Acronyme	**AGAPE**		
Titre du projet en français	Algorithmes de graphes paramétrés et exacts		
Titre du projet en anglais	Parameterized and exact graph algorithms		
CSD principale	X 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	759 699 €	**Durée du projet**	48 mois

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

The classical complexity theory established important concepts like polynomial time solvable problems, NP-hardness of problems and the famous and still open P-NP problem. No NP-hard problem can be solved by a polynomial time algorithm unless P=NP. (Even if there is yet no proof of this statement) NP-hardness is considered as a strong certificate that the problem is intractable. Nevertheless constructing algorithms for NP-hard problems has always been an important concern and challenge for computer scientists. Indeed many problems arising from applications (e.g. in networking, biology, linguistics or economy) turned out to be NP-hard. In fact, one might say that there are "much more NP-hard problems than polynomial time solvable ones". Even whole research communities are working on one (general) NP-hard problem, like constraint satisfaction.
Various strategies have been considered to cope with NP-hardness: restrict the instances on which the problem is solved, compute an approximation rather than the exact solution to the problem or even use *heuristic methods* (branch-and-bound, genetic algorithms etc.). However it is often the case that real applications require the computation of an optimal, or with other words an exact solution (compared to approximations).

The aim of the proposed research programme is to develop new techniques to solve exactly NP-hard problems on graphs. To do so, we envisage two approaches which are closely related ways to reduce the combinatorial explosion of NP-hard problems. They have lots of connections ranging from very practical questions in algorithm design to the fundamental complexity theoretical problems. ·
The first approach is to find exponential exact algorithms while minimizing the base c of the exponential time complexity function. Then with the ever-growing computing power, one can hope to handle these problems if c is not too large. The second approach is fixed-parameter tractability. Its idea is to isolate problem parameters that can be expected to be small in certain applications and then develop algorithms whose running time is polynomial in the instance size n but depends arbitrarily of these parameters. Hence as long as the parameters are small, the problem may be considered as tractable. Since the choice of suitable parameters allows a great flexibility, fixed-parameter algorithms have found their way into practical applications such diverse as computational biology, database systems, computational linguistics, and automated verification. For example, there are error coding problems that can be modelled by vertex covers of small size. In software engineering, register allocation in most of the structured programming languages can be modelled by a graph of *bounded treewidth* [Tho98]; this latter

parameter also plays an important structural role in biological data used in phylogeny reconstruction problems [SLH+05].

The originality of the proposal is to combine tools of graph theory, such as structural theorems, the probabilistic method, the discharging method, together with algorithmic tools, such as "measure and conquer", inclusion-exclusion principle, in order to obtain efficient algorithms. To estimate their practical efficiency, they will be implemented on Mascopt (a library developed by INRIA) in order to be compared with other algorithms. Thereby, our choice to analyse the algorithms in practice and not only under their theoretical aspects is a major concern. For example, the DFG in Germany has just last year initiated a huge project in algorithm engineering.

Exact and parameterized algorithms form a growing area which is now investigated by an large number of groups all over the world. But to our knowledge, no French team specifically works on this topic. However some works on graph decomposition like those of B. Courcelle (LaBRI, Université Bordeaux 1) on the graphs with bounded treewidth are strongly related with fixed parameterized algorithms. Beyond the scientific goals of this proposal, one of our objectives is to build a French research group in the domain and to let it be a world leader.

Our proposal is loosely related to two ANR programmes, GRAAL and ALADDIN.

- The ANR GRAAL (2007-2009) focus on graph decompositions. Some techniques based on such decompositions may be used to obtain exact and parameterized algorithms. However graph decomposition is only one of the techniques envisaged in this programme to obtain algorithms.
- The ANR ALADDIN (2008-2011) is dedicated to networks analysis and algorithmics. It includes an important part of modelling. It will provide us some pertinent applications to our work.

2. DESCRIPTION SCIENTIFIQUE ET TECHNIQUE / SCIENTIFIC AND TECHNICAL DESCRIPTION

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

In the last decade, the size of the data to be handled (world wide web, networks, biology, meteorology, etc.) has grown enormously. Meanwhile, the computing power has considerably increased making the handling of massive data possible. This has opened the perspectives for studying new approaches to compute exact solutions of NP-hard problems. *Exact exponential-time algorithms*, promoted by the recent survey of Woeginger [Wo03], and *fixed parameter algorithms*, issued from the work of Downey and Fellows [DoFe99] have recently been central in this line of research and important advances have been established. On the theoretical side, new algorithmic paradigms have been developed to build these two kinds of algorithms, as well as new methods to analyse their running times. On the application side, various problems (e.g. in biology) have a parameter that allows FPT algorithms solving the problem for a large part of the instances of practical interest. Furthermore for some applications, combining fast exponential-time algorithms with preprocessing and algorithm engineering methods is likely to provide computer programmes solving all (or most of the) required instance sizes within a reasonable amount of time. Both approaches are closely related. The corresponding theories are still to be augmented and new fundamental challenges have emerged.

Exact exponential-time algorithms. When designing exact exponential-time algorithm the main objective is to minimize the exponential basis of the running time. Various drastic improvements on the best known running times of such algorithms for central NP-hard problems have been obtained recently: for example on 3-SAT [IwTa04], on the Maximum Independent Set Problem [FoGr06] or on graph colouring [BjHu06]. Although those results are recent, some general algorithmic paradigms have already been identified: *branch-and-reduce*, the memorization, *measure-and-conquer* or the use of the inclusion-exclusion principle. Such paradigms may be used to improve the running time to solve some other NP-hard problems. In particular, problems consisting in finding a maximum induced subgraph with a given property can be solved in time $O(2^n)$ if the property can be verified in polynomial time. However only few of them are known to have exact algorithms with a running time of $O(c^n)$ with $c<2$. It is a natural question to ask whether the "2^n barrier" can be broken for more problems of this type. More optimistic, could there be a kind of general approach that guarantees to obtain an exact algorithm of running time $O(c_P{}^n)$ for each such problem.
The running time is just one aspect of the global complexity of an algorithm. Another central issue is the space complexity. Typically, branching algorithms need only polynomial space while dynamic programming algorithms need exponential space. It is easy to state that polynomial space is better than exponential space, in particular if two algorithms for the same problem have (almost) the same running time. However what if the polynomial space algorithm needs significantly more time than the exponential space algorithm? The current opinion of the researchers in the domain tends to "exponential space is usually not of much use in practice". A definite analysis seems to require experimental analysis. This is part of an emerging domain within algorithms that is called "algorithm engineering". Some interesting questions for algorithm engineering deal with the relation of exponential and polynomial space. Robson [Rob86] showed how to use "memorization" to speed up branching algorithms on the price of using exponential space. The other direction seems much more important: develop techniques for constructing polynomial space algorithms (on the price of increased running time) when only an exponential space algorithm is known. Examples are studied in [Bax94, BjHu06, BFK06]. It would in particular be most desirable to have such a general method for dynamic programming algorithms.

Fixed parameterized algorithms and complexity. A usual critic made to the classical complexity theory is that it considers worst-case complexity. Indeed it has often been observed that on real world instances exact solutions of NP-hard problems can be computed efficiently. For some problems, the explanation of this phenomenon is that the combinatorial explosion does not depend of the size n of the input but is rather a function of some parameter k. A typical example is given by the vertex cover problem, which asks for a set S of vertices covering the edge set of a graph, and which can be solve in time $O(2^k n)$ if k is the size of S. From this context has emerged the notion of parameterized complexity and fixed-parameter tractable algorithms whose theory has been developed by Downey and Fellows in the 90's [DoFe99]. Since then it became a well-regarded research domain within Algorithms and Complexity. Two important books have recently been published on this topic [FlGr06, Nie06].
Formally, a decision problem **P** parameterized by a parameter k, denoted (**P**,k), is *fixed parameter tractable* (FPT) if it can be solved by an algorithm whose complexity is O(f(k).poly(n)) with f(k) an arbitrary function (e.g. an exponential one) depending only on the parameter k and a polynomial poly(n) depending on the input size n. Parameterized complexity theory establishes a hierarchy of complexity classes: FPT W[1] $\subseteq \ldots \subseteq$ W[P] (and under the assumption that P≠NP, problems belonging to some class W[i] do not have FPT algorithms). The choice of the parameter is the crux in the design of FPT algorithms. First of all, a problem can be non-FPT for some parameter and FPT for another one. Moreover, to ensure practical efficiency one has to find a parameter that is indeed sufficiently small in real-world instances.

Some major advances in fixed parameter complexity rely on the theory of *tree-decomposition* and the associated width parameters (*tree-width, branch-width…*) developed by Robertson and Seymour [RoSe85]. A deep theorem of Courcelle [Cou91] shows that any property expressible in *monadic second order logic* on graphs of tree-width at most k is in FPT, and can even be tested in time linear in the input size, i.e. O(f(k) n). Unfortunately, the function f(.) is huge: an exponential tower [FrGr02] and the algorithms obtained with this machinery turn out to be inefficient in practice.
Some other algorithmic paradigms have been developed during the last decade to obtain efficient FPT algorithms: Bounded search tree method, Iterative compression [ReSmVe04], Color-coding [AYZ94], and Reduction to polynomial kernel (or Kernelization). The later one is certainly the most active topic in parameterized complexity today. A parameterized problem can be reduced to a kernel if there exists a set of polynomial time reduction rules which transforms the instance (I,k) into an equivalent instance (I',k') such that $k'\leq k$ and the size of I' is a function of k. A parameterized problem $(\mathbf{P},k)$ has a kernel if and only if it is FPT but this equivalence only implies the existence of exponential size kernels which are usually of little practical interest. Although few lower bounds on kernel size are known (via approximation theory arguments), there are very few results towards a theory distinguishing parameterized problems with polynomial kernel from those whose kernel has to be exponential (unless some unexpected collapse happens in the classical class complexity hierarchy). Only very recently, such a breakthrough has been established by Bodlaender et al. [BDFH08]. Extending these recent progress into a well-established theory, would really have a deep impact on complexity theory as well as in practical issues

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

In this programme we want to design algorithms to solve NP-hard graph problems exactly. The objectives are to develop new tools for the design and analysis of exact and parameterized algorithms and to apply them for designing algorithms better than the best known ones from a theoretical point of view and efficiently in practice. The practical efficiency of the algorithms will be validated on Mascopt platform by comparison with already existing algorithms.

The proposed approach aims at combining two different aspects of graph problems, the one mathematical and the other algorithmic. Significant advances in algorithms on graphs (as in various other combinatorial settings) seem to be closely allied with deep combinatorial structure theory. The treewidth and graph minor theory have a huge impact on algorithm design and complexity theory. This includes parameterized complexity as a striking example. However with few exceptions, most of the exact exponential-time algorithms and FPT algorithms use rudimentary graph theory. Several techniques, commonly used in graph theory, could be of great help. Let us briefly mention two such techniques which have developed in the last two decades: the probabilistic method and the discharging method. The first one has provided several major results in graph theory and recently, a new randomized method has been used for solving graph optimisation problem [CCS06]. The second one seems particularly adapted to find configurations for which the problem may be reduced to a simpler or smaller one, in particular for kernelization. It also has a major advantage because, in most of the cases, it leads to simple and efficient algorithms (usually linear or quadratic) for finding the desired configurations. The existence of a small kernel (polynomial or even linear in the size of the parameter) for a parameterized problem is a guarantee for efficient algorithms with which large data-sets can be handled. Among the main challenges are the questions of the existence or not of polynomial kernels and the identification of powerful reduction rules. Recent results show that (under some common assumptions) the complexity class of fixed parameterized tractable problems can be refined with respect to the kernel size. But only few tools are available to deal with this aspect of kernel theory. Thedesign of a new transformation or reduction tools and concepts between parameterized problems is an important issue in that perspective. Concerning the reduction rules, one can distinguish rules that depend on the parameter k from those that do not. Parameter independent rule are more difficult to establish andrequire a deep understanding of the graph theoretical aspects underneath the problem. For various long-standing open problems concerning the existence of polynomial (or even linear) kernels, finding parameter independent rules will be the crux.

This project is original in the considered topics as well as in the proposed method. Firstly, very few people in France work in the area of parameterized and exact algorithms. Moreover, very little in this area has been done on digraphs. Secondly, combining the powerful mathematical tools described above and algorithmic tools seems to be innovative. The project will produce important new insights, new techniques for the design and analysis of such algorithms and publications in high level conferences and journals.

More specifically, in this project, we will have a special focus on graph colouring problems and problems on digraphs.

Colouring and partitions problems: In 1976 Lawler presented an O(2.44n) algorithm to compute an optimal colouring of a graph. Despite various attempts no essential improvements have been made until Bjorklund, Husfeldt [BjHu06] and Koivisto [Koi06] showed that the classical graph colouring problem can be solved in time O(2n) using the inclusion-exclusion principle. It seems that various other colouring problems can be solved by this approach as it applies in a more general setting for partition and covering problems. One objective of this programme is to improve the present algorithms for various colouring problems using either the above approach or branching algorithms combined with a recharging mechanism and/or a time analysis based on Measure and Conquer.
A colouring of a graph is a partition of its vertex set into stable sets. Hence colouring problems are a special type of partition problems. Moreover the method developed for colouring problems generally extend to other partition problems. Therefore we would like to investigate some other partition problems, some of them regarding digraphs. Among them let us mention Minimum Degree Graph Partition : Given a graph G=(V,E) and two positives integers k and d, is it possible to partition V into disjoints subsets V1, É, Vm such that for all 1²i²m, |Vi|²k and at most d edges have exactly one endvertex in Vi. It has been open for ten years whether this problem is FPT or not with respect to k and d and it extends naturally in several ways to digraphs.
Regarding FPT algorithms, the choice of the parameter k is a crucial issue. One has to choose a parameter for which the problem is FPT and such that being FPT is a non-trivial information. If so, one may expect the corresponding FPT algorithm to be practically efficient. In particular, colouring problems are often NP-hard, and thus not in FPT, with respect to the natural parameter which is the number of colours. However there may be some interesting parameters for which a colouring problem might be in FPT. For example, the Dual Colouring Problem which asks if a given graph G may be |V(G)| -k properly coloured is FPT with respect to k. Though this result is not of practical interest since the chromatic number is usually a lot smaller than its number of vertices, others might be. One may expect to obtain practically

efficient FPT algorithms by replacing the upper bound |V(G)| by another one. For example, a result of Molloy and Reed suggests that Dual Colouring is still FPT when the bound |V (G)| is replaced by Æ(G) the maximum degree of G.

Digraph problems: While exact and FPT algorithms have been designed for many classical problems on undirected graphs, only very few results are known for directed graphs. However, some of the most important open problems on FPT algorithms involve digraphs. As an example, the major result in the area this year is the proof [JCLL+08] that the Directed Feedback Vertex Set problem has an FPT algorithm. Therefore we would like to investigate some classical digraph problems. The first one to deal with are those problems consisting in finding a subdigraph (induced or not) with some given property., as e.g. the problem of finding a spanning strong subdigraph (of a strong digraph) with the minimum number of edges. Moreover, all the problems mentioned in the above section on induced subgraphs like domination have their counterpart (usually a generalisation) for digraphs. In addition, we would like to study some of the important open problems in parameterized complexity that regard digraphs; see [GuYe07].
Regarding such problems, the major obstacle to overcome is the lack of deep and algorithmically useful combinatorial structure theory.
Hence, we will need to find a dedicated structure for each problem.
Possibly, we would identify a general method to find such structures.

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 project is divided into seven tasks (excluding the organisation and management one), some of which being divided into several subtasks. They are summarized in the following table.

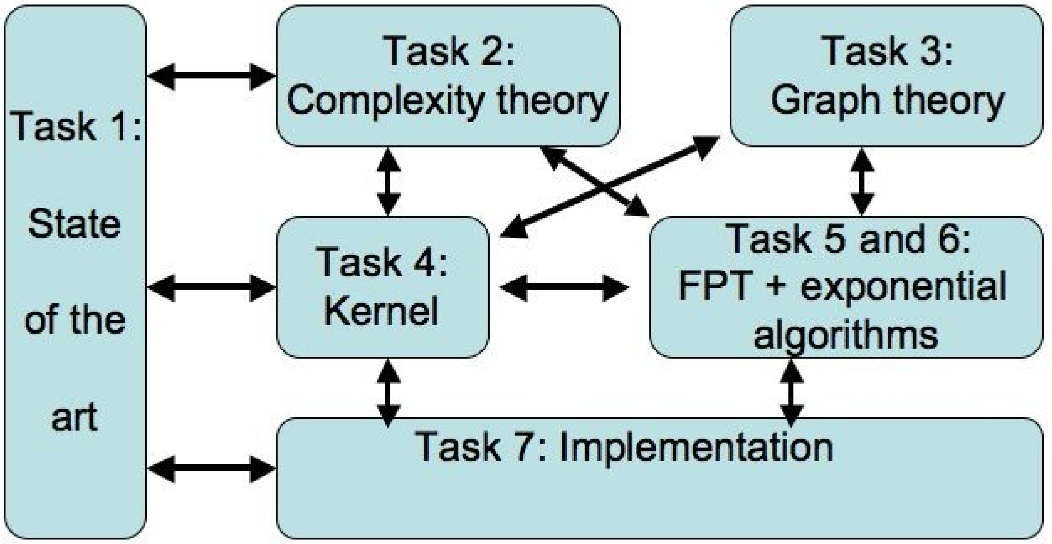
Task	Title	Tasks	
Task 0	Organisation and management.	T0.1	Project coordination
		T0.2	Meetings organisation
		T0.3	School organisation
		T0.4	Conference organisation
Task 1	State of the art and synthesis	T1.1	Knowledge acquisition
		T1.2	Knowledge dissemination
		T1.3	Survey writing
Task 2	Complexity theory	T2.1	Kernel hierarchy inside FPT
		T2.2	Polynomial vs exponential space
		T2.3	Sub-exponential time algorithms

Task 3	Graph Theory	T3.1	Decomposition of graphs and digraphs.
		T3.2	Combinatorial bounds
		T3.3	Enumerative combinatorics, extremal graph theory
Task 4	Kernel and reduction rules	T4.1	Existence of polynomial kernel
		T4.2	Reduction rules
Task 5	Fixed parameterized algorithms	T5.1	Time complexity
		T5.2	Space complexity
		T5.3	Kernel size
Task 6	Exponential time algorithms	T6.1	Algorithm design
		T6.2	Worst case bound analysis
		T6.3	Crossing techniques
Task 7	Implementation and experimentations	T6.1	Implementation
		T6.2	Experimentations

The Task 0 is non-scientific and not related to the others.

The knowledge acquired during Task 1 will be useful in all the other tasks. Results in complexity theory (Task 2) and graph theory (Task 3) will serve as a foundation of most of the solutions (algorithmic or not) to the problems we will consider. For example, tools from complexity theory will be used for problem classification ; graph theory is important in the parameter identification process and for the design of efficient reduction rules. The interaction between implementations (Task 7) and algorithm design (Task 4, 5 and 6) is clearly two-ways. Of course the feedback resulting from experimentation will also have an impact on the algorithm design and may be useful to identify new graph properties or complexity phenomena to be analysed.

The depencies between the different workpackages (except Task 0 management) is outlined in the following diagramm.



3.2. COORDINATION DU PROJET / PROJECT MANAGEMENT

3.2.1TÂCHE 0 / TASK 0: ORGANISATION AND MANAGEMENT

Leader: INRIA (F. Havet)

The AGAPE project is managed by INRIA (Mascotte), with the support of its partners.

The Task 0 is particularly concerned with the following subtasks:

T0.1: Coordinating partners in the project execution. This will partly done using the INRIA facility InriaGforge.

T0.2: Organising the project meetings and outside presentations

T0.3: Organising a school during the first year.

T0.4: Organising a conference at the end of third year or beginning of fourth year.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	4	3	3	**10**

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

3.3.1 Tâche 1 / task 1 State of the art and synthesis

Leader: INRIA (F. Havet)

The goal here is to upgrade the global level of the participants of the project. Each scientific leader will be asked to share its specific knowledge. By the end of the task, each project participant may become an active researcher at the international level for any of the topics addressed by the project. That is, any participant has to master the main methods and to understand the main challenges and their impacts in any of the subjects we will consider.

This task subdivides into three subtasks:

- **T1.1: Knowledge acquisition:** bibliographic research, attendance to seminars and lectures.
- **T1.2: Knowledge dissemination:** lectures and seminars to other members.
- **T1.3: Writing a survey.**

This workpackage will mainly be done in the first year. It will start from the kick-off meeting gathering all the project members and end with the organisation of a school on "parameterized and exact algorithms". Such a school will be an opportunity for us to invite leading researchers and to work with them. (Note that this workpackage has already started and we are organized in June a meeting JCALM on fixed-parameter tractable algorithms.)

The main challenge here is to sufficiently upgrade the level of everybody in each of the topics we shall consider. As this is a never ending task, we insist on the fact that during each annual meeting, special sessions will be devoted it. That way, we will be able to push higher and higher the global expertise of our consortium.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	4	4	5	**13**

3.3.2 Tâche 2 / task 2 Complexity theory

Leader: LIRMM+LIFO (C. Paul + M. Liedloff)

Complexity theory forms a wide research area ranging from logic to combinatoric and requires specific background and knowledge. This is not the purpose of this project to develop new results in complexity theory. However as algorithm designers, the members of the project need to used tools and concepts from complexity theory. One of the Task 1 (state of the art) objectives is indeed to teach to the whole group the important concepts involved in fixed parameterized complexity and in exponential time algorithms. Three subtasks can be identified:

Task 2.1: Kernel size refining FPT complexity class

It is known that for a parameterized problem, the existence of an FPT algorithm is equivalent to the existence of a kernel. But by default, the size of the kernel is an exponential function of the parameter. Clearly, a hierarchy can be defined among the set of FPT problems: the first level corresponds to the problems having a linear kernel, the second level contains the problems with a quadratic kernel… the higher level is the whole FPT class (problems with an exponential kernel). Whether this hierarchy is composed of an infinite number of levels is not known and is one of the important open question in fixed parameterized complexity. Only recently, it has been proved that, unless some unexpected collapse happens in some classical complexity hierarchy, some FPT problems do not have polynomial kernel. Very few tools have yet been proposed to classify parameterized problems with respect to their kernel size. This direction of research has to be developed further and the members of the project have to be familiar with this ideas.

Task 2.2: Polynomial versus exponential space

We shall distinguish two different aspects for the complexity analysis. The first one concerns the evaluation of the time complexity of the algorithms. However determining the time complexity is not the end of the story. The size of the memory space used is also important and has to be determined. Given an exponential-space algorithm, we are asking about the possibility of reducing the amount of space needs by the algorithm. We will have to analyse the space complexity to offer the best theoretical trade-offs time complexity/space complexity. Clearly, some knowledge is needed to theoretically evaluate the best trade-off. More basically, we aim at providing general techniques for going from exponential-space algorithms to polynomial-space algorithms, even if such operations need to increase the running-time. Conversely, such techniques are already known: E.g, the memorization technique introduced by Robson allows some branching based algorithms to speed-up their running-time by making use of exponential spaces.

Task 2.3: Existence of sub-exponential time algorithms

Besides solving NP-hard problems in super-polynomial time, the question of designing sub-exponential time algorithms is natural. Considering the Dominating Set problem on graph, it has been shown [FoKrWo04] that the problem cannot be solved in sub-exponential time, unless SNP is contained in SUBEXP (which is considered to be unlikely). On the other hand when the problem is restricted to planar graphs it remains NP-hard but a a sub-exponential time algorithm exists [Do07]. In this task we aim to be acquainted with methods for (a) proving the non-existence of sub-exponential time algorithm, (b) deriving results based on the well-accepted Exponential-Time Hypothesis (ETH), and (c) proving negative results based on any "unexpected statement". On the other hand, it is worth to note that few algorithmic techniques are known for designing sub-exponential time algorithms.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	0	27	11	**38**

3.3.3 Tâche 3 / task 3 Graph theory

Leader: INRIA (F. Havet)

The objective of this task is to provide theoretical results that could be useful in an algorithmic setting.

This task subdivides into three subtasks:

T3.1: Decomposition of graphs and digraphs: As we said before, major advances in FPT and exact algorithms for graphs rely on the fact that there exist numerous deep structural theorems. The most important one which has application in the context of fixed-parameterized complexity is tree-decomposition and related decompositions (see e.g. Courcelle's Theorem).
From such decompositions, one can derived logical based algorithms for a large number of graph optimization problems. However this algorithms are far from being practical as their mathematical foundations involve some huge constant in their complexity. In order to overcome this problem one has to develop the theory of such tree-like decomposition in order to design efficient algorithms. In particular, the rank decomposition seems a promising tree-like decompostion to be studied
Regarding digraphs there is a lack of such structural theorems that could be algorithmically useful. Hence for each of the studied problem we will have to find some dedicated useful structural properties. One hope would be that some general theory or paradigms will be identified. This would lead to important breakthrough on digraph algorithms.

T3.2: Combinatorial properties: In order, to get good reductions rules or to bound the branching process of the algorithms, it will be necessary to establish some specific combinatorial properties. For example, for colouring problems a general upper bound on the required number of colours allows to cut all the branches in which we have a partial colouring with more colours. Another kind of useful properties are precoloring extension results as they will yield good reductions rules or bounds for the branching process of the algorithms.

T3.3: Enumerative combinatorics, extremal graph theory. Some of the algorithms that we will design are likely to rely on some combinatorial objects to be enumerated. Hence one shall be able firstly to enumerate them and secondly to obtain precise upper bounds on the number of such objects in order to analyse the complexity of the algorithm.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	30	24	21	**75**

3.3.4 Tâche 4 / task 4 Kernels

Leader: LIRMM (S. Thomasse)

Two instances (I,k) and (I',k') of some parameterized problem are equivalent if they are both TRUE or both FALSE. A very natural tool in computation is to transform complicated instances into equivalent ones which are simpler to handle. This roughly stated technique is now a well-defined and extremely active area of parameterized algorithms.
Precisely, we say that a parameterized problem has a polynomial kernelization if there exists a polynomial algorithm which transforms any instance (I,k) into an instance (I',k') such that the size of I' is polynomial in terms of k. The instance (I',k'), called the **kernel**, concentrates the hardness of the problem. Hence, it can be seen as a compressed instance of (I,k).
The goal here is of course to minimize the size of the kernel, or to certify that no polynomial kernel exists.
In usual computation theory, the calculation of a solution can be expressed as a search tree. The goal of kernelization is simply to apply as many non branching operations as possible in the

search tree in order to reduce the original instance. Roughly speaking, the search tree starts with a path of operations admitting only one output. These are the central tools of kernelization: the reduction rules. Intuitively, a reduction rule is a way to get rid of unimportant part of the instance. For example, if the instance is a graph having some isolated vertices (and provided that they play no role in the problem), one of the easiest reduction rules simply consists in suppressing them. But the design of reduction rules is much more sophisticated than just trivial observations. And a kernelization algorithm often presents several reduction rules to perform, together with a proof that if no reduction rule can be performed, the instance is certainly polynomial in k.

The design of efficient reduction rules is maybe the most fascinating area of parameterized complexity. Basically, we can identify three types of rules:

1. The first one are the obvious cleaning rules which delete isolated vertices, or useless parts of the instance. These are the simplest rules one can introduce. They usually do not present any difficulty.
2. The second kind of rules are based on counting techniques. Basically, if the instance is large compared to k, some parts of the instance are replicated a large number of times (giving a vertex of large degree, or a large matching, etc...). One can then take advantage of these replications to discard useless parts of the graph, or in some cases directly give a negative conclusion.
3. The last kind of rules is based on combinatorial optimization tools. One first use of LP-relaxation is to calculate a fractional soution and analyze the vertices valued 0, trying to discard them (this is the case for the linear kernel of VERTEX COVER). A second use of duality is to strenghten the rules based on counting. For instance, instead of obtaining a large matching thanks to some degree counting argument, one can use the full duality aspect and use the co-certificate. This often improve the size of the kernel by an order.

The main goal in this task will be to design new efficient reduction rules. Our expertise in combinatorial optimization tools and graph width-parameter will guide us in this task.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	11	37	11	**59**

3.3.5 Tâche 5 / task 5 FPT Algorithms (design and analysis)

Leader: LIRMM (C. Paul)

The first task in the design of a fixed parameterized algorithm is to identify a pertinent parameter. Pertinent with respect to its practical impact, it has to somehow characterize practical data-sets, and also pertinent with respect to the complexity issues (see Task 5.1). Then one has a number of algorithm techniques (among which the reduction to kernel) that can be interleaved or used independently (Task 5.2). As shown by the recent solution to the parameterized directed feedback vertex set problem [CLLOR08], the development of new techniques is still an important challenge (Task 5.3).

Task 5.1: Parameter identifications.

The role of parameter is essential as for some parameters the problem could be FPT while with some others, it remains intractable. Also for practical issues, it is crucial to find parameters whose value remains small in general as the complexity of FPT algorithms is measured by an exponential function of the parameter. So identifying *good* parameters is the very first step in the design of efficient exact algorithms.

The *natural* parameter is usually the size of the solution. Of course, such a parameterization does not always yield an FTP algorithm or its value may be too large in practice. In that case ; more involved structural parameters have then to be considered such as *treewidth,* or other classical width parameters. Then theoretical study (see [Task 3]) is required to really understand the impact of a parameter on instances. The soundness of a parameter can also be experimentally checked. To that aim we first have to design elementary reduction rules with respect to this parameter (see [Task 4]). Then an implementation of these rules (see [Task 7]) will permit an experimental analysis of the impact and the role of the parameter on practical data-sets.

Task 5.2: Crossing techniques.
Interleaving different algorithm techniques, such as bounded search trees and kernel reduction, has been proved to be efficient in practice. Though the communities working on fixed parameterized algorithms and on exact exponential time algorithms are close to each other, crossing specific methods of each domain has not been really considered yet. Gathering in the same group researchers from each topic will help to establish such connections.

Task 5.3: Developing (new) FPT methods.
Some of the known parameterized algorithm methods have not been used or tried as systematically as the other (e.g. iterative compression vs bounded search tree), which reveals a lack of understanding. Indeed, we believe that the use of methods like iterative compression requires to master deep graph theory results (see [Task 3]). It is not suprising that recent advances rely on fundamental graph theory problem (e.g. the linkage problem for directed feedback vertex set, or more generally graph separation problems). To identify such central problems toward which one can reduce or transform the problem to be solved has always been an important feature of algorithm design. However it has not been oftently used in the context of fixed parameterized complexity.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	14	13	21	**48**

3.3.6TÂCHE 6 / TASK 6 EXPONENTIAL TIME ALGORITHM (DESIGN AND ANALYSIS)

Leader: LIFO (D. Kratsch)

The aim of this task is to work on the design and analysis of exponential time algorithms. We are looking for general designing techniques for solving graph problems as well as for the challenging task of analyzing these algorithms.

T6.1: Designing algorithms: new problems, new techniques. Various classical techniques for designing exponential time algorithms are known (dynamic programming, branch-and-reduce, inclusion-exclusion…). Nevertheless, each problem is different and requires some specific and often tricky study to be attacked under the exponential algorithms point of view. Going from establishing useful combinatorial results to designing new techniques, the aim of this part of the project is to algorithmically solve digraph problems, colouring and partitioning problems etc. We believe that many general techniques are still to be discovered and we intend to consider several directions. An important issue in exponential algorithms is to design algorithms using polynomial space. Very often dynamic programming algorithms require exponential space, and we aim at obtaining general methods reducing exponential to polynomial space. Another idea is to combine techniques for better algorithms. For example in some cases graphs either have a strongly constrained structure (e.g. bounded treewidth) or other combinatorial properties (e.g. vertices of large degree), and using the best technique according to each case leads to faster exact algorithms. Other domains like subexponential algorithms or the use of branch-and-reduce methods in combination with measure-and-conquer analysis require further research.

T6.2: Analysing the worst-case upper bound. This ANR project combines theoretical and practical analysis of the efficiency of algorithms. The practical efficiency needs meticulous implementations and experimentations (see Task 7). The theoretical analysis is done by a worst case analysis using the classical big-Oh notation. Unfortunately, unlike worst-case analysis of polynomial-time algorithms, exponential-time analysis can be very difficult.
E.g., to analyze the running-time of a Branch-and-Reduce based algorithm, one needs to measure the progress done by the algorithm at each step. However, establishing a loosely upper bound on this progress leads to an overestimated running-time upper bound. One of the most powerful tools used to improve the analysis is the measure-and-conquer technique, introduced by Fomin, Kratsch and Grandoni. Our deep knowledge of this technique should allow us to bring further refinements and new ideas. Another way to derive upper-bounds on the worst case running-time is the use of the discharging method described in Section 2.2. We would like to focus our attention on some tools involving non-standard measures as well as discharging mechanism. Since the worst-case running-time is often overestimated, it is natural to ask for lower bounds on the worst-case running time. Such bounds would give insights on how far the real upper bounds can be and some clues on the possible practical behaviour on the algorithm on the worst cases.

T6.3: Crossing techniques. Several techniques can be transferred from FPT to exponential algorithms or vice-versa. For example, reduction rules used in FPT algorithms (which do not make use of the parameter) and the iterative compression technique can also be applied for exponential algorithms. Conversely, we believe that measure-and-conquer analysis could be used in the design of FPT algorithms.
There is also a strong relationship between exponential algorithms and combinatorics. The analysis of exact algorithms enumerating objects as maximal independent sets or minimal dominating sets provide upper bounds on the number of these objects. Conversely, better combinatorial bounds sometimes lead to improved exact algorithms (see e.g. the best algorithms for treewidth). This subtask aims at improving and finding new crossing techniques between areas like FPT algorithms, exponential algorithms and combinatorics.

This task implies all partners at different degrees. D. Kratsch is a leader scientist in exact algorithms and M. Liedloff has deep experience in the area. Other partners bring complementary knowledge in digraphs (F. Havet, S. Thomassé…), FPT algorithms (C. Paul, S. Thomassé…) and combinatorial techniques (F. Havet, I. Todinca…). Although some of the topics listed above might prove to be difficult, we are absolutely confident that our joined teams would be able to achieve new, important results in the area.

Given the wide perspectives of this domain, we ask for a financial support for a PhD thesis on *Exact algorithms design (theory and practice)* under the supervision of D. Kratsch. The student would have the opportunity to be involved in this ambitious project and would provide new perspectives and fresh ideas (see also the joint PhD subject).

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	23	0	47	**70**

3.3.7 TÂCHE 7 / TASK 7 IMPLEMENTATION AND EXPERIMENTATION

Leader: INRIA (M. Syska)

The main objective of this workpackage is to test the practical efficiency of the algorithms resulting from the project against already existing algorithms. Another concern is the ability to provide ready to use implementation code and experimental data (benchmarks) to the research community, so as to anyone could verify, compare or adjust the software experiments, and help with improving the work done.

T7.1: Implementation: This will be done using the Mascopt library (http://www-sop.inria.fr/mascotte/mascopt). Mascopt is a free Java library developed within the Mascotte team (with strong involvement of JF. Lalande from LIFO) and distributed under the terms of the LGPL license. Mascopt is dedicated to graph and network processing and includes a collection of Java interfaces and classes that implement fundamental graph data structures and algorithms.
The main objective of the Mascopt library is to ease rapid software development in the field of graph optimization. Mascopt helps implementing an algorithm to such problems by providing a structured data model, classes to handle graphs and ready to use implementation of existing algorithms or linear programs (e.g. spanning trees, shortest paths or integral multicommodity flow).

T7.2: Experimentation: In this subtask, we will pay a particular attention to the experimental sets of data used to test the algorithms, and we will publish all the data or code generating the data sets. In one word, the objective here is the reproducibility of the experimental work.

Partners	INRIA	LIRMM	LIFO	**Total**
Man Months	30	0	29	**55**

Overall resources involved by Workpackage for each partner:

Resources (Man months)	INRIA	LIRMM	LIFO	Total Man months
Task 0	4	3	3	**10**
Task 1	4	4	5	**13**
Task 2	0	27	11	**38**
Task 3	30	24	21	**75**
Task 4	11	37	11	**59**
Task 5	14	13	21	**48**
Task 6	23	0	47	**70**
Task 7	30	0	29	**59**
Total resources (man months)	**116**	**108**	**148**	**372**

3.4. CALENDRIER DES TÂCHES, LIVRABLES ET JALONS / PLANNING OF TASKS, DELIVERABLES AND MILESTONE

	Partenaires/*Partne*			Chronogramme / chemin critique (*Timing diagram/ critical path*)																							
				Année / *Year* 1						Année / *Year* 2						Année / *Year* 3						Année / *Year* 4					
	1-INRIA	2-LIRMM	3-LIFO	2	4	6	8	10	12						24						36						48
T.0.1																											
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T.0.3																											
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T6.2																											
T6.3																											
T.7.1																											
T.7.2																											
Livrables /Jalons *Deliverables/Milestones*																											
Rapports d'avancement / états des dépenses *Progress report/expenses*						☺			☺			☺			☺			☺			☺			☺			☺
Accord de consortium/rapport final *Consortium agreement/final report*									✪																		☆

☺ : Rapport d'avancement semestriel/ *6 month-progress report*

☺ : Rapport d'avancement semestriel + état des dépenses/ *Progress report + expenses*

✪: Accord de consortium/ *Consortium agreement*

☆: Rapport de synthèse + récapitulatif des dépenses/ *Final report + expenses summary*

One of the possible blocking point in this programm would be that all the envisaged methods to solve problems are theoretically non-efficient. In this case, we will have no new algorithms to implement and test. However, a good alternative goal for T7 would be to implement and experiment on the already existing algorithms to solve major central problems like Vertex Cover. Doing so we will produce a library of algorithms that will be useful for the scientific community.

1. *TABLEAU des LIVRABLES et des JALONS (le cas échéant)/ Deliverables and milestones*			
Tâche/ *Task*	Intitulé et nature des livrables et des jalons/ *Title and substance of the deliverables and milestones*	Date de fourniture nombre de mois à compter de T0/ *Delivery date, in months starting from T0*	Partenaire responsable du livrable/jalon/ *Partner in charge of the deliverable/ milestone*
1.			
	Lectures notes of the school	T+10	INRIA
2.			
	Survey on exact and parameterized algorithms	T+12	INRIA
3.			
	Proceedings of the conference on Efficient Graphs Algorithms	T+40	LIRMM
	Data sets and code	T+48	INRIA

4. Stratégie de valorisation des résultats et mode de protection et d'exploitation des résultats / Data management, data sharing, intellectual property and results exploitation

The expected results are algorithms to solve some NP-hard graph problems exactly, as well as new design techniques and tools to analyse FPT and exact exponential-time algorithms. This will give rise to publications in journals and as well as communications to conferences and publications in proceedings. These algorithms will also be implemented on Mascopt. As Mascopt is open source, the scientific community will be able to use, modify or improve our algorithms and also to reproduce our tests to validate them. As the problems that we will study are used to model many real world problems, it is expected that in a second stage our algorithms lead to practical applications.

5. Organisation du partenariat / Consortium organisation and description

5.1. Description, adéquation et complémentarité des partenaires / Relevance and complementarity of the partners within the consortium

The consortium proposed for this programme is particularly relevant because it gathers together leader scientists in all the complementary aspects that the proposal aims at combining: exact algorithms, parameterized algorithms, digraph theory, graph colouring, graph proof techniques, implementation of combinatorial algorithms.

INRIA Sophia-Antipolis (projet Mascotte): project has a strong expertise in network design and algorithms for communications. It is used to collaborate with industrial partners, mainly Orange Labs (formerly France Telecom R & D) via the "Contrat de Recherche Collaborative" CORSO, but also Alcatel, Alcatel Space Industries, and some small enterprises. It is very proficient in modelling real world problems in terms of graphs. It also has a very good knowledge on graph theory and combinatorial optimisation. In particular, it is has obtained important results on graph colouring using the probabilistic method and the discharging method. Finally, Mascotte has a long experience in the *implementation and the experimental validation of algorithms.* In particular, it has initiated the platform Mascopt on which all our algorithms will be tested.

LIFO (+LITA): The members of this partner have a strong expertise in graph algorithms and specifically exact exponential time algorithms. In particular D. Kratsch is a leader scientist in this domain. He has co-authored several striking articles with the best known algorithms for fundamental problems (minimum dominating set, maximum stable set, treewidth) and introduced the *Measure and conquer* technique. He is a member of the programme committee of IWPEC – International workshop on parameterized and exact algorithms. Other members of the team also made noticeable work on exact algorithms: M. Liedloff on domination problems, I. Todinca on decomposition problems and P. Berthomé on how to compute the chromatic polynomial. They also have a deep knowledge on graph decomposition. In addition, they are now used to implementation and experimentation with Mascopt since the arrival of J.-F. Lalande who developped it when he was in Sophia-Antipolis.

LIRMM: The team VAG of LIRMM has an important competence in graph theory and graph algorithms. Its members are specially known for their work on graph decompositions on both theoretical and algorithmic aspects. It also obtained some striking results on digraphs like the proof of Gallai conjecture by Bessy and Thomasse. In the last few years, this group has made a successful effort to turn its scientific objectives towards fixed parameter algorithms. As witnessed by its recent international collaborations with some of the most recognized research of the domain (Fomin, Heggerness, Telle from Bergen - Norway; Bodlaender from Utrecht - Nederlands; and Fellows from Newcastle - Australia), the VAG team is now the most renowned French group on fixed parameterized complexity. Finally it is also used to model and tackle some problems arising form bio-informatics.

5.2. QUALIFICATION DU COORDINATEUR DU PROJET / QUALIFICATION OF THE PROJECT COORDINATOR

The scientific leader of this proposal is Frédéric Havet. He is a CNRS Chargé de Recherches first class (CR1).

He has supervised two PhD students (J.-S. Sereni and O . Amini) and is currently supervising two others (M. Aste and N. Cohen). He has also supervised several postdoc, predoc and master students.

He is active in organising scientific meeting. He was the chairman of the organising committee of several conferences (ICGT05, JGA08, Journees GALET) as well as in the programme committee of some others (Algotel04, JCB60, WG06) . He also initiated the Journees CALM and organized the first (October 2006) and the fourth (June 2008). Finally he has been in charge of the seminar of Mascotte for 6 years.

He has already leaded several scientific projects:

- Action Color (Local collaboration) Dynamic between Mascotte team and LIRMM (Montpellier), 2002.
- ATIP Young Researcher on Frequency Assignment, 2002-2004.
- Bilateral exchange programme between Mascotte and the Mathematical Institute of Oxford University on Channel assignment, funded by Region PACA, 2003-2005.
- ECONET exchange programme between Mascotte, Charles Univesity (Prague), and the University of Ljubljana on Graph colouring 2007-2009.
- Action Color (Local collaboration) PaGro between Mascotte team and LIRMM (Montpellier) on Digraph partitions, 2008.

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

INRIA (Mascotte)	Nom	Prénom	Emploi actuel	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinator	Havet	Frederic	CR1 (CNRS)	24	Global and local coordinator; Head of T1 andt T3; Research. Competences: Graph theory (Structural and algorithmic aspects)
Other members	Coudert	David	CR1 (INRIA)	8	Research. Competences: Graph algorithms , Applications to telecommunications
	Syska	Michel	MDC (UNS)	12	Head of T6, Research, Implementation and experimentation. Competences: Combinatorial optimisation
	Perennes	Stephane	CR1(CNRS)	6	Research. Competences: Graph algorithms , Applications to telecommunications
	Aste	Marie	PhD Student	12	Research. Competences: Graph colouring
	Cohen	Nathann	PhD Student	18	Research. Competences: Graph theory
	X	X	PostDoc	18	Research.

					Competences: FPT and/or exact algorithms
	X	X	Ingenieur	18	Implementation and experimentation

LIRMM (Univ. of Montpellier)	Nom	Prénom	Emploi actuel	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinator	Thomasse	Stephan	PR (Univ. Montpellier 2)	16	Local coordinator; Head of T4, Research. Structural graph and digraph theory. FPT algorithms
Other members	Bessy	Stephane	MDC (Univ. Montpelleir 2)	12	Research. Competences: Digraphs. Kernelization.
	Goncalves	Daniel	CR2 (CNRS)	6	Research. Competences: Graph theory
	Paul	Christophe	CR1(CNRS)	14	Head of T5, Cohead of T2, Research. Competences: FPT Algorithms and complexity Applications to biology
	Daligault	Jean	PhD Student	18	Research. Competences: FPT algorithms
	Perez	Antony	PhD Student	18	Research. Competences: FPT algorithms
	X	X	PostDoc	12	Research. Competences: FPT algorithms
	X	X	PostDoc	12	Research. Competences: Minor theory, tree decomposition

LIFO (University of Orleans)	Nom	Prénom	Emploi actuel	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinator	Todinca	Ioan	PR (University of Orleans)	20	Local coordinator, Research. Competences: Algorithmes de graphes
Other members	Berthome	Pascal	PR (University of Orleans)	10	Research. Competences: Algorithmes de graphes, applications aux telecommunications.
	Durand-Lose	Jerome	PR (University of Orleans)	6	Research. Competences: Complexity
	Kratsch	Dieter	PR (University of Metz)	20	Head of T6, Research. Competences: Exact exponential algorithms
	Lalande	Jean-Francois	MDC (University of Orleans)	12	Research. Implementation and experimentation
	Liedloff	Matthieu	MDC (University of	20	Co-head of T2, Research.

			Orleans)		Competences: Exact exponential algorithms
	Chapelle	Mathieu	PhD student	6	Research. Competences: Graph algorithms
	X	X	PhD student	36	Research. Competences: Exponential exact algorithms
	X	X	Engineer	18	Implementation and experimentation

6. Justification scientifique des moyens demandés / scientific justification of requested budget

6.1. Partenaire 1 / partner 1 : INRIA (Projet Mascotte)

Équipement / Equipment

None

Personnel / Staff

Engineer: 18 months. The engineer will be engaged in the middle and the end (between T+18 T+48) of the project to implement and validate the developed algorithms in this project. Mascotte has no permanent engineer.
Cost: 18 * 3290 = 59 220 euros.
Postdoc: 18 months. He will be engaged after roughly one year (T+9, T+18), once the technical scientific problems are identified. Having a dynamic postdoc mastering exact and parameterized algorithms would help the Mascotte project to improve its expertise in this domain.
Cost: 18 * 4000= 72 000

Prestation de service externe / Subcontracting

None.

Missions / Missions

6 missions to national conferences + 6 missions to international conferences per year.
Cost: 15 000 euros per year so 60 000 euros in total.

12 weeks of visits to another partner per year + meetings
Cost: 10 000 euros per year so 40 000 euros in total.

Dépenses justifiées sur une procédure de facturation interne / Internal expenses

None.

Autres dépenses de fonctionnement / Other expenses

2 personal computers: they will be assigned to the post-doc and the engineer to be funded by this programme.
Cost: 4 000 euros.

Organisation of the school on Parameterized and Exact Algorithms in the spring of the first year.
Cost: 10 000 euros.

6.2. PARTENAIRE 2 / PARTNER 2 : LIRMM (UNIVERSITY OF MONTPELLIER)

Équipement / Equipment

None.

Personnel / Staff

Postdoc: 24 months. A first one year post-doc will be engaged at the beginning of the project and another one at the end. The first one will be recruited with a more theoretical profile to help the consortium to identify the good parameters and the pertinent structural properties of graphs. The second one will be chosen with some skills and background in algorithm analysis. He will help to improve the algorithms before and after implementations.
Cost: 24 * 4083 = 98000 Euros

Subjet of the 2 post-docs:

Kernel reduction and parameterized complexity

Kernel reduction with respect to a parameterized problem consists in reducing in polynomial time an arbitrary instance to one whose size depend only of the parameter k while preserving the existence of a solution to the problem. It is known that a problem has a kernel if and only if it has a parameterized algorithm, i.e. with complexity f(k).poly(n). However having a small kernel (by small we mean polynomial in k or even linear) is not a common property of fixed parameterized tractable problems. Only few tools are available to prove (under classical complexity assumptions) that an FPT problem only has exponential kernel. The research program for the postdoc fellows is that study kernel reductions in the context of classical graph problems or more generally combinatorial problems.

Graph minor theory, width parameters

Tree decomposition and graph minor theory is one of the most important theoretical tools which has applications in the context of fixed-parameterized complexity (see e.g. Courcelle's Theorem). While the notion of tree-width has been central in the proof of the graph-minor theorem, the rank-width has been introduce in for the vertex-minor conjecture. Rank-width, which is a parameter equivalent to clique-width, also enjoys an algebraic characterization. From this, one can derived logical based algorithms for a large number of graph optimization problems. However this algorithms are far from being practical as their mathematical foundations involve some huge constant in their complexity. The objective of this research programme is twofold: 1) develop the vertex-minor theory and the associated rank decomposition; 2) design efficient rank-width based algorithms.

Prestation de service externe / Subcontracting

None.

Missions / Missions

6 missions to national conferences + 6 missions to international conferences per year.
Cost: 15 000 euros per year so 60 000 euros in total.

12 weeks of visits to another partner per year + meeting
Cost: 10 000 euros per year so 40 000 euros in total.

Dépenses justifiées sur une procédure de facturation interne / Internal expenses

None.

Autres dépenses de fonctionnement / Other expenses

2 personal computers: they will be assigned to the two post-docs decribed below.
Cost: 4 000 euros
Organisation of the confererence on Efficient Graph Algorithms in the fourth year.
Cost: 10 000 euros.

6.3. Partenaire 3 / partner 3 : LIFO (University of Orleans)

Équipement / Equipment

None.

Personnel / Staff

1 PhD :The PhD student will be supervised by Dieter Kratsch. It will start in the first year of the project.
Cost: 3 years * 33 000 = 99 000 euros.

Engineer : 18 months. The engineer will be engaged in the middle and the end (between T+18 T+48) of the project to implement and validate the developed algorithms. LIFO has no permanent engineer.
Cost: 1.5 years * 35 000 = 52 500 euros.

Subject of the PhD:
Title : Exact exponential-time algorithms : theoretical and experimental analysis
Supervisor : Dieter Kratsch, professor, university of Metz

Today NP-hardness of an algorithmic problem is considered as a strong indication that there is no efficient algorithm to solve the problem. On the other hand, the number of NP-hard problems enormous; and many of them have important applications in computer science, telecommunication, biology, etc. Thus there is a large need for algorithms solving NP-hard problems.
A large number of the often studied NP-hard problems in algorithms are graph problems such as: Independent Set, Clique, Coloring, Dominating Set or Hamiltonian Circuit. If exact solutions of NP-hard problems are needed (such that the algorithm works correctly for all graphs), then the only hope is to construct an exact algorithm with a good exponential (worst-case) running time. The best one can hope for is often O(c^n) for a constant c close to 1.
During the last decade the interest in exact exponential-time algorithms has increased significantly: from very few papers per year to some important contributions to the high level conferences every year. Two of the best results in this research direction are a branching algorithm of Fomin, Grandoni and Kratsch (ICALP 2005) to compute a minimum dominating set of a graph in time O(1.5137^n) and an inclusion-exclusion algorithm of Björklund, Husfeldt and Koivisto (FOCS 2006) to compute the chromatic number of a graph in time O(2^n).
The main objective of the PhD project is to design and analyse exact exponential-time algorithms to solve NP-hard graph problems. New techniques to develop such algorithms as well as new and competitive algorithms for NP-hard problems are to be studied and established. One of the important open problems of the domain is the running time analysis of branching algorithms. The value of new tools for analysing such algorithms can hardly be overestimated.
The study of the relations of exact exponential-time algorithms and fixed-parameter (ecxact) algorithms introduced by Downey and Fellows, should be fruitful. Main questions would be the transfer of techniques and analysis tools from one domain to the other.
Finally an experimental analysis of exact exponential-time algorithms should be carried out to study phenomena that can hardly be explained via theoretical (worst-case time) analysis. A natural task would be to obtain as efficient as possible implementations of the best known algorithms for a collection of NP-hard graph problems.

Prestation de service externe / Subcontracting

None.

Missions / Missions

7 missions to national conferences + 7 missions to international conferences per year.
Cost: 17 500 euros per year so 70 000 euros in total.

9 weeks of visits to another partner per year + meeting
Cost: 8 000 euros per year so 32 000 euros in total.

Invitations for international experts:
Cost: 6 * 1 week = 10 000 euros

Dépenses justifiées sur une procédure de facturation interne / Internal expenses

None.

Autres dépenses de fonctionnement / Other expenses

2 personal computers: they will be assigned to the PhD student and the engineer to be funded by this programme.
Cost: 4 000 euros.

Total cost LIFO : 278 200 euros (including 4 % for management)

7. ANNEXES

7.1. RÉFÉRENCES BIBLIOGRAPHIQUES / REFERENCES

[AYZ94] N. Alon, R. Yuster and U. Zwick, Color coding: a new method for finding simple paths, cycles and other small subgraphs within large graphs. In *Proc. Symp. Theory of Computing (STOC)*, 326-335, 1994.

[Bax94] E. Bax, Algorithms to count paths and cycles, Inform. Process. Lett. 52: 249-252, 1994

[BjHu06] A. Bjorklund and T. Husfeldt, Inclusion-exclusion algorithms for counting set partitions, In *Proc. Symp. Foundations of Computer Science (FOCS 2006),* pp. 575-582, 2006.

[BHKK08] A. Bjorklund, T. Husfeldt, P. Kaski and M. Koivisto. Computing the Tutte polynomial in vertex-exponential time, to appear in *Proc. Symp. Foundations of Computer Science (FOCS 2008).*

[BDFH08] H. L. Bodlaender, R. G. Downey, M. R. Fellows and D. Hermelin. On problems without polynomial kernels. In *Proceedings of ICALP 2008*, *Lecture Notes in Comput. Sci. 5125: 563-574*, 2008.

[BFK06] H. L. Bodlaender, F. V. Fomin, A. M. C. A. Koster, D. Kratsch and D. M. Thilikos: On Exact Algorithms for Treewidth. ESA 2006: 672-683.

[ChGr04] L. S. Chandran and F. Grandoni. Refined memorisation for Vertex Cover, *Information Processing Letters.* 93(3):125--131, 2004.

[Cou91] B. Courcelle. Graph grammars, monadic second-order logic and the theory of graph minors. In Graph Structure Theory 1991, *Contemporary Mathematics*, 147 :565-590, 1993.

[JCLL+08]. Chen, Y. Liu, S. Lu, B. O'Sullivan and I. Razgon. A Fixed-Parameter Algorithm for the Directed Feedback Vertex Set Problem. In *Proceedings of 40th Annual ACM Symposium on Theory of Computing (STOC 2008),* May 2008.

[Do07] F. Dorn. Designing Subexponential Algorithms : Problems, Techniques & Structures. PhD thesis, University of Bergen, Norway, July 2007.

[DoFe99] R. Downey and M. Fellows. Parameterized complexity. (1999) Springer. ISBN 0-387-94883-X.

[FeKu02] S. S. Fedin and A. S. Kulikov. A 2|E|/4-time algorithm for Max-Cut. *Zapiski nauchnyh seminarov POMI,* 293:129-138, 2002.

[FlGr06] J. Flum, M. Grohe, Parameterized Complexity Theory, Springer, Berlin, 2006.

[FoGrKr05] F. Fomin, F. Grandoni and D. Kratsch. Measure and conquer: Domination – a case study. In *Proceedings of ICALP 2005*, *Lecture Notes in Comput. Sci. 3380: 192-203*, 2005.

[FoGrKr06] F. Fomin, F. Grandoni and D. Kratsch. Measure and conquer: A simple $O(2^{0.288n})$ independent set algorithm. In *Proceedings of the 17th Annual ACM-SIAM Symposium on Discrete Algorithms SODA 2006*. Society for Industrial and Applied Mathematics, pp. 18-25, 2006.

[FoKrWo04] F. Fomin, D. Kratsch and G. Woeginger. Exact (exponential) algorithms for the dominating set problem. In *Proceedings of WG 2004*, *Lecture Notes in Comput. Sci. 3353: 245-256*, 2004.

[FrGr02] M. Frick and M. Grohe. The Complexity of First-Order and Monadic Second-Order Logic Revisited. In LICS 2002: 215-224, 2002.

[IwTa04] K. Iwama and S. Tamaki. Improved upper bounds for 3-SAT. In *Proceedings of the Fifteenth Annual ACM-SIAM Symposium on Discrete Algorithms* (New Orleans, Louisiana, January 11 - 14, 2004). Symposium on Discrete Algorithms. Society for Industrial and Applied Mathematics, Philadelphia, PA, 328-328.

[HPTV07] P. Heggerness, C. Paul, J.A. Telle and Y. Villanger. Interval completion with few edges. In *Proceedings of 39th ACM Symposium on Theory of Computing - STOC*, 2007.

[Koi06] M. Koivisto: An O*(2^n) algorithm for graph coloring and other partitioning problems via inclusion-exclusion. *Proceedings of the 47th Annual IEEE Symposium on Foundations of Computer Science (**FOCS 2006**)*, pp. 583-590, IEEE Computer Society, 2006.

[Nie06] R. Niedermeier, Invitation to Fixed-Parameter Algorithms, Oxford University Press, 2006.

[ReSmVe04] B. Reed , K. Smith and A. Vetta. Finding odd cycle transversals. *Operations Research Letters* 32:299-301, 2004.

[RoSe85] N. Robertson and P. D. Seymour, Graphs Minors: A survey In: *Surveys in Combinatorics,*
I. Anderson, ed. Cambridge University Press: Cambridge, 1985, 153-171.

[Rob86] J. M. Robson, Algorithms for maximum independent sets, *Journal of Algorithms* 7(3):425--440, 1986.

[SLH+05] Y. Song, C. Liu, R.L. Malmberg, F. Pan, and C. Lai. Tree decomposition based fast search of RNA structure including pseudoknots in genomes. In *Proc. IEEE Computer Society Computational Systems Biology Conference,* 2005.

[Tho98] M. Thorup. All structured programs have small tree width and good register allocation, *Information and Computation* **142** (2): 159–181, 1997.

[Wi04] R. Williams, A new algorithm for optimal constraint satisfaction and its implications, In *ICALP 2004,* In *Lecture Notes in Comput. Sci.,* 3142:1227-1237, 2004.

[Woe03] G.J. Woeginger, Exact algorithms for NP-hard problems: A survey, Combinatorial Optimization -- Eureka, You Shrink, Springer, Berlin, LNCS 2570, 2003, pp. 185-207.

7.2. Biographies / CV, Resume

Marie Aste
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Short bio : M. Aste studied mathematics at the university of Montpellier the two first years of university and of Marseille the 3 last ones. She is now under the supervision of F. Havet, and works on graph colouring in the Mascotte team since October '07.

Selected Publications:
M. Asté, F. Havet, and C. Linhares-Sales. Grundy number and lexicographic product of graphs. ***In Proceedings of International Conference on Relations, Orders and Graphs and their Interaction with Computer Science (ROGICS 2008), May 2008.***

Stephane Bessy
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Short bio : S. Bessy studied mathematics at the university of Lyon, France. During his PhD he worked, under the supervision of S. Thomassé, on structural and algorithmic graph theory, more precisely, on decomposition of digraphs into circuits. In 2003, he got his PhD from the

university of Lyon. After one year spent as post-doctoral researcher in Mascotte Team, Inria Sophia Antipolis, he got in 2005 a permanent position as associate professor in University of Montpellier, France.
His research interests are structural and algorithmic graph theory and discrete mathematics.

He has 6 papers published in international journals and 2 communications in international conferences.

Selected publications :

[1] S. Bessy, S. Thomassé, Every strong digraph has a spanning strong subgraph with at most *n+2α -2 arcs*. *Journal of Combinatorial Theory, Series B*, **87**, (2003), 289—299.

[2] S. Bessy, S. Thomassé, Spanning a strong digraph with *α* cycles: a conjecture of Gallai. *Combinatorica*, , 6, (2007).

[3] S. Bessy, E. Birmelé, F. Havet, Arc-chromatic number of digraphs in which every verte has bounded outdegree or bounded indegree. *Journal of Graph Theory* , **53,4**, (2006), 315—332.

[4] S. Bessy, N. Lichiardopol and J.-S. Sereni, Two proofs of Bermond-Thomassen conjecture for regular tournaments. *Electronic Notes in Discrete Mathematics*, **28**, (2007), 47—53,

[5] S. Bessy, Paths partition with prescribed sources in digraphs, a Chvátal-Erdös condition approach. *Discrete Mathematics*, Volume 308, Issue 18, (2008), 4108--4115

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Short Bio : Nathann COHEN studied 5 years in the University of Lyon. He recently completed his Master's degree with a 6 months internship in the MASCOTTE Project. Since October 08, he is a PhD Student at MASCOTTE.

Jean Daligault
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Short Bio : Jean Daligault had his graduate studies at ENS Cachan, and has been a PhD student at LIRMM since October 2007. His research areas include Graph Theory, Graph Algorithms and Parameterized Complexity. He is a member of research team VAG.

Frederic Havet
35 years old
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S*hort bio :* Frederic Havet received his PhD degree from the University of Lyon 1 in 1999. From March 1999 to December 2000, he was postdoctoral research fellow at the University of Oxford under contract with British Telecom. From January 2001 to September 2001, he was a postdoctoral research fellow at University of Nice-Sophia Antipolis under contract with France Telecom. Since October 2001, he his a CNRS research fellow in Mascotte project (joint team INRIA/CNRS/UNS).
He received his HDR from the Nice-Sophia Antipolis University in 2007. He has 26 papers published in international journals and 9 communications in international conferences. He has been an invited speaker at ten conferences including International Conference onDiscrete Mathematics in Bangalore (India) 2006, AMS Workshop on Structural Graph Theory in Baton-Rouge (USA) 2008, 14th SIAM Meeting on Discrete Mathematics in Burlington (USA) 2008 and Cycle and Colourings in Graphs in Slovakia, 2008. He was a member of the program committee of Algotel'04(chair), JCB60 and WG'06.
He was the chairman of the organizing committees of the international conference (ICGT'05) and the national conference JGA'08. He also organised and steered several smaller events (JCALM, Journee Galet, ...).
His research interests include networks and graph theory. In particular, F. Havet is a leader scientist in *graph colouring* and its applications. He also obtained noticeable results on digraphs.

PhD students : J.-S. Sereni (2003-2006), O. Amini (2005-2007), M. Aste (since 2007) and N. Cohen (since 2008).

Selected publications :
[1] F. Havet, J.-S. Sereni and R. Skrekovski. 3-facial colouring of plane graphs. *SIAM Journal of Discrete Math.*, 22(1): 231-247, 2008.
[2] F. Havet, B. Reed and J.-S. Sereni. L(2,1) labeling of graphs In *Proccedings of SODA'08,* pages 621-630, 2008.
[3] F. Havet, J. van den Heuvel, C. McDiarmid and B. Reed. List colouring squares of planar graphs In *Proceedings of Eurocomb '07,* 2007.
[4] F. Havet and J.-S. Sereni. Improper choosability of graphs and maximum average degree. *J. of Graph Theory* 52(3) : 181-199, 2006.
[5] L. Addario-Berry, F. Havet and S. Thomasse. Paths with two blocks in n-chromatic digraphs. *Journal of Combinatorial Theory Ser. B,* 97:620-626, 2007.

Dieter Kratsch
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Short bio : Dieter Kratsch received his PhD degree from the University of Jena (Germany) in 1989. He received his habilitation (Dr. rer. nat. habil.) from the University of Jena in 1996. He was assistant professor at the University of Jena from 1989 to 1999. During this time he was a postdoctoral researcher at the IRISA Rennes in 1994 and visiting professor at the University of Paderborn (Germany) in 1997. Since September 1999 he is professor at the Université Paul Verlaine at Metz.
He has published 63 papers in international journals and 43 papers in proceedings of international conferences (mainly in Lecture Notes of Computer Science).

He was program committee member of WG'2001, MFCS'2004, WG'2006 and IWPEC'2008. He was program committee chair of WG'2005 and program committee co-chair of WG'2007. He was organiser of WG'2005 at Metz. He was co-organiser of two seminars at Dagstuhl (Leibniz Centre of Research, Germany), the recent one entitled "Moderately Exponential-Time Algorithms". He is member of the steering committee of WG. He was editor of the Proceedings of WG'2005, co-editor of the Proceedings of WG'2007 and editor of a special issue of DAM in 2003. He attended three seminars on fixed parameter algorithms at Dagstuhl.

His main research interests are in graph algorithms, algorithms to solve NP-hard problems, graph theory and partially ordered sets. His research in the last five years was mainly on the analysis and design of exact exponential-time algorithms. Regarding the latter, Dieter Kratsch is a leader scientist. He has co-authored several striking articles with the best known algorithms for fundamental problems (minimum dominating set, maximum independent set, treewidth) and introduced the Measure and conquer technique.

PhD students : M. Rao (2002-2006), M. Liedloff (2004-2007)

Selected publications :

[1] F. Fomin, D. Kratsch, I. Todinca, Y. Villanger, Exact (exponential) algorithms for treewidth and min fill-in, SIAM Journal on Computing 38 (2008), 1058-1079.
[2] F. Fomin, F. Grandoni, D. Kratsch, Solving Connected Dominating Set faster than 2^n, Algorithmica 52 (2008) 153-166.
[3] F. Fomin, F. Grandoni, D. Kratsch, Measure and conquer : Domination - A case study, In: Proceedings of ICALP 2005, LNCS 3380, Springer, 2005, 192-203.
[4] F. Fomin, F. Grandoni, D. Kratsch, Measure and Conquer : A simple O(2^{0.288n}) Independent Set Algorithm, In: Proceedings of SODA 2006, ACM, 18-25.
[5] F. Fomin, S. Gaspers, D. Kratsch, M. Liedloff, S. Saurabh, Iterative compression and exact algorithms, In: Proceedings of MFCS 2008, LNCS 5162, Springer 2008, 335-346.

Jean-Francois Lalande

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Short bio : Jean-Francois Lalande is an Associate Professor in the SDS team (Security and Distributed Systems), in the Laboratoire d'Informatique de l'Universite d'Orleans (LIFO). He obtained his Engineer Diploma from the ISIMA in Clermont- Ferrand, in 2002. He then made his PhD at INRIA of Sophia-Antipolis, in the Mascotte project (CNRS/INRIA/UNSA). His research interests were the combinatory optimization inside optical and satellite networks. He has also contributed to the developpement of Mascopt, an optimization library for networks and graphs. Since his recruitment in 2005, he has been working on the verification of security policies and intrusion detection using policy graph analysis. He is currenlty working on security aspects of peer-to-peer systems and graph algorithms on embedded operating systems such as Java Card. He is organizing the COLSEC workshop since 2006, participates to program commitees SHPCS 07-09, SECURWARE 09 and serves as a reviewer in CTS 06-09, IJCA 08. He is currently involved in the ANR project SEC&SI which is a challenge between selected research teams for designing a secured linux distribution.

Selected publications :

[1] M. Bouklit, D. Coudert, J.- F. Lalande, C. Paul, and H. Rivano. Approximate multicommodity flow for {WDM} networks design. *In Proc. SIROCCO*, Umea, Sweden, 2003, pp. 43-56.

[2] J.- F. Lalande, M. Syska, and Y. Verhoeven. Mascopt - A Network Optimization Library: Graph Manipulation. INRIA Sophia Antipolis, 2004 route des lucioles - BP 93 - FR-06902 Sophia Antipolis, RT-0293, 2004.

[3] S. Alouf, E. Altman, J. Galtier, J.-F. Lalande, and C. Touati. Quasi-Optimal Resource Allocation in Multi-Spot MFTDMA Satellite Networks. M. Cheng, Y. Li, and D.- Z. Du, Eds. Kluwer Academic Publishers, 2006,

[4] M. Blanc, J. Briffaut, J.-F. Lalande, and C. Toinard. Distributed Control Enabling Consistent MAC Policies and IDS based on a Meta-Policy approach. *In Proc. IEEE Workshop on Policies for Distributed Systems and Networks*, Canada London, 2006.

[5] J. Briffaut, J.-F. Lalande, and C. Toinard. A proposal for securing a large-scale high-interaction honeypot. In Ratan Kumar Guha and Luca Spalazzi, editors, *Workshop on Security and High Performance Computing Systems*, Cyprus, 2008. ECMS.

Mathieu Liedloff
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Short bio : Mathieu Liedloff studied computed sciences at the university of Metz, France. During his PhD he worked on the design and the analysis of exponential-time algorithms for various domination like problems in graphs. In 2007, he got his PhD from the university of Metz. Since September 2008, he has a permanent position as an associate professor at the University of Orléans, France. He has 3 papers published in international journals and 8 communications in international conferences, published in the LNCS serie. He also gave a presentation of his research at two national conferences: JGA'06 and JGA'07. He was invited to 2 seminars in Schloss Dagstuhl - Leibniz Center for Informatics (Germany).
He was a member of the organizing committee of two international conferences: WG'05 (Metz, France) and WG'07 (Jena, Germany).
He works on designing polynomial and exponential-time algorithms for NP-hard problems. He also has some skills of analyzing running-time of algorithms by non-standard measures. He is interested in graph problems like domination or labeling problems.

Selected publications:

[1] M. Liedloff, T. Kloks, J. Liu and S.-L. Peng. Efficient algorithms for Roman domination on some classes of graphs, *Discrete Applied Mathematics,* to appear.
[2] D. Kratsch and M. Liedloff. An exact algorithm for the minimum dominating clique problem, *Theoretical Computer Science* 385:226-240, 2007.
[3] S. Gaspers, D. Kratsch and M. Liedloff, Exponential time algorithms for the minimum dominating set problem on some graph classes. In *Proceedings of SWAT 2006, Lecture Notes in Computer Science* Vol. 4059 (pp. 148-159).

[4] F.V. Fomin, P.A. Golovach, J. Kratochvil, D. Kratsch, M. Liedloff. Branch and Recharge: Exact algorithms for generalized domination. In *Proceedings of WADS 2007, Lecture Notes in Computer Science* Vol. 4619 (pp. 508-519).
[5] F.V. Fomin, S. Gaspers, D. Kratsch, M. Liedloff, S. Saurabh, Iterative compression and exact Algorithms. In *Proceedings of MFCS 2008, Lecture Notes in Computer Science* Vol. 5162 (pp. 335-346).

Christophe Paul
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S*hort bio :* Christophe Paul received his PhD degree from the University of Montpellier 2 in 1998. From October 1998 to September 2001, he was assistant professor at the University of Bordeaux 1, making then research at the LaBRI laboratory. Since October 2001, he his a CNRS research fellow in VAG research group at the LIRMM laboratory, University of Montpellier 2. He has defended an "habilitation for research direction" on graph decompositions, in July 2006. He was (or is currently) the chairman of the organizing committees of several national (JGA 1998, AlgoTel 2001) and international conferences (STACS 2004, WG 2009) and served as a program committee member in several conferences (AlgoTel 2006-2007, COSI 2006-2007, WG 2008). He is the leader of the ANR project GRAAL (ending this year).
His main research interests are on graph algorithms and graph decomposition methods with a particular attention to computational biology. In 2007, he was one of the coauthors of a paper which solved one of the long-standing open problem in parameterized complexity (the interval graph completion, published at STOC 2007). Since them, he is keeping working in fixed parameter tractability with a special interest kernalization theory.

PhD students : C. Crespelle (2003-2007), P. Gambette (since October 2007) and A. Perez (since October 2008).

Publications: 22 articles published or to appear in international journals (SIAM J. of Computing, SIAM Journal on Computing, ACM Transaction on Algorithms, ACM Transaction on Computational Biology and Bioninformatics, Theoretical Computer Science, Discrete Applied Mathematics, Discrete Mathematics. . .), and 28 articles in international conference proceedings (ICALP, STACS, ESA, ISAAC, WG, WABI, PODC. . .)

Selected publications :
[1] M. Tedder, D. Corneil, M. Habib and C. Paul. Simple, linear-time modular decomposition. In *International Colloquium on Automata, Languages and Programming - ICALP*. Number 5125 in *Lecture Notes in Computer Science*, pages 634-645, 2008.
[2] P. Heggerness, C. Paul, J.A. Telle and Y. Villanger. Interval completion with few edges. In 39th *ACM Symposium on Theory of Computing - STOC*, pages 347-381, 2007. Journal version to appear in *SIAM Journal on Computing.*
[3] C. Gavoille and C. Paul, Optimal Distance Labeling for Interval and Circular-Arc Graphs. In *SIAM Journal on Discrete Mathematics*, 22(3) :1239-1258, 2008.
[4] C. Paul and J.A. Telle. C. Paul and J.A. Telle. New Tools and Simpler Algorithms for Branchwidth. In *European Symposium on Algorithm - ESA*. Number 3669 in *Lecture Notes in Computer Science*, pages 379-390, 2005. Journal version to appear in *Discrete Applied Mathematics*.
[5] A. Bergeron, S. Bérard, C. Chauve, and C. Paul. Sorting by Intervals with Common In-

tervals is not Always Difficult. *IEEE-ACM Transaction on Computational Biology and Bioinformatics*, 4(1), 2007.

Anthony Perez
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Current Position : PhD Student
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Short Bio :
Anthony PEREZ just achieved his Master's degree in the team VAG (LIRMM), on the subject of finding polynomial kernels for certain graph modification problems. In October 2008, he started a PhD thesis, under the supervison of C. Paul and S. Bessy, on parameterized complexity in general and more specifically on the existence of polynomial kernels (or not) for graph problems.

Selected publications :

[1] S. Bessy, C. Paul and A. Perez. Polynomial kernels for 3-leaf power graph modification problems. http://arxiv.org/abs/0809.2858

Michel Syska
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Short Bio : Michel Syska received the PhD degree in computer science from the University of Nice-Sophia Antipolis, France, in 1992. Since 1993 he is a Maitre de Conferences of Computing Science at the University of Nice-Sophia Antipolis, and is a member of the Mascotte project (joint team INRIA/CNRS/UNS). His current research interests include network communications, and combinatorial optimization. The main active project is the development of `mascopt` (which stands for Mascotte Optimization), a free Java library distributed under the terms of the LGPL license which is dedicated to graph and network processing.

PhD students : O. Dalle (1994-1998) and J-F. Lalande (2002-2004).

Selected publications :
[1] J.-F. Lalande, M. Syska, and Y. Verhoeven. Arrondi aléatoire et protection des réseaux WDM. In Ecole Polytechnique de l'Université de Tours, editor, ROADEF, number 6, Tours, France, pages 241--242, 2005
[3] J.-F. Lalande, M. Syska, and Y. Verhoeven. Mascopt - A Network Optimization Library: Graph Manipulation. Technical report RT-0293, INRIA, April 2004.
[2] G. Huiban, S. Pérennes, and M. Syska. Traffic Grooming in WDM Networks with Multi-Layer Switches. In IEEE ICC, New-York, April 2002.

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Short bio: Stéphan Thomassé received his PhD degree from the University of Lyon 1 in 1995. From October 1997 to September 2005, he was assistant professor at the University of Lyon 1, in the LaPCS laboratory. In 2005-2006, he spend one year in the Mascotte team (Sophia Antipolis) as an CNRS associate researcher. Since October 2006, he is a Professor in the VAG research group at the LIRMM laboratory, University of Montpellier 2. He has defended an "habilitation for research direction" in October 2005.

Research interests: Graph theory, combinatorial optimization, graph decompositions and parameterized algorithms.

Prominent results: The proof of Gallai's conjecture (with S. Bessy). A solution to the Erdos-Simonovits problem on dense triangle-free graphs (with S. Brandt). The proof of Rosenfeld's conjecture (with F. Havet). The equality of the branchwith of a graph and its matroid (with F. Mazoit). The NP-completeness of Feedback Arc Set in tournaments (with P. Charbit and A. Yeo).

Expertise in FPT: He started to work on kernelization in 2008 with four results so far: A quadratic kernel for Feedback Vertex set (SODA09). A polykernel for Multicut in Trees (STACS09, with N. Bousquet, J. Daligault and A. Yeo). The nonexistence of a kernel for disjoint cycles (with H. Bodlaender and A. Yeo, preprint). A quadratic kernel for almost regular induced subgraph (with F. Guinez, preprint).

PhD students: S. Bessy (2001-2003), J. Daligault (since October 2008).

Invitations: He was plenary speaker of the British Combinatorial Conference 2007, the LAGOS 07 conference, and EUROCOMB 2009.

Publications: Around 30 papers published or to appear in international journals (Combinatorica, Journal of Combinatorial theory B, Combinatorics, Probability and Computing, Transactions of the American Math. Soc., Journal of Graph Theory, Discrete Maths, Journal of Complexity...). Also some papers in international conference proceedings (STACS, SODA, IPCO, SWAT,...)

Selected publications :
[1] With S. Bessy, Spanning a strong digraph by alpha circuits: A proof of Gallai's conjecture, *Combinatorica,* 27 (2007), 659--667.
[2] A quadratic kernel for feedback vertex set, accepted to SODA 2009.
[3] With F. Havet, Oriented Hamiltonian paths in tournaments: a proof of Rosenfeld's conjecture, *J. Combin. Theory Ser. B,* 78 (2000), 243--273,
[4] With P. Charbit and A. Yeo, The minimum feedback arc set problem is NP-hard for tournament, *Combinatorics, Probability and Computing,* 16 (2007), 1--4.
[5] With N. Bousquet, J. Daligault et A. Yeo, A polynomial kernel for Multicut In Trees, accepted to *STACS09.*

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Short bio: Ioan Todinca received the M. Sc. in Computer Science and the engineer degree from INSA Lyon in 1996, and the Ph.D. in Computer Science from ENS Lyon in 1999. In 2000 he obtained an associated professor position at the University of Orleans. He has defended an "habilitation for research direction" on tree decompositions, in December 2006, and became full professor in 2007.
He served as co-chair and co-organiser of SOFT'06, an international workshop on soft constraints, satellite of the Constraint Programming conference CP'06, as organizer of the "Journees Graphes et Algorithmes 06", French national meeting on graphs and algorithms, and as PC member of WG 2009.
He is currently head of the "Graphs and algorithms" team of the LIFO (Laboratory of Fundamental Informatics, Orleans)

PhD students : Karol Suchan (2003-2006), Laurent Lyaudet (2004-2007, co-advised with J. Mazoyer) and Mathieu Chapelle (since 2008)

Publications: 11 articles published or to appear in international journals (SIAM J. of Computing, Theoretical Computer Science, Discrete Applied Mathematics. . .), about 15 articles in conference proceedings (ICALP, STACS, ESA, LATIN, ISAAC. . .)

Selected publications:
[1] F. Fomin, D. Kratsch, I. Todinca, and Y. Villanger. Exact (exponential) algorithms for treewidth and minimum fill-in. *SIAM J. of Computing* 38(3): 1058-1079 (2008).
[2] D. Kratsch, H. Muller and I. Todinca. Feedback vertex set of AT-free graphs. *Discrete Applied Mathematics* 156(10): 1936-1947 (2008).
[3] K. Suchan and I. Todinca. Powers of graphs of bounded NLC-width (clique-width). *Discrete Applied Mathematics* 155(14): 1885-1893 (2007). Special issue devoted to Cologne-Twente Workshop (CTW'04).
[4] K. Suchan and I. Todinca. Pathwidth of Circular-arc Graphs. In *Workshop on Graph-theoretic Concepts in Computer Science (WG 2007)*, vol. 4769 of LNCS, pp. 258-269 (2007).
[5] F. Fomin, F. Mazoit, and I. Todinca. Computing branchwidth via efficient triangulations and blocks. *Discrete Applied Mathematics.* To appear. Preliminary version in *Proceedings of WG 2005.*

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

INRIA	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
	Havet	21 (sur 4 ans)	Europe FET 360 000	AEOLUS	Kaklamanis (Grece)	09/05 08/09
	Perennes	21 (sur 4ans)	Europe FET 360 000	AEOLUS	Kaklamanis (Grece)	09/05 08/09
	Coudert	21 (sur 3 ans)	ANR Jeune chercheurs 98 100	OSERA	Rivano	01/05 12/08
	Syska	6 (sur 3 ans)	ANR Telecommunications 200 000	SPREADS	Dalle	12/07 12/10
	Coudert	7 (sur 3 ans)	Demande ANR Jeunes Chercheurs 188931	IMAGRIN	Giroire	09/09 09/12

The Eurpean project AEOLUS and the three ANR OSERA, SPREADS and IMAGRIN focus on different kind of networks (ambiant networks, peer-to-peer networks and access and backbone networks respectively). Some of the problems identified in this programme are modelled by graphs and are natural applications of our work.

LIRMM	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
	Paul	18 (sur 3 ans)	ANR Blanc 387 000	GRAAL	Paul	09/05 08/09
	Thomasse	9 (sur 3 ans)	ANR Blanc 387 000	GRAAL	Paul	09/05 08/09

	Bessy	3 (sur 3 ans)	ANR Blanc 387 000	GRAAL	Paul	01/05 12/08
	Paul	6 (sur 3 ans)	ANR DEFIS Domaines emergents 350 000	PHYL-ARIANE	Berry	11/08 14/11

The ANR GRAAL (2007-2009) focus on graph decompositions. Some techniques based on such decompositions may be used to obtain exact and parameterized algorithms. However graph decomposition is only one of the techniques envisaged in this programme to obtain algorithms.
The ANR PHYL-ARIANE study bioinformatics and more precisely phylogenetic reconstruction. It may provide use some pertinent applications to our work.

LIFO	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
	Todinca	6 (sur 3 ans)	ANR Blanc 400 000	ALADDIN	Fraignaud	01/08 12/11

The ANR ALADDIN (2008-2011) is dedicated to networks analysis and algorithmics. It includes an important part of modelling. It will provide us some pertinent applications to our work.