including quantum computation, cellular automata, discrete tomography, scheduling, online algorithms, and recently algorithmic game theory.

Cf. .

Implication des personnes dans nodautres contrats / involvement of project participants to other grants, contracts, etc

(un tableau par partenaire)

Cf.

Mentionner ici les projets en cours devaluation soit au sein de programmes de lANR, soit aupres dorganismes, de fondations, a lUnion Europeenne, etc. que ce soit comme coordinateur ou comme partenaire. Pour chacun, donner le nom de lappel a projets, le titre du projet et le nom du coordinateur.

Partner PRiSM

Part.	Nom de la Personne participant au projet	Personne .Mois	Intitulé de l'appel à projet source de financement Montant attribué	Titre du projet	Nom du Coordinateur	Date début & date de fin
N^o1	J. Cohen	40% =(4.8)	ANR VERSO Montant total en négotiation	SHAMAN	Sébastien Tixieul (LIP6)	10/07-9/11
N^o1	D. Barth	6	RNRT Montant total ????	ECOFRAME	D.Chiaroni ALCATEL	2007-2009
N^o1	D. Barth	12	Pôle de comptétivité. SYSTEM@TIC	CARRIOCAS	O. Audouin ALCATEL	2007-2009
N^o1	D. Barth		Digiteo (RTRA)	PASAPAS	F. Quessette PRiSM	2007-2010

In particular, this partner is involved in several on-going projects.

- The ANR VERSO SHAMAN projet has no deep intersection with this proposal. In particular, it focuses on the algorithmic foundations of resource-constrained autonomous large scale systems, dedicated to enabling the sustainability of network functions in spite of abrupt system evolutions, component failures, and attacks.
- The projet RNRT ECOFRAME (2006 - end 2009): stands for Elements de COnvergence pour les Futurs Reseaux. ***Dominique?***

Within SYSTEM@TIC "pôle de competitivite", Dominique Barth is involved in projet CARRIOCAS (ending August 2009). It studies and implements an ultra high bit rate (up to 40Gb/s per channel) optical fiber core network to meet the scientific and industrial needs in remote usage of computing and storage resource for high performance interactive/collaborative simulations and virtual prototyping.

Partner LIG

Part.	Nom de la Personne participant au projet	Personne .Mois	Intitulé de l'appel à projet source de financement Montant attribué	Titre du projet	Nom du Coordinateur	Date début & date de fin
N^o2	C. Toauti	80% =(9.6)	ANR jeunes Chercheurs Montant total ?????	DOCCA	Florence PERRONNIN (LIG)	9/07-8/10
N^o2	B. Gaujal		ANR SETIN Montant (partner) 50 K €	Check-bound	Nihal Pekergin (Paris 1)	2007–2009

In particular, this partner is involved in several projects.

- The ANR *jeune chercheur* DOCCA project (2000–2010) aims at developing a peer-to-peer collaborative computing protocol with a strong emphasis on theoretical aspects of fairness issues and collaboration incentives. Our target system is a fully decentralized architecture, where desktops are both volunteers and clients (they can submit jobs). Our objective is Design a P2P architecture based on the algorithms designed in the second step and to create a novel P2P collaborative computing system.

- The ANR SETIN Check-bound (2007–2009) focused on safety-critical applications, coupled with their increasing complexity. The presence of systems in safety-critical applications makes indispensable their verification to see if they behaves as required. Thus the model checking which is the automated manner of formal verification techniques is of particular interest. Since verification techniques have become more efficient and more prevalent, the natural extension is to extend the range of models and specification formalisms to which model checking can be applied. Indeed the behavior of many real-life processes is inherently stochastic, thus the formalism has been extended to probabilistic model checking.

Within the Minalogic "pôle de competitivite" Bruno Gaujal participates in the project Sceptre (2007-2010) with STMicroelectronics, Verimag and LIP on optimized software compilation for multicore embedded systems. We have started a PhD with STMicroelectronics on monitoring and performance measures of embedded systems on chips.

A new project within the same "pôle de competitivité", whose objective is to provide small companies with federated computing resources has started in 2008. It involves the Mescal and Moais teams of LIG.

Partner LIX

Part.	Nom de la Personne participant au projet	Personne .Mois	Intitulé de l'appel à projet source de financement Montant attribué	Titre du projet	Nom du Coordinateur	Date début & date de fin
N^o3	O. Bournez	40% =(4.8)	ANR VERSO Montant total ??????????	SHAMAN	Sébastien Tixieul (LIP6)	10/07-9/11
N^o3	C. Dürr	10% = (3.6)	ANR jeunes chercheurs Montant total 136 K€	ARS	Léo Liberti (LIX)	08/2008–07/2011

In particular, this partner is involved in several on-going projects.

- The ANR VERSO SHAMAN projet is already defined.
- The ANR *jeune chercheur* ARS project (2008-2011) stands for automatic reformation search. The idea is that various optimisation problems can be modeled as linear or quadratic programs. Some modelisations are better than others, in the sense, that they can be easier approximated or that they have less variables or constraints and therefore e solved more efficiently. The goal of this project is to come up with algorithms, that automatically reformulate one model into a better model.