4/ GALaC

Graphs, Algorithms and Combinatorics

équipe Graphes, ALgorithmes et Combinatoire

Responsable: Florent Hivert, Hao Li

L'équipe Algorithmique et Complexité est une équipe historique au LRI. Le travail est centré sur les fondements théorique du calcul: Algorithmique, Complexité et Combinatoire.

Le programme scientifique est structuré en trois activités: l'algorithmique des graphes, la combinatoire et la complexité des algorithmes classiques et quantiques. Le travail sur les graphes porte sur les graphes colorés par arêtes en vue d'applications à la biologie, au web et aux réseaux sociaux. En combinatoire sont étudiés divers aspect algébrique et énumératif (Algèbres de Hopf, théorie des représentations, partitions et q-série, combinatoire des mots) en lien avec les systèmes dynamiques, les systèmes de numération, et la complexité. La troisième activité s'intéresse au test de propriété, aux algorithmes en ligne, à la cryptographie, à la complexité de communication et aux algorithmes quantiques. La recherche s'appuie sur une forte composante expérimentale impliquant une participation importante au développement de logiciels de calculs (Sage).

Sur la période 2008-2013, l'équipe a connu une profonde réorganisation avec de nombreux départ et recrutement. En janvier 2013, l'équipe Algo s'est regroupée avec des membres des équipes Graphes, Parallélisme et Réseaux pour former l'équipe GALaC: Graphs, ALgorithms and Combinatorics.

En théorie des graphes, nos travaux portent sur des problèmes théoriques fondamentaux. Nous travaillons aussi sur la théorie des matroides et les approches spectrales dans les graphes. Certains problèmes étudiés ont des applications directes en réseaux de capteurs et réseaux sociaux.

Graphs, ALgorithms and Combinatorics

Head: Florent Hivert, Hao Li

The Algorithmic and Complexity team is an historic team of the LRI. The work is centered on the theoretical foundations of computation: study of algorithms, complexity theory and combinatorics.

The scientific program is organized in three activities: Graphs algorithms, Combinatorics, and Complexity of classical and quantum algorithms. The work on graphs is mainly on edge-colored graphs, with important applications to biology, web technologies and social networks. In combinatorics various algebraic and enumerative aspects (combinatorial Hopf algebras, representation theory, partitions and q-series, combinatorics on words) are studied in relation to dynamical systems, numeration, and complexity analysis. The third activity covered mainly Property Testing, Streaming and Online Algorithms, Cryptography and Game Theory, Query and Communication Complexities as well as Quantum algorithms. The research work is strongly supported by computer experiments which require a large involvement in the development of open source mathematics software (Sage).

During the 2008-2013 time frame, the team witnessed a profound reorganization with many departures and hiring. Since January 2013, the Algo team gathered with former members of the Graphs, Parallelism and Network teams to create the GALaC team for Graphs, ALgorithms and Combinatorics.

In graph theory, most of our work focuses on fundamental problems. We also work on matroid, and spectral approaches in graph theory. Some problems of graph theory that have practical background in energy conservation, in wireless sensor networks and social networks.

Research Group members

The GALaC team includes 16 permanent faculty (1 DR CNRS, 6 Professors, 3 CR-CNRS, 5 Assistant Professors), 11 doctoral students and 2 temporary personnel (post-docs).

Permanent Members (October 1st, 2013)			
Name	*First name*	*Position*	*Institution*
CHEN	Lin	MCF	PARIS SUD
COHEN	Nathann	CR2	CNRS
COHEN	Johanne	CR1	CNRS
DELAET	Sylvie	MCF	PARIS SUD
DEZA	Antoine	DR2	CNRS
DJELLOUL	Selma	MCF	PARIS EST
FIORENZI	Francesca	MCF	PARIS SUD
FLANDRIN	Evelyne	PREM	PARIS 5
FORGE	David	MCF	PARIS SUD
GOUYOU-BEAUCHAMPS	Dominique	PR1	PARIS SUD
HIVERT	Florent	PR1	PARIS SUD
LI	Hao	DR2	CNRS
MANOUSSAKIS	Yannis	PREX	PARIS SUD
MARTIGNON	Fabio	PR2	PARIS SUD
NASERASR	Réza	CR1	CNRS
THIÉRY	Nicolas	PR2	PARIS SUD

PhD students (October 1st, 2013)			
Name	*First name*	*Funding*	*Institution*
ANGLES D'AURIAC	Jean-Alexandre	Alloc. Ministère	PARIS SUD
ARALDO	Andrea Giuseppe	DIGICOSME	PARIS SUD
BAI	Yandong	ETR	PARIS SUD
HE	Weihua	ETR	PARIS SUD
LEGAY	Sylvain	Alloc. Ministère	PARIS SUD
MANGILI	Michele	Alloc. Ministère	PARIS SUD
PRIEZ	Jean-Baptiste	Alloc. Ministère	PARIS SUD
SUN	Qiang	ETR	PARIS SUD
VIRMAUX	Aladin	Digiteo	PARIS SUD
YANG	Weihua	ETR	PARIS SUD
YU	Jihong	Alloc. Ministère	PARIS SUD

Temporary personnel (October 1st, 2013)			
Name	*First name*	*Position*	*Institution*
CHEN	Meirun	Post-Doc	PARIS SUD
MONTERO	Leandro Pedro	Post-Doc	PARIS SUD

The GALaC team is resulting from the merging of the Algo team and the Graphs theory group of the GraphComb team. The research activities of the Algo team over the five previous years will be first presented, followed by the research activities of the Graphs theory group, and finally the strategy and the five-year project of the GALaC team.

Algorithms: Synthetic presentation

Responsable de l'équipe : **Florent HIVERT** depuis Juin 2013 (Yannis MANOUSSAKIS jusqu'en mai 2013).

Effectifs de l'équipe

- Au premier janvier 2008, 13 permanents; enseignants-chercheurs: 1 MdC, 1 PR2, 3 PR1, chercheurs CNRS: 2 CR2, 3 CR1, 1 DR2, 2 DR1.
- Au 30 juin 2013, 6 permanents; enseignants-chercheurs: 1 MdC, 2 PR2, 1 PR1, 1 PrEx, chercheurs CNRS: 1 CR2.

Personnels ayant quitté l'équipe pendant le contrat en cours: 11

- Nisheeth Vishnoi, CR1, depart en mars 2009 pour UC Berkeley (USA)
- Sylvie Corteel, CR1 CNRS mutation en Septembre 2009 au LIAFA
- Jean-Paul Allouche, DR1 CNRS, mutation en Septembre 2010 à l'Institut de mathématiques de Jussieu
- Adi Rosen (DR2), Iordanis Kerenidis (CR1), Julia Kempe (DR2) et Frédéric Magniez (DR2), Miklos Santha (DR1), mutation en Octobre 2010 au LIAFA
- Pascal Ochem (CR2), Mutation en Juillet 2011, au Lirmm
- Sylvain Peyronnet, arrivé en fin 2010 depuis l'équipe Parall, MCF, recruté en Septembre 2012 professeur au GREYC, Université de Caen
- Sophie Laplante (PR2), mutation en septembre 2012 au LIAFA

Nombre de recrutements réalisés au cours de la période considérée et origine des personnels: 3 + 2

- Florent Hivert, Professeur Paris Sud, mutation en 2011 depuis le LITIS, Université de Rouen.
- Nicolas Thiéry, Professeur Paris Sud, recruté en 2012, était maître de conférences au laboratoire de Mathématiques d'Orsay.
- Nathann Cohen, CR CNRS 2012, était PostDoc à l'Université Libre de Bruxelles (Belgique) avec Jean Cardinal, thèse en 2012 à Sophia Antipolis.
- Deux chercheurs sont attendus: Johane Cohen (CR1 CNRS) en Septembre 2013 et Antoine Deza (DR2 CNRS) en janvier 2014.

Production scientifique au cours de la période écoulée

1. La définition et l'étude en profondeur des algèbres et monoïdes de BiHecke. Ce sont des contreparties algébriques d'algorithmes de tris, avec des applications en théorie des représentations et en combinatoire des polynômes multivariés. Cet exemple a permis de franchir la barrière formée par les monoïdes apériodiques, et on peut maintenant espérer étudier la théorie des représentations de tous les monoïdes.
2. L'étude combinatoire du modèle de physique théorique PASEP (Partially ASymmetric Exclusion Process) grâce aux tableaux de permutations. Cette étude à donnée naissance à de nombreux nouveaux objets combinatoires.
3. Le projet Sage-Combinat : ALGO est coordinatrice d'une équipe internationale de développement de plus de cinquante chercheurs (organisation d'ateliers, nombreuses invitations, cours pour jeunes chercheurs, chapitres de livre).
4. La mise à jour de conditions suffisantes de type Dirac sur les degrés coloriés d'un graphe arête colorié, pour que le graphe en questions contienne des cycles et chaînes hamiltoniens. C'est la première fois que ce type de conditions est établi pour cette famille importante de graphes.
5. La détermination des paramètres optimaux du tirage à pile ou face et de la mise en gage de bit et étude d'autres primitives cryptographiques.

Bilan quantitatif des publications de l'équipe

- Articles de revues : majeures internationales : 49, autres : 18
- Livres et chapitres de livres: 3
- Articles de conférences : majeures internationales : 21, autres : 26
- Édition de livres: 3

5 publications majeures

1. Florent Hivert, Anne Schilling, and Nicolas M. Thiéry. The biHecke monoid of a finite Coxeter group and its representations, Algebra and Number Theory, Vol. 7(3), 595–671, 2013.
2. Dominique Gouyou-Beauchamps, Philippe Nadeau Signed enumeration of ribbon tableaux: an approach through growth diagrams, Journal of Algebraic Combinatorics, Vol. 36(1), pp 67-102, 2012.

3. J. Araujo and N. Cohen and F. Giroire and F. Havet, Good edge-labelling of graphs, Discrete Applied Mathematics, Vol. 160(18), pages 2502–2513, 2012.
4. A. Abouelaoualim, K. Ch. Das, W. Fernandez de la Vega, M. Karpinski, Y. Manoussakis, C. A. Martinhon and R. Saad, Cycles and Paths in Edge-Colored Graphs with Given Degrees. J. of Graph Theory 64(1) 63–86, 2010.
5. F. Magniez, C. Mathieu, A. Nayak. "Recognizing well-parenthesized expressions in the streaming model". In: Proceedings of 42nd ACM Symposium on Theory of Computing (STOC), 261–270, 2010.

5 (max) documents majeurs (autres que publications)

1. Participation au développement du logiciel Sage : l'équipe à contribué plus de 30000 lignes de code à Sage.
2. L'équipe coordonne le projet Sage-Combinat qui vise à améliorer le système Sage comme boîte à outils extensible pour l'exploration informatique en combinatoire, en fédérant et mutualisant les efforts de développements des chercheurs dans ce domaine. Sage-Combinat regroupe une cinquantaine de contributeurs internationaux (Europe, Amérique du Nord, Australie, Japon, Corée, etc.).
3. Rapports d'expertise (AERES, AERES Greque, NSF (USA), NSERC(Canada)).

5 (max) faits illustrant le rayonnement ou l'attractivité académique

1. Insigne de chevalier dans l'ordre national du mérite et prix Femme en or de la recherche, en 2010, pour J. Kempe.
2. Cofinancement National Science Foundation, USA, grant OCI-1147247, 2012-2015, Collaborative Research: SI2-SSE: Sage-combinat: Developing and Sharing Open Source Software for Algebraic Combinatorics $500k.
3. Coorganisation du semestre thématique "Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series" à l'Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, Providence, Rhodes Island, USA (**http://icerm.brown.edu/sp-s13**). Coorganisation des conférences internationales "Sage Days 45", February 11 - 15, 2013, ICERM, Brown University, Providence, Rhode Island, USA et "Sage Days 49", June 17th-21st, Orsay, France et de l'atelier AIM "Online databases: from L-functions to combinatorics", January 21 to January 25, 2013 at the International Centre for Mathematical Sciences, Edinburgh, Scotland, UK.
4. Co-Chair of the 8th french combinatorial conference Orsay 2010 (350 participants), Co-Chair of the Workshop JGA 13-15 Novembre 2013, Orsay; organisation de la deuxième conférence IEEE "Computational Complexity", 2009, Paris.

5. Editorial boards: Applied and Computational Mathematics, Open Journal on Discrete Mathematics , ISRN Discrete Mathematics, Scientific committees: ICGT2014, Grenoble June 30-July 4, 2014, international workshop on discrete structures, University of Islamabad from March 5-7, 2014, FPSAC 2012.

5 (max) faits illustrant les interactions de l'équipe avec son environnement socio-économique ou culturel

1. Organisation de la Fête de la Science 2013.
2. Invitation exposé "Jonglerie Automate et Combinatoire" 24ème congrès MATh.en.JEANS 5 au 7 avril 2013.
3. S. Laplante. "Le plus grand des hasards : Surprises quantiques". In: ed. by J.-F. Dars and A. Papillaut. Belin, 2010. Chap. Linfluence de l'informatique, pp. 152-154.
4. participation au GdR Informatique Mathématique.

Principales contributions de l'équipe à des actions de formation

1. Chapitres d'ouvrages pédagogique: A. Casamayou, N. Cohen, G. Connan, T. Dumont, L. Fousse, F. Maltey, M. Meulien, M. Mezzarobba, C. Pernet, N. M. Thiéry, P. Zimmermann : Calcul mathématique avec Sage, Licence libre : Creative Commons, France, 468 pages, publié le 30 mai 2013, ISBN: 1481191047.
2. Écoles pour jeunes chercheurs: Thierry Monteil, Nathann Cohen, Vincent Delecroix, Samuel Lelievre, Cours sur Sage dans le cadre de l'École Jeunes Chercheurs en Informatique Mathématique, 8-12 Avril 2013, Perpignan; Nicolas Thiéry : Cours et TP invités lors de l'École d'automne Mathématiques discrètes : aspects combinatoires, dynamiques et algorithmiques, Bobo-Dioulasso, Burkina Faso. **http://www.ragaad.org/bobo2012/**; École des Jeunes Chercheurs en Informatique Mathématique (2009, co-organisation) Participation à deux écoles thématiques sur linformatique quantique à Montréal (2010)
3. Porteur du projet de création du parcours MIFOSA (parcours informatique théorique) dans le cadre de la création d'un master2 recherche mention informatique à l'Université Paris Saclay
4. Responsable du master Franco-Hellénique, master international commun entre les universités Paris-Sud, Joseph Fourier de Grenoble et université de Crète.

Research Group Members and evolution since 2008

Permanent Members (June 30th, 2013)			
Name	*First name*	*Position*	*Institution*
COHEN	Nathann	CR2	CNRS
FIORENZI	Francesca	MCF	PARIS SUD
GOUYOU-BEAUCHAMPS	Dominique	PR1	PARIS SUD
HIVERT	Florent	PR1	PARIS SUD
MANOUSSAKIS	Yannis	PREX	PARIS SUD
THAPPER	Johan	ECC	PARIS SUD
THIÉRY	Nicolas	PR2	PARIS SUD

Doctoral Students (June 30th, 2013)			
Name	*First name*	*Funding*	*Institution*
ANGLES D'AURIAC	Jean-Alexandre	Alloc. Ministère	PARIS SUD
PRIEZ	Jean-Baptiste	Alloc. Ministère	PARIS SUD
VIRMAUX	Aladin	Digiteo	PARIS SUD

Post Doc & Engineers (June 30th, 2013)			
Name	*First name*	*Position*	*Institution*
HARUTYUNYAN	Ararat	Post-doc	Digiteo
MONTERO	Leandro Pedro	ATER Post-doc	PARIS SUD

Visitors (2008-2013)					
Name	*First name*	*Position*	*Institution*	*Arrival*	*Departure*
FRAGOPOULOU	Paraskevi	PR	Techn. Educational Institute of Crete	1/09/2012	28/02/2013
AKIYAMA	Jin	PR	Tokyo Univ. of Science	1/10/2012	30/10/2012
TOLLIS	Yannis	PR	University of Crete	1/05/2012	30/05/2012
KARPINSKI	Marek	PR	University of Bonn	1/04/2012	30/04/2012
RAFIEY	Arash	Res	Simon Fraser University	1/11/2011	30/12/2011
GROSHAUS	Marina	PR	Univ. of Buenos Aires	1/09/2011	30/09/2011
DEZA	Antoine	PR	McMaster University	1/09/2010	30/09/2010
PATT-SHAMIR	Boaz	PR	Tel Aviv University	1/07/2010	30/07/2010
REGEV	Oded	PR	New York University	1/07/2010	30/07/2010
AGUEDA	Raquel	MCF	University of Toledo	1/02/2010	30/06/2010
NAYAK	Ashwin	PR	University of Waterloo	1/02/2008	28/02/2008
VAN MELKEBEEK	Dieter	PR	Univ. of Wisconsin	1/06/2008	30/06/2008
MISHNA	Marni	PR	Simon Fraser University	1/01/2008	30/01/2008

Post-Doc and Temporary personnel (2008-2013)					
Name	*First name*	*Position*	*Institution*	*Arrival*	*Departure*
SADYKOV	Ruslan	Post-doc	PARIS SUD	01/09/200	31/08/2008
RICHTER	Peter	Post-doc	PARIS SUD	10/10/2007	24/12/2008
VIEILLERIBIERE	Adrien	Post-doc	PARIS SUD	15/09/200	31/12/2008
KIM	Jang Soo	Post-doc	PARIS SUD	03/03/2009	31/10/2009
MUTHU	Rahul	Post-doc	PARIS SUD	01/12/200	30/11/2009
XIAO	David	Post-doc	PARIS SUD	01/09/2009	31/10/2010
KULKARNI	Raghar	Post-doc	PARIS SUD	01/06/201	31/08/2011
STROZECKI	Yann	ATER Post-Doc	PARIS SUD	01/09/2011	31/08/2012
BOROZAN	Valentin	ATER Post-Doc	PARIS SUD	04/09/200	31/08/2012
NARAYANAN	Narayanan	Post-doc	PARIS SUD	01/11/2011	31/10/2012

Group evolution

Since 2009, the group witnessed a lot of movement:

Departures: In September 2009 Sylvie Corteel left the LRI for the LIAFA, followed by Jean-Paul Allouche in September 2010, thereby weakening the Combinatorics activity of the LRI.

In November 2010, the head of the team, Miklos Santha, left the LRI for the LIAFA with all the researchers working on classical and quantum algorithms: Frédéric Magniez, Jordanis Kerenis, Julia Kempe, Adi Rosen and Michel de Rougemont. Sophie Laplante joined them in September 2012, thereby ending the quantum algorithms activity at LRI.

Hiring: To maintain a strong activity on combinatorics, the LRI hired two professors: Florent Hivert in September 2011 and Nicolas Thiéry in September 2012. Nathann Cohen was hired in October 2012 as a CNRS researcher to strengthen the research on Graph algorithms.

In September 2013, two more researchers arrived: Johanne Cohen (CR1 CNRS moved from PRISM) and Antoine Deza (hired as DR2 CNRS with a DIGITEO chair).

Reorganization: Since June 2013, the Algo team was joined by Selma Djelloul, Evelyne Flandrin, David Forge, Hao Li and Reza Naserasr from the former GraphComb team, and Lin Chen, Sylvie Delaët, Fabio Martignon (Junior member at IUF, 2013-2018) from the former Réseaux and Parall teams to build a new team called GALaC for Graphs, ALgorithms and Combinatorics.

4/ Algorithms

Research Description

The Algorithmic and Complexity team is an historic team of the LRI. The work is centered on the theoretical foundations of computation: study of algorithms, complexity theory and combinatorics.

The scientific program is organized in three activities: Graphs algorithms, Combinatorics, and Complexity of classical and quantum algorithms. The work on graphs is mainly concentrated on edge-colored graphs and graph colorings, with important applications to biology, web technologies and social networks. In combinatorics, various algebraic and enumerative aspects (combinatorial Hopf algebras, representation theory, partitions and q-series, combinatorics on words) are studied in relation to dynamical systems, numeration, and complexity analysis. The third activity covered mainly Property Testing, Streaming and Online Algorithms, Cryptography and Game Theory, Query and Communication Complexities as well as Quantum algorithms.

The research work is strongly supported by computer experiments, which in turn requires an important software development effort. Therefore, the team is strongly involved in the development of the open source SAGE mathematical system, and is the leader of the SAGE-COMBINAT project which regroups 50 contributors around the world.

Graph algorithms

Since 2008, we basically worked on three extensions to the basic structural and algorithmic graph theory. First, to handle edge-colored graphs, i.e. graphs whose edges are colored by a given number of colors. Second, to study some interesting applications of such graphs to social networks. Third, to study non repetitive vertex-colorings of graphs.

Algorithmic and structural study of edge-colored graphs. Studies of spanning subgraphs with specified color patterns in edge-colored graphs has witnessed significant developments over the last decade. The

most natural pattern in such a context is that of a proper coloring, which entails adjacent edges/vertices having different colors.

Our first aim in respect of such proper colorings is to deal with *proper cycles and paths*. Petersen's famous works on graphs seem to be the first place where one can find applications of properly colored trails. Besides a number of applications in graph theory and algorithms, the concept of proper trails and its special cases, paths and cycles, appears in various other fields including genetics, VLSI applications and social sciences. In our recent works (1, 71), we investigate sufficient degree conditions on the number of edges for the existence of properly edge-colored cycles and paths in edge-colored graphs, multigraphs and random graphs. In particular, we prove that an edge-colored multigraph of order n on at least three colors and with minimum colored degree greater than or equal to $\frac{n+1}{2}$ has properly edge-colored cycles of all possible lengths, including hamiltonian cycles. Longest properly edge-colored paths and hamiltonian paths between given vertices are considered as well.

Our second aim was to extend the graph theoretic fundamental concept of *connectivity* to colored graphs with a view to gaining some insight into our problem from Menger's basic theorem. In other words, we intend to define some sort of local color-connectivity for edge-colored graphs. Difficulties arose, however, from local connectivity being not polynomially characterizable in edge-colored graphs (70). Thus, there can be no counterpart to Menger's Theorem as such, and even the notion of a connected component as an equivalence class does not carry over to edge colored graphs since the concatenation of two properly edge colored paths is not necessarily properly edge colored. In (70), the authors settled then for some practical and theoretical results which deal with the existence of vertex-disjoint paths/trails between given vertices in c-edge colored graphs. In particular, given two vertices s and t in a c-edge colored graph G^c, they proved that deciding whether there exist or not k pairwise vertex/edge disjoint properly edge-colored $s-t$ paths/trails in G^c is NP-complete even for $k=2$ and $c=O(n^2)$, where n denotes the number of vertices in G^c and c the number of used colors. These problems remain NP-complete for c-colored graphs containing no properly edge colored cycles and $c=O(n)$. In another approach of connectivity, we deal with the proper connection problem. More precisely, an edge-colored graph G is k-proper connected if every pair of vertices is connected by k internally pairwise vertex-disjoint proper colored paths. The k-proper connection number of a connected graph G, denoted by $pc_k(G)$, is the smallest number of colors that are needed to color the edges of G in order to make it k-proper connected. In (10) we prove several upper bounds for $pc_k(G)$. We state some conjectures for general and bipartite graphs, and we prove them for the case $k=1$. In particular, we prove a variety of conditions on G which imply $pc_1(G)=2$.

It seemed also useful to work on some other generalizations of the classical connectivity, for instance, *the k-linking problem*. More precisely, for some positif non zero integer k, a graph is said to be k-linked (k-edge-linked), if for each k ordered pairs of vertices $(x_1,y_1),\ldots,(x_k,y_k)$, there exist k pairwise vertex-disjoint (respectively edge-disjoint) paths, one per pair x_i-y_i. Clearly, the 1-linking problem is equivalent to the classical connectivity. The investigation of k-linkings for non colored graphs gave some important and interesting results both from a mathematical and algorithmic point of view (for a synthesis, see (143)). Here we wish to deal with the colored version of the k-linked problem in edge-colored multigraphs. In (8), we give conditions on colored degrees and/or number of edges, sufficient for an edge-colored multigraph to be k-linked (k-edge-linked). However, as the k-linking problem is trivially NP-hard, it should be interesting to establish approximation algorithms in the general case.

Our last aim is to study the existence of *spanning proper trees* in edge colored graphs. In graph theory, there exist many important problems related to trees with different levels of difficulty depending on the properties of the tree we are looking for. For example, although there are many polynomial algorithms for finding spanning trees in simple graphs, the problem becomes NP-hard for spanning trees with bounded degrees or for spanning trees maximizing the number of leafs. In the case of colored graphs, we focus on spanning trees with properties based on coloring. Namely, we deal with proper and weak proper spanning trees, denoted PST and WST, respectively, first defined in (92, 2, 136). More precisely, a proper spanning tree is a spanning proper subgraph, whose uncolored version is connected and acyclic. A weak proper spanning tree is rooted to some fixed vertex r, such that all root-to-leaf paths are properly colored. While these concepts seems very close and some ideas are common for PST and WST, the proofs and results differ dramatically. Both problems PST and WST, as well as their optimization versions, are proved to be NP-Complete and some nonapproximability bounds are established (5a). Some earlier related work was with rainbow spanning trees, i.e., spanning trees in which each pair of edges differ in color. However the rainbow spanning tree problem is polynomial. Various degree conditions guaranteeing the existence of PST and WST in edge colored graphs can be found in (136, 2).

Applications of Edge-Colored graphs to Social networks. Within the rapid growth of the Internet and the Web, and in the ease with which global communication now takes place, connectedness took an important place in modern society. Global phenomena, involving social networks and the behavior of people based on the links that connect us, appear in a regular manner. Motivated by these developments, there is a growing multidisciplinary interest to understand how highly connected social systems operate. Here we study a rich part of social network theory that involves taking a network and annotating its links (i.e., its edges) with positive and negative signs. Positive links represent friendship, while negative links represent antagonism. Thus a signed graph is one in which relations between entities may be of various types, in contrast to an unsigned graph where all relations are of the same type.

In the study of the behavior of such social antagonist environments, an important problem is to understand the tension between these two, positive and negative, opposite forces. The notion of structural balance Heider (1946) is one of the basic frameworks for such studies asserting that a social system is balanced if there is no tension and that unbalanced social structures exhibit a tension resulting in a tendency to change in the direction of balance. Since this first work of Heider, the notion of balance has been extensively studied by many mathematicians and psychologists. A cornestone result (the so called « the balance theorem ») by Cartwright and Harary (1956) asserts that a signed graph is balanced if and only if its vertex set can be partitioned into two classes so that every edge joining vertices within a class is positive and every edge joining vertices between classes is negative.

Here we are interested in randomness and balance in random social systems (16). More precisely, we defined a probabilistic model where relations between individuals are assumed to be random. A good mathematical model for representing such random social structures is the so called random signed graph $G_{n,p,q}$ on n vertices, where we suppose that between each pair of distinct individuals there is either a positive edge with probability p or a negative edge with probability q, or else there is no edge with probability $1-(p+q)$. Having this random graph in hands, we proved that for n arbitrarily high, almost always, a population on n individuals is unbalanced. Subsequently we estimate the maximum order of a balanced induced subgraph in $G_{n,p,q}$, and show that its order achieves only a finite number of values. Next, we study the asymptotic behavior of the degree of m-relative balance (i.e., the ratio of the number of positive cycles of length at most m to the total number of cycles of length at most m). We also give upper and lower bounds for the frustration Index of balance (i.e., the smallest number of edges whose inversion of signs results in a balanced graph. Finally, we study the threshold function of balance, e.g., a function $p_0(n)$ such that if $p >> p_0(n)$, then almost always the random signed graph $G_{n,p,q}$ is unbalanced, else it is almost always balanced.

We also investigate on the concept of *weakly balanced networks*. More precisely, a signed graph is weakly balanced if and only if there is no set of three nodes such that the edges among them consist of exactly two positive edges and one negative edge. Since weak balance imposes less restrictions on what the network can look like, we should expect to see a broader range of possible structures for weakly balanced networks than for normal balance. In that context, very recently, we studied the weak balance of the random graph $G_{n,p,q}$ (134). In particular, we established bounds for the order of the maximum weakly balanced component of $G_{n,p,q}$, the threshold of weak balance for the case of $p = q$ as well as the weak frustration-index. We concluded the work with a study of the degree of the relative m-weak balance (i.e., the number of cycles of length m that contain exactly one negative edge over the number of cycles of length m that have odd number of negative edges).

Nonrepetitive vertex-coloring of graphs The question whether the Thue choice number of trees are bounded by a constant was asked by Grytczuk, Przybyło and Zhu in 2011. We gave a negative answer to this question (20), by proving that for any positive integer ℓ, there is a tree T with $\pi_{\mathrm{ch}}(T) > \ell$. So, the tree-width of a graph does not provide an upper bound on its Thue choice number. On the other hand, the graphs of bounded tree-depth have bounded Thue choice number. We proved a more general class of graphs have bounded Thue choice number: for any integers Δ, z, there is a constant $c(\Delta, z)$ for which the following holds: if G is obtained from a graph G' of maximum degree at most Δ by attaching to each vertex v of G' a connected graph of tree-depth at most z, then $\pi_{\mathrm{ch}}(G) \leq c(\Delta, z)$.

Combinatorics

Combinatorics is a traditional research theme of the Algo team. It currently groups together Francesca Fiorenzi, Dominique Gouyou-Beauchamps, Florent Hivert, and Nicolas M. Thiéry. The former members were Sylvie Corteel, Jean-Paul Allouche and Pascal Ochem.

The combinatorics theme is grounded in theoretical computer science. The two main subjects are algebraic and enumerative combinatorics, on the one hand, and combinatorics on words and dynamical systems on the other hand. It is a multidisciplinary theme whose main computer science application is the analysis of algorithms, but with strong links with mathematics, in particular number theory and algebra, as well as physics and specifically statistical physics. We highlight here some important results:

Algebraic and enumerative Combinatorics

Algebraic combinatorics aims at exploring the links between algorithms, combinatorial objects and algebraic identities.

Combinatorial Hopf algebras Generating series are at the core of combinatorics. By encoding a sequence of numbers into a single algebraic expression, properties like recurrence relations typically translate into functional equations. This opens the door for using algebraic (if not analytic) tools to tackle enumeration problems (how many objects of a given kind are there of size n?) or complexity problems (how many steps will my algorithm take for an input of size n?). However, one often requires more sophisticated inductions involving not only integers but objects such as trees, relations, grammars, or graphs. Combinatorial algebra are algebraic objects generalizing power series which permit to manipulate algebraically those induction. The main results in this theme are generalization of the Hook length formula for trees (62) and the study of the so called transformation of alphabet which are analogs of change of variables (28, 61, 129). This work takes place within the ANR Carma project, under the lead of Jean-Yves Thibon in Marne-la-Vallée.

Representation theory of sorting monoids This subject is related to combinatorial Hopf algebras and language theory. Indeed, several Combinatorial Hopf algebras are constructed from the representation theory of towers of monoids. Recall that the idea of representation theory is to encode a monoid as a matrix monoid allowing to use the arsenal of linear algebra in its study. The seminal example is the Hopf algebra of Symmetric functions which encodes the representation theory of the symmetric groups. Until now, few Hopf algebras were constructed this way, by lack of appropriate technology for studying the representation theory of monoids. Indeed, even though the representation theory of groups is well known since over a century ago, at least in the non-modular case, until recently, only the first elements of the theory were known for monoids.

An important barrier was the class of aperiodic monoids; introduced by Schützenberger, these monoids are in correspondence with rational languages without stars. The results of Hivert and Thiéry in collaboration with Anne Schilling from UC Davis on biHecke Monoids (27) seem to have opened a breach. Inspired by them, Thiéry indeed showed how to exploit the well known properties of the Cayley graph of an aperiodic monoid to reduce the calculation of its Cartan matrix (an important invariant of its representation theory) to the calculation of the characters of some small modules (90). The complexity improvement allowed to treat in an hour a monoid size 31 103, whereas hitherto the treatment of similar monoids of size 500 could take weeks.

Recently, Thiéry together with international collaborators has been applying this technology to the study of discrete Markov chains (128) and statistical physics models, among which directed versions of sandpile models.

Tableaux and partitions combinatorics Tableaux and partitions are among the most important objects in algebraic combinatorics thanks to their connection with the symmetric group. The results obtained here concern three of their generalizations: *overpartitions, Permutation tableaux and ribbon tableau*.

The first set of results concerns the classical links between combinatorics of Partition and q-series. The importance of *overpartitions* was highlighted, especially in Rogers-Ramanujan (one of the most important in partition theory and q-series) identities (13) and the q-Bailey identity (59). More results were obtained on lecture hall partitions introduced by Mireille Bousquet-Mélou and Kimmo Eriksson in 1997 (5).

Permutation tableaux are new objects that come from the enumeration of the totally positive Grassmannian cells. They are also connected to a statistical physics model called the Partially ASymmetric Exclusion (PASEP). We have proposed two bijections between permutation tableaux and permutations (14). These bijections show how natural statistics on the tableaux are equidistributed to classical statistics on permutations: descents, RL-minima and pattern enumerations.

For *ribbon tableaux*, where ribbons are allowed to be of different sizes, we gave an extension of the

famous Robinson-Schensted correspondence by extending Fomin's growth diagram approach of the classical correspondence, in particular by allowing signs in the enumeration (26).

Combinatorics and Statistical Physics Alternating sign matrices (ASMs) are generalization of permutations which currently witness a considerable research effort in statistical physics, in particular around the (now proven) Razumov-Stroganov conjecture on the Temperley-Lieb algebra.

The enumeration formula for ASMs was first proved by Doron Zeilberger in 1996 by showing that monotone triangles (called also Gog triangle) naturally associated to them are equinumerous to Magog triangles associated to totally symmetric self-complementary plane partitions. We demonstrate a natural bijection between a sub-class of alternating sign matrices defined by a condition on the corresponding monotone triangle which we call the gapless condition and a subclass of totally symmetric self-complementary plane partitions defined by a similar condition on the corresponding fundamental domains or Magog triangles (57). We prove that, when restricted to permutations, this class of ASMs reduces to 312-avoiding permutations.

Many interesting enumerative quantities can be expressed in terms of products of matrices satisfying certain relations. In such a situation, a *Matrix Ansatz* can be useful for a variety of reasons: having explicit matrix expressions gives rise to explicit formulas for the quantities of interest; finding combinatorial objects which obey the same relations gives rise to a combinatorial formula for the quantities of interest; finding two combinatorial solutions to the same set of relations identifies the generating functions for the two sets of combinatorial objects. This approach can be applied to various domains like moments of orthogonal polynomials, permutations, signed permutations, and tableaux (75) (139).

Dynamical system and combinatorics on words

Cellular automata, groups and Cayley graphs We study cellular automata defined on the Cayley graph of a finitely generated group (19) or monoid (96), (104).

In the case of a residually finite group and in that of a group shift space on an abelian group, we proved that the periodic configurations are dense. In the one-dimensional case we proved the density for irreducible sofic shifts. In connection with this, we studied the surjunctivity of cellular automata and local selfmappings. Some related decision problems for shift spaces of finite type are also investigated (19).

The Cayley graph of a finitely generated free monoid is a regular rooted tree. Our investigation on cellular automata on regular rooted trees included the characterization of sofic tree shifts in terms of unrestricted Rabin automata and the decidability of the surjectivity problem for cellular automata between sofic tree shifts (96). In the same context we proved that for $k \geq 2$ there do not exist positively expansive cellular automata defined on the full k-ary tree shift (104). Moreover, we investigated some topological properties of these automata and their relationships, namely permutivity, surjectivity, preinjectivity, right-closingness and openness.

Combinatorics on words The first kinds of results concern pattern avoidance. In 2005, Ilie, Ochem, and Shallit generalized the notion of repetition threshold, which is the object of Dejean's conjecture. This generalization consisted in taking into account the length of the avoided words. We gave a lower and an upper bound on this generalized repetition threshold (58, 21, 105). More results classify the infinite words over the two-letter alphabet $\{0, 1\}$ that avoid the pattern AABBCABBA (45) and approximate square avoidance (67).

Words, fractals and number theory The second set of results on combinatorics on words concerns the connections between formal languages and words, on one hand, and number theory, symbolic dynamic on the other hand.

Sturmian sequences are in some sense the "least complicated" aperiodic sequences on a binary alphabet. We generalize a result of Niu and al. by proving, using a work of Cosnard and al. (1982-1983), that a large class of Thue-Morse-like sequences belong to the sets of binary sequences introduced by Erdös, Joó, and Komornik (1990). The case of alphabets of size larger than 2 yields similar results (119). Starting from a study of Y. Bugeaud and A. Dubickas (2005) on a question in distribution of real numbers modulo 1 via combinatorics on words, we survey some combinatorial properties of (epi)Sturmian sequences and distribution modulo 1 in connection to their work (53). We focus on extremal properties of (epi)Sturmian sequences, some of which have been rediscovered several times.

In the line of research related to the *combinatorics of representations of real numbers in non-integer bases*, one can define univoque numbers are real numbers $\lambda > 1$ such that the number 1 admits a unique expansion in base λ. We show that the smallest univoque number belonging to the interval $(b, b+1)$ is transcendental, where b is any positive integer. An avatar of the Thue-Morse sequence, namely the fixed point beginning in 3 of the morphism $3 \to 31$, $2 \to 30$, $1 \to 03$, $0 \to 02$, occurs in a "universal" manner (3). We study (purely) periodic unique β-expansions and show that for each $n \geq 2$ there exists $\beta_n \in [\frac{1+\sqrt{5}}{2}, 2)$ such that there are no unique periodic β-expansions of smallest period n for $\beta \leq \beta_n$ and at least one such expansion for $\beta > \beta_n$ (52).

Classical and Quantum algorithms and complexity

The results described here were developed by the part of the team that moved to LIAFA (de Rougemont, Kempe, Kerenidis, Laplante, Magniez, Rosen and Santha). They cover mainly Property Testing, Streaming and Online Algorithms, Cryptography and Game Theory, Query and Communication Complexities, Quantum algorithms.

Classical algorithms and complexity In the area of *Property Testing* (a statistics based approximation technique to decide whether an input satisfies a given property, or is far to any input satisfying the property), we initiated the study for the edit distance with moves in the contexts of words (22), XML databases (101) and Markov Decision Processes (116). For *streaming and online algorithms* we have defined a novel model of online computation with advice, where online algorithms have some partial information about the future. We also gave online algorithms, and sometimes offline approximation algorithms, for various problems in communication networks and adjacent fields (39). We also initiated the study of memory space complexity of language recognition (85) with application to large XML databases. Concerning *cryptography and game theory*, one of the challenges brought on by the new pervasive nature of data is the question of trust. Trust can come in the form of cryptographic protocols, which ensure secrecy and authenticity, or it can come in the form of game-theoretic mechanisms that use money and utility to incentivize individuals to behave truthfully. Here we have studied the robustness of the computational problems underlying modern cryptography (77, 86), the optimal efficiency of various cryptographic protocols such as Zero Knowledge and bit commitment (107), and the efficiency of analyzing their behavior as in computing equilibria (78). We have also studied the "converse" of cryptography, relating the complexity of various models of machine learning (91). In the area of *query and communication complexities* we developed the study of the limitations of the models described above. In particular, we developed general methods to prove lower bounds based on Kolmogorov arguments (32). Motivated by streaming algorithms applications, we also provided new lower bounds to explicit problems (85).

Quantum algorithms and complexity Concerning *quantum computing*, one of the main purposes was to design, for specific problems, faster quantum algorithms than any known classical procedure. In that aim, we have conceived fast quantum algorithms for group theoretic questions, often related to the paradigmatic hidden subgroup problem (29). Our research has also concentrated on quantum query complexity of search algorithms via quantum walks. We have obtained several generic results about the quantization of classical Markov chains (84, 111, 117). A second purpose was to consider *communication complexity* with the aim to study the classical and quantum models side-by-side in order to understand the similarities and differences between them. We have shown exponential gaps between classical and quantum models for the Hidden Matching problem (7). We have also studied the complexity of entangled games (34) and shown hardness results on approximating the quantum value of a game. In quantum *cryptography*, one of the main goals is to study the optimal security parameters for specific fundamental primitives. Moreover, it is important to extend the security proofs in realistic conditions that take into account the imperfections of the quantum devices. First, we have found the optimal parameters for coin flipping and bit commitment (74) and we have studied a number of other cryptographic primitives, including oblivious transfer, zero knowledge and computational bit commitments (73, 99, 100). Second, we have studied security in the device independent model and in the presence of losses and errors. (98).

Collaborations

Participation to national and international collaborative research projects

- Coorganization (with Anne Schiling and Daniel Bump) of the thematic semester "Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series" at the Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, Providence, Rhodes Island, USA (**http://icerm.brown.edu/sp-s13**).
- Collaborative Research: SI2-SSE: "Sage-combinat: Developing and Sharing Open Source Software for Algebraic Combinatorics", NSF, 2012-2015, Coordinator: Dan Bump, Gregg Musiker, Anne Schilling, William Stein (and Nicolas M. Thiéry).
- The team is involved in several european and national research projects, including a very large number of scientific contacts, listed in the "Contracts and Grants´´ section.

Collaborations with other laboratories

- Anne Schilling, Tom Denton, University of California at Davis, USA: representation theory of monoids (60, 27, 128)
- Benjamin Steinberg, City College of New York, USA: (128)
- Arvind Ayyer, Indian Institute of Science, Bangalore, India: (128)
- Vic Reiner, University of Minnesota, USA: (62)
- University of Crete (Franco-Hellenic Master)
- Gervais Mendy, University of Dakar, Graph Theory (two visits) (8, 71, 143, 2)
- Raquel Agueda, University of Toledo, Graph Coloring, (two visits) (71, 2)
- Antoine Deza, MacMaster Univ, Combinatorial Geometry.
- Jean Christophe Novelli (IGM, Univ. Marne-la-Vallée), Frédéric Chapoton (Institut Camille Jordan, CNRS), ANR Carma (129)
- Hivert and Thiéry are both associated members of the Laboratoire International Franco-Québécois de Recherche en Combinatoire (LIRCO), Quebec, UQàM.

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Volunteer Professional Service

Management Positions in Scientific Organisations

- LRI: Manoussakis, Vice Director (Since January 2012).
- GdR-IM: Hivert, Coordinator of the CombAlg group (until 2009).
- European Mathematical Society: Allouche, Member of the Ethic Committee (Since 2010).
- Société Mathématique de France: Allouche, Publication director (until 2010).
- Comité National Français des Mathématiciens: Allouche, Member (until 2010).
- University Paris-Sud: Manoussakis, Elected Member of scientific council (2006-2008).
- LRI: Manoussakis, Elected Member of laboratory council (2001-2009).
- University Paris-Sud: Manoussakis, Member of the research council, UFR Sciences (2007-2008).

Organisation of Conferences and Scientific Events

- 8th french combinatorial conference Orsay 2010 (350 participants): Manoussakis, Co-Chair.
- Workshop JGA 13-15 Novembre 2013, Orsay: Manoussakis, Co-Chair;
- Organisation de la deuxième conférence IEEE "Computational Complexity", 2009, Paris, Laplante, Co-Chair.
- ICERM, Coorganisation of the thematic semester «Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series» at the Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University, Providence, Rhodes Island, USA (http://icerm.brown.edu/sp-s13).
- Sage Days 49, Free and Practical Software for (Algebraic) Combinatorics (satellite of the FPSAC conference), Paris, France, 2013: Thiéry, local organizer.
- Sage Days 45: Multiple Dirichlet series, combinatorics, and representation theory, ICERM, Brown, RI, 2013: Thiéry, coorganizer.

- Online databases: from L-functions to combinatorics, Edinburgh, Scotland, UK, 2013: Thiéry, coorganizer
- «Sage-Combinat Days in Cernay», 6–10 février 2012, Cernay-la-Ville: Hivert, organizer.
- Organizer and Chair of the "Séminaire parisien de combinatoire Philippe Flajolet", Monthly seminar, IHP, Paris: Hivert, organizer.

Honors

Prizes and Awards

- J. Kempe, Insigne de chevalier in the "ordre national du mérite" and award «Femme en or de la recherche», 2010.
- A. Chailloux, Gilles Kahn PhD prize, 2011

Keynote Addresses

International

- Hivert: 22nd International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC'10), San Francisco State University, August 2-6, 2010, USA.
- Hivert: LACIM 2010, 2010 August 29-31, UQAM, Quebec, The 1-E transform in combinatorial Hopf Algebras.
- Allouche: Groups generated by automata, Centre Stefano Franscini, Ascona, Monte Veritá, SUISSE, 2009 February 11-15.
- Allouche: CNTA 2008 (Canadian Number Theory Association X Meeting), Fields Institute and University of Waterloo, Waterloo, CANADA, 2008 July 13-18
- Allouche: p-adic differential equations: a conference in honor of Gilles Christol, Bressanone (Université de Padoue), ITALIE, 2008 September 6-9;
- Workshop on Dynamical Systems and Symbolic Dynamics, Bielefeld, 2010, Germany, May 17-19.
- Allouche: Mini-Workshop : Combinatorics on Words, MFO, Oberwolfach, Germany, August 23-28, 2010

Evaluation of Research

Editorial Boards

International

- Journal de Théorie des Nombres de Bordeaux, Allouche, *Director of publication*
- Advances in Applied Mathematics: Allouche
- Journal of Integer sequences: Allouche
- Mathématiques et Sciences Humaines: Allouche, *Redaction committee*
- Journal of Mathematics and Music: Allouche
- Pure Mathematics and Applications: Allouche
- Uniform Distribution Theory: Allouche
- Open Journal on Discrete Mathematics: Manoussakis
- ISRN Discrete Mathematics: Manoussakis
- Applied and Computational Mathematics: Manoussakis
- International Journal of Mathematics and Statistics: Manoussakis

Program Committees

Member (international events)

- "JAC 2008", Journées Automates Cellulaires 2008, Uzès, April 2008: Allouche.
- "CanaDAM 2009", Canadian Discrete and Algorithmic Mathematics Conference 2009, CRM, Montréal, Canada, May 2009: Allouche.
- 7th International Conference on Words, Université de Salerno, Fisciano, Italie, 14–18 September 2009: Allouche.
- Formal Power series and Algebraic Combinatorics FPSAC 2012, Nagoya, Japan, at Nagoya University, July 30–August 3: Hivert.
- "9th International colloquium on graph theory and combinatorics", Grenoble, June 30-July 4, 2014, Manoussakis, Scientific committee.
- International Workshop on Discrete Structures (IWODS) March 5-7, 2014 Islamabad, Pakistan, Manoussakis, Scientific committee.

Evaluation Committees and Invited Expertise

International

- Greek AERES Agency: Manoussakis.
- Greek national projects, Manoussakis, grant evaluation expert.
- National Science Fundation (NSF), USA: Hivert, grant evaluation expert.
- Natural Sciences and Engineering Research Council of Canada (NSERC), Canada: Hivert, grant evaluation expert.

National

- ANR, Hivert, grant evaluation expert.
- ANR, Thiéry, grant evaluation expert.
- Regional, Manoussakis, grant evaluation expert.

Other evaluation activities

Hiring Committees

- Hivert: Prof (Calais 2013), Mdc (Rouen 2010, Marne-la-Vallée 2009);
- Fiorenzi: Mdc (Paris-Sud 2009, Marne-la-Vallée 2009, Paris-Sud 2010)
- Thiéry: Mdc (Paris-Sud 2009), PRAG (Paris-Sud 2010, 2011)
- Manoussakis: President Prof (Paris-Sud 2009, 2010), Prof (Paris-Sud 2011, 2012, 2013), MdC (Paris-Sud 2013, Versailles 2012, Évry 2012)

PhD and Habilitation Juries

- Manoussakis: Habilitation referee for the conseil scientifique de l'Université Paris SUD 11 for applications in physics, economy, mathematics (roughly 60-80 files per year: Manoussakis, 2006-2008)
- Manoussakis: president (9), reviewer (5), examiner (10)
- Hivert: HdR reviewer (2), president (3), reviewer (2), examiner (2)
- Thiéry: reviewer (2), examiner (4)

Interactions with the social, economic and cultural environment

Popularisation of Research Results

- Organizer of the "Fête de la Science 2013".
- Hivert, Invitation to give the plenary talk "Jonglerie Automate et Combinatoire", 24ème congrès MATh.en.JEANS, April 5-7, 2013.
- S. Laplante. Chapter "Le plus grand des hasards : Surprises quantiques". In: ed. by J.-F. Dars and A. Papillaut. Belin, 2010. Chap. L´influence de l'informatique, pp. 152-154.

Contracts and grants

Public contracts and grants (jan 2008 - jun 2013)

Type	*Name*	*Managing Institution*	*Start / Duration*	*Amount*
ANR	ICOMB	Université Paris XI	07.2008 / 60 mo.	71.00 k€
Subvention	GT CMF	CNRS	01.2007 / 36 mo.	8.00 k€
ANR	VERAP	CNRS	01.2008 / 36 mo.	121.68 k€
Subvention	AAP 2013	Université Paris XI	01.2013 / 12 mo.	10.40 k€
DIGITEO	SAGE	Université Paris XI	01.2012 / 2 mo.	1.50 k€
ANR	CRYQ	CNRS	01.2009 / 57 mo.	196.00 k€
Subvention	GT IQ	CNRS	01.2006 / 48 mo.	8.00 k€
Subvention	JST-ICT	CNRS	01.2008 / 48 mo.	90.00 k€
Contrat europeen	QCCC	Université Paris XI	05.2006 / 24 mo.	80.00 k€
ANR	ALGOQP	CNRS	12.2005 / 42 mo.	280.00 k€
ANR	DIQIP	Université Paris XI	09.2011 / 36 mo.	24.44 k€
DIGITEO	QNLCC	autre	09.2011 / 36 mo.	102.20 k€
Contrat europeen	CSQIP	Université Paris XI	10.2008 / 39 mo.	138.00 k€
Subvention	MAGNIN L	Université Paris XI	06.2009 / 46 mo.	7.50 k€
ANR	QRAC	Université Paris XI	01.2009 / 48 mo.	420.00 k€
DIGITEO	ASSECGA	Université Paris XI	10.2012 / 12 mo.	51.30 k€
Subvention	MENDY G.	Université Paris XI	04.2008 / 46 mo.	7.50 k€
Subvention	HSP	CNRS	01.2008 / 24 mo.	6.80 k€
Contrat europeen	QAP	Université Paris XI	11.2005 / 48 mo.	158.40 k€

Software Licensing and Distribution

Sage - a free open-source mathematics software system

http://www.sagemath.org/

Contact: Hivert-Thiéry

SAGE is a free open-source mathematics software licensed under GPL. It is similar to MAPLE, MUPAD, MATHEMATICA, MAGMA, and up to some point MATLAB. It combines the power of many open-source packages GAP4, Linbox, Singular, Symmetrica, etc.) into a common interface and is based on the popular Python programming language.

It is developed by an international community of 300 teachers and researchers. The development process include a public referring process. Each line of code must be validated before being integrated into SAGE.

Sage-Combinat - to improve the open source mathematical system Sage
http://combinat.sagemath.org
Contact: Hivert-Thiéry

The mission of SAGE-COMBINAT itself is to improve SAGE as an extensible toolbox for computer exploration in combinatorics, and to foster code sharing between researchers in this area. `Sage-Combinat` is developed under the lead of the LRI (Thiéry-Hivert) and groups now approximatively 50 contributors all over the worlds (Europ, North America, Australia, Japan, Korea, ...). In practice, `Sage-Combinat` is a collection of experimental extension on top of `Sage`, which are developed by a community of researchers. Those extension are progressively intergrated to SAGE as soon as they are stable enough. The code volume is around 120 000 lines of codes integrated into `Sage`. The combinat team participated in more that 700 Tickets (=modification, bug fix, enhancement...). The team also have 150 000 lines of experimental line of codes which are in stabilization process.

Training and Education

Book

1. Book chapters: A. Casamayou, N. Cohen, G. Connan, T. Dumont, L. Fousse, F. Maltey, M. Meulien, M. Mezzarobba, C. Pernet, N. M. Thiéry, P. Zimmermann : Calcul mathématique avec Sage, Licence: Creative Commons, France, 468 pages, published in May 30, 2013, ISBN: 1481191047.

School for graduate students and young researchers

1. School for young researchers: Thiery Monteil, Nathann Cohen, Vincent Delecroix, Samuel Lelievre, Sage Cours within the École Jeunes Chercheurs en Informatique Mathématique, April 8-12, 2013, Perpignan;
2. Nicolas Thiéry : Invited cours and laboratory within the École d'automne "Mathématiques discrètes : aspects combinatoires, dynamiques et algorithmiques", Bobo-Dioulasso, Burkina Faso, October 2012. **http://www.ragaad.org/bobo2012/**;
3. «Ecole des Jeunes Chercheurs en Informatique Mathématique» (2009, co-organization);
4. Two thematic schools on "Quantum Computing", Montréal (2010);

Graduate Courses

- The team is the leader of projet MIFOSA which aims to create a research Master 2 at the Paris Saclay University (opening in September 2015).
- Coordinator of the international Franco-Hellenic master, common to the University Paris-Sud, Joseph Fourier at Grenoble and the University of Crete.
- Coordinator of the Master 2 «Compétences Complémentaires en Informatique», Paris-Sud University.

Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Sylvain PEYRONNET	07.12.2010
Iordanis KERENIDIS	03.12.2010
Julia KEMPE	14.09.2010

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Valentin BOROZAN	01.10.2007	30.09.2011	Alloc. Ministère	MANOUSSAKIS
André CHAILLOUX	15.09.2007	24.06.2011	ENS	SANTHA
Claudia HESS	15.12.2005	25.01.2008	ETR	DE ROUGEMONT
Matthieu JOSUAT-VERGES	09.01.2007	25.01.2010	Alloc. Ministère	CORTEEL
Marc KAPLAN	01.10.2005	28.09.2009	Alloc. Ministère	LAPLANTE
Gervais MENDY	20.11.2006	28.09.2011	ETR	MANOUSSAKIS
Leandro Pedro MONTERO	01.12.2009	13.12.2012	Alloc. Ministère	MANOUSSAKIS
Luc SANSELME	14.10.2004	10.12.2008	Alloc. Ministère	SANTHA
Mathieu TRACOL	01.10.2007	15.06.2010	Alloc. Ministère	DE ROUGEMONT
Adrien VIEILLERIBIERE	01.10.2004	22.09.2008	Alloc. Ministère	DE ROUGEMONT
Xavier ZEITOUN	01.10.2009	13.06.2013	Alloc. Ministère	DE ROUGEMONT

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Jean-Alexandre ANGLES D'AURIAC	01.10.2011	Alloc. Ministère	MANOUSSAKIS
Michele MANGILI	01.10.2012	Alloc. Ministère	MARTIGNON
Jean-Baptiste PRIEZ	01.10.2012	Alloc. Ministère	HIVERT
Aladin VIRMAUX	01.10.2012	Digiteo	THIÉRY

4/ Algorithms

Self Assessment

Strengths

- Very high quality in research production;
- High international visibility;
- High attractivity;
- Leader in development of combinatorics software (Sage-Combinat).

Weaknesses

- Lots of movements, the team is in stabilization process;
- Very few young researchers (1 CR CNRS), a large part of the researchers are Professor or Research director;
- Few industrial contact.

Risks

- Integration of the team: The team is in complete reorganization (lots of hiring) as well as its environment (plateaux de Saclay);
- The team is currently missing some access to Master courses.

Opportunity

- The team is a funding member of the Fédération d'Algorithmique du plateau de Saclay and the associate Seminar;
- The team is the coordinator of the newly created master MIFOSA (Master d'informatique fondamentale du plateau de Saclay).

Graphs: Synthetic presentation

Nom du responsable de l'équipe : **Abdel LISSER**

Effectifs de l'équipe
Au premier janvier 2008: 9 permanents dont 8 enseignants-chercheurs : 3 PRs, 4 MDC et un DR CNRS.

Personnels ayant quitté l'équipe pendant le contrat en cours

- Didier Fayard, Professeur IUT Orsay, départ à la retraite 2012.
- Mekkia Kouider, Maitre de conférences université de Paris Sud, départ à la retraite 2010.
- Charles Delorme, Maitre de conférences université de Paris Sud, départ à la retraite 2011.
- Jean-François Saclé, Maitre de conférences université de Paris Sud, départ à la retraite 2012.
- Evelyne Flandrin, Professeur université de Paris Descartes et chercheuse au LRI, départ à la retraite 2012.
- 13 doctorants ont soutenus leur thèse durant cette période.

Nombre de recrutements réalisés au cours de la période considérée et origine des personnels

- Céline Gicquel, Maitre de conférences IUT Orsay, recrutée en 2011.

Production scientifique au cours de la période écoulée

- En considérant le théorèmes de Ramsey et de Turan; Li Hao a introduit une nouvelle classe de problèmes Ramsey-Turan qui fait partie des 15 nouvelles questions et conjectures proposées par Shelp.
- Li Hao a montré que si G est un graphe élémentaire tel que $|V(G)| \geq 3r + 4s$ sommets dont le degré minimum est $\geq 2r + 3s$, alors G contient $r + s$ cycles sommets disjoints dont chaque cycle contenant s a soit deux cordes, soit un cycle de longueur 4 ayant une corde. Ce résultat montre que la conjecture de Bialostochi, Finkel et Gyarfas est vraie.

Bilan quantitatif des publications de l'équipe

- Articles de revue : internationales majeures 80 ; autres revues 70

5 publications majeures

- H. Li, V. Nikiforov and R.H. Schelp, A new class of Ramsey-Turán problems, Discrete Mathematics 310 (2010) 3579-3583.
- Mahdad Khatirinejad, Reza Naserasr, Mike Newman, Ben Seamone, Brett Stevens: Vertex-colouring edge-weightings with two edge weights. Discrete Mathematics & Theoretical Computer Science (DMTCS) 14(1):1-20 (2012).
- E. Flandrin, A. Marczyk, J.F. Saclé, M. Wozniak "Neighbor sum distinguishing index" Graphs and Combinatorics, (DOI) 10.1007/S00373-012-1191-X, May 2012.

5 (max) faits illustrant le rayonnement ou l'attractivité académique

- Hao Li, *Changjiang Lectureship Chair Professor* (by Changjiang Scholar Award Program of Chinese Minister of Education and the Li Ka-Shing fondation)

Principales contributions de l'équipe à des actions de formation

- Cours au Master Recherche en Informatique de l'université de Paris Sud (**https://www.dep-informatique.u-psud.fr/formation/lmd/M2R_NSI**)

Research Group Members and evolution since 2008

Permanent Members (June 30th, 2013)			
Name	*First name*	*Position*	*Institution*
DJELLOUL	Selma	MCF	PARIS EST
FLANDRIN	Evelyne	PREM	PARIS 5
FORGE	David	MCF	PARIS SUD
LI	Hao	DR2	CNRS
NASERASR	Réza	CR1	CNRS

Group evolution

- Mekkia Kouider, Charles Delorme, Jean-François Saclé and Evelyne Flandrin are retired

Research Description

Graph theory

Participants: Hao Li, Réza Naserasr, David Forge, Odile Favaron, Charles Delorme, Evelyne Flandrin, Mekkia Kouider, Jean-François Saclé, Maryvonne Maheo, Selma Djelloul

Most of our works focus on fundamental problems in graph theory. We also work on matroids and some problems of graph theory that have practical background in energy conservation in wireless sensor networks and social networks.

The theory of hamiltonian graphs and various cycles structures are one of the core topics in graph theory. Li and Yang obtained partial results on an important conjecture of Thomassen on hamiltonian line graphs. Li et al. developed new definitions of implicit-degrees that generalize the degree of a vertex and in a series of 10 papers, we show new theorems on hamiltonian cycles, pancyclic, cyclability, dominating cycles, etc, that are stronger than classical theorems. Invited by an editor, Li wrote a survey on generalizations of the Dirac theorem which is the base of the hamiltonian extremal graph theory. Li et al. proved in 2009 a result on partitions of a graph into cycles with chords. This result is stronger than a conjecture of Bialostocki, Finkel, and Gyárfás and is a generalization of well known results of Pósa and Corrádi and Hajnal. Flandrin and Li studied cyclability of given vertex subsets or edge subsets, some of these works are specially related with claw-free graphs, bipartite graphs and the (generalized) prisms of graphs.

Developing theory of homomorphism of signed graphs, Naserasr proved that while the size of largest planar signed clique is 8, the largest signed-chromatic number of a planar signed graph is somewhere between 10 and 48. Naserasr $et\ al$. have managed to introduce a new reformulation of the Hadwiger's conjecture. Using this reformulation we have proved an essential difference between the cases where the conjecture is proved and unproved cases. Results are also obtained in homomorphisms of planar signed graphs to signed projective cubes.

Extremal graph theory is an important topic that has potential applications. Ramsey theory and Turán's extremal graph theorem are both among the most basic theorems in graph theory. Li et al. introduced and studied a new class of Ramsey-Turán problems. Based on a conjecture we made and a partial result obtained, Schelp proposed a series of new conjectures that generalize many classical conjectures in

Ramsey theory. Delorme studied large graphs, that is, given degree, diameter and some other conditions, like being bipartite, or planar or Cayley, what the largest order of a graph is subject to these conditions. Many tools are used either to build "large graphs" and therefore provide lower bounds or improve, (that is decrease) upper bounds. Erdős stated several conjectures in extremal graph theory related to triangles and pentagons. Bollobás and Győri studied the problem: what can we say about the number of triangles in a graph not containing any pentagon? Upper and lower bounds are proved by Li et al. for the number of triangles in C_{2k+1}-free graphs. The bounds involve extremal numbers related to appropriate even cycles.

Favaron studied various domination parameters. For most of them, the subdivision number of a graph is the minimum number of edges to subdivide in order to increase the parameter. She got with some Iranian colleagues many results on this well-studied topic. They also proved a conjecture of Alon and Bollobás on the game domination number of a graph, improving the previously known result by a coefficient 2/3.

Kouider defined the quasi-monotonous property that is related to dominating colorings and she showed that chordal graphs are not quasi-monotonous in general whereas graphs in a subclass of chordal graphs are quasi-monotonous. Kouider has different results on the existence of factors with prescribed degrees. On the other hand she has several results on the conjecture El Sahili-Kouider on the b-coloring of regular graphs.

Forge's research is on matroid theory with basic links to graphs. He studied arrangements of hyperplanes in terms of graphs with gains. Many questions can be asked and they of course correspond to questions on the arrangement like finding the combinatorial invariants such as characteristic or Tutte polynomials. Forge has a series of articles on finding such polynomials for gain graphs and sometime some special gain graphs like the braid, the Shi or the Linial gain graphs.

Delorme also adressed some questions concerning algorithmic (domination by edges) and extremal (generalised cages) theory of graphs, as well as spectral (in relation with existence of homomorphisms questions) or algebraic or even geometric aspects.

Djelloul obtained results for graph products about treewidth and its connections with graph grammars and with logical definability of graph properties. She designed an algorithm that, given a tree-decomposition of a graph G and a tree-decomposition of a graph H, provides a tree-decomposition of the cartesian product of G and H. In the context of graph grammars and graph logic, S. Djelloul proved that the cartesian product of a class of graphs by a finite set of graphs preserves the property of being a context-free set, and that the cartesian product by a finite set of connected graphs preserves MS_1-definability and MS_2-definability.

We have also worked on graph theory problems that have strong practical background. Results have obtained by Li et al. on energy conservation in wireless sensor networks and connectivity of graphs. In collaboration with John Hopcroft who received the Turing Award in 1986, Li et al. obtained results on labeling vertices and edges in social networks.

Collaborations

Participation to national and international collaborative research projects

- PEPS project on homomorphisms of signed graph, coordinator: Reza Naserasr

Collaborations with other laboratories

- Pr. E. Sopena and other members of the team including students, LaBRI Bordeaux, Signed graph homomorphisms.
- Pr. P. Hell and Pr. B. Mohar, Simon Fraser University, Vancouver Canada, tropical homomorphisms and orthogonality graphs.

- Dr. L. Beaudou, LIMOS, Clement-Ferrand. Homomorphism to projective cubes.
- Pr. R. Skrekovski, Slovenia, discharging methods for homomorphisms problems.
- Pr. S. Fujita Tokyo, Japan. Longest path problems
- Pr. H. Hajiabolhassan, Tehran, Iran. Homomorphism via topology
- Dr. N. Narayanan, k-intersection edge-colorings.
- PR. El Sahili , University of Beyrouth, colouring of graphs
- DR. Valencia-Pabon,University of Nancy, colouring of graphs
- Pr Volkmann, University of Aachen, Germany. k-domination.
- Prs Cockayne and Mynhardt, University of Victoria, Canada. Open irredundance.
- Pr Blidia and Chellali, Universities of Alger and Blida. k-independence.
- Pr Arumugam, Kalasalingam university, India. Irredundance saturation.
- Pr Henning, Universities of Pietermaritzburg and Johannesburg, South Africa. Paired domination.
- Pr Hansen, Gerad, University of Montreal, Canada. Girth, independence and irredundance.
- Prs Karami, Sheikholeslami et al., Azerbaijian University, Tabriz, Iran. Subdivision domination parameters.
- Pr. John Hopcroft, Cornell University, USA, Graph Theory Problems in Social Networks.
- Pr. Herbert Fleischner, Vienna Univqersity of Technology, Austria, Cycles in Graph.
- Pr. Hajo Broersma, University of Twente, Netherlands, Cycles in Graph.
- Pr. Mirka Miller, University of Newcastle, England, Graph Theory in Networks.
- Pr. Wozniak, AGH, Poland, Cycles in Graph.
- Pr. Guantao Chen, Georgia State University, USA, Cycles in Digraph.
- Pr. Michael D. Plummer, Vanderbilt University, USA, Cycles in Graph.
- Pr. Bing Wei, University of Mississippi, USA, Hamilton cycle.
- Pr. Ralph Faudree, Richard Schelp, Paul Balister and Vlado Nikiforov, University of Memphis, USA, Hamilton cycle and Ramsey-Turan problems.
- Pr. Ervin Gyori, Alfred Renyi Institute of Mathematics, Hungary, Cycles in Graph.
- Pr. Xiaoya Zha, Middle Tennessee State University, USA, Cycles in Graph.
- Pr. Heping Zhang, Lanzhou University, China, Graph Theory in Networks.
- Pr. Jinlong Shu, East China Normal University, China, Cycles in Graph.
- Pr. Guizhen Liu, Shandong University, China, Colouring in Graphs.
- Pr. Guiying Yan,Chinese Academy of Sciences, China, Cycles in Graph.
- Pr. Xueliang Li, Nankai University, China, Cycles in Graph.

Other Collaborations

Participation to national and international networks

Volunteer Professional Service

Organisation of Conferences and Scientific Events

- Organizing Bordeaux workshop on identifying codes, Nov. 2011 Bordeaux.
- Autumn school on signed graphs, at Thézac, Aquitaine. October 2012.
- Autumn school on signed graphs, at Thézac, Aquitaine. October 2013.
- Journée graphs et Algorithm, organizer (co-chair), Nov. 2013.
- The 8th French Combinatorial Conference, Orsay, France, Jun. 2010: Hao Li and Yannis Manoussakis are co-Chairs and Organizers.

Honors

Prizes and Awards

- Jiangiang Cheng, *Best student paper at ICORES Conference* (2012)
- Chen Wang, *Best student paper at ICORES Conference* (2013)

Keynote Addresses

International

- <Favaron>, *CombinaTexas 2013*, invited plenary speaker

France

Other Honors

- Hao Li, *Changjiang Lectureship Chair Professor* (by Changjiang Scholar Award Program of Chinese Minister of Education and the Li Ka-Shing fondation)

4/ Graphs

Interactions with the social, economic and cultural environment

Contracts and grants

Public contracts and grants (jan 2008 - jun 2013)				
Type	*Name*	*Managing Institution*	*Start / Duration*	*Amount*
ANR	DOPAGE	Université Paris XI	10.2009 / 36 mo.	60.00 k€
ANR	TEOMATRO	Université Paris XI	12.2010 / 36 mo.	20.28 k€
Subvention	ALPAGE	Université Paris XI	12.2005 / 42 mo.	70.00 k€
Subvention	PEPS-INS2I	CNRS	01.2012 / 12 mo.	8.00 k€
CNRS	CCAS	CNRS-Chinese Academy of Sciences	2013 / 3.2 mo.	

4/ Graphs

Thesis

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Lech ADAMUS	01.12.2006	06.11.2008	ETR	FLANDRIN
Ailian CHEN	01.09.2005	26.08.2008	ETR	LI
Haiyan KANG	01.11.2008	25.05.2010	ETR	FLANDRIN
Li LIU	27.11.2006	04.12.2008		LI
Huifang MIAO	01.09.2005	23.05.2008	ETR	LI
David SOGUET	01.10.2004	02.07.2008	Alloc. Ministère	DJELLOUL
Yi YANG	01.09.2005	25.08.2009		LI
Shan ZHOU	30.11.2005	30.05.2008	Etranger	LI
Yan ZHU	01.09.2006	25.05.2010		LI

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Yandong BAI	14.09.2011	ETR	LI
Weihua HE	14.09.2011	ETR	LI
Qiang SUN	01.10.2012	ETR	LI
Weihua YANG	24.01.2011	ETR	LI

Self Assessment

The main criticisms addressed to GraphComb team after the former evaluation are the high number of small impact published papers and lack of industrial real world applications. During the last period, we continue our scientific production with high impact for some our papers in graph theory. Reza Naserasr joined our team as CNRS researcher and developed new topics, organized our seminars and different schools on graph theory.

Strategy and five-year project

The research work of the "**Al**gorithms, **G**raphes and **C**ombin**a**toire" team, **GALaC**, is concentrated on several highly competitive fields in Theoretical and Applied Computer Science.

Driven by the common goal of developing the theory of efficient algorithms, our group was born as the result of the federation of several autonomous researchers and research groups from the previous Algo, Graph, Networks and Parall teams of LRI.

Rooted in the common ground of algorithmics, multiple research directions are *jointly investigated* by our group, which is structured by the following activities: combinatorics, graph theory, and the design of algorithms tailored for networked and distributed systems.

Research on networked systems, for example, needs the theoretical tools developed in the graph activity, in order to model networking problems, while combinatorics is necessary to evaluate the complexity of the developed (often distributed) algorithms.

The strong involvement in the development of the open source Sage mathematical software represents another key example of the synergies between the research activities developed in GALaC, and in particular between the combinatorics and graph theory ones. Indeed, the experimental research and development which characterizes this project, based on the mutualization of software development, is a federating factor for the research efforts of several members of these two activities (namely, F. Hivert, N. Thiéry, and N. Cohen).

More in depth, the main focus of our research activities is as follows: the combinatorics activity studies the strong interactions and relations that exist between algorithms and algebraic structures. At the same time, graph structures constitute the core of the research of the graph theory activity, which is mainly focused on both structural and algorithmic approach. Finally, algorithms for networked systems are developed in the third activity, using theoretical tools like algorithmic game theory and distributed computing, with the aim of designing efficient modeling, control and performance optimization algorithms especially tailored for networked and distributed systems, as well as their applications.

Our group is well integrated in the international scientific community. The number of high level publications, recognitions and research grants are witnesses of the high scientific quality of the work of the members of GALaC. Scientific excellence is and will remain in the future our main and highest aspiration.

Specifically, several common directions, detailed in the following, are present in the research conducted by the members of GALaC, and these form the federating factors of our group. We plan to develop our research within these areas.

The Combinatorics activity

Combinatorics is a research activity that takes place within the "**Al**gorithms, **G**raphes and **C**combin**a**toire" team **GALaC**. It has four permanent members, namely Francesca Fiorenzi, Dominique Gouyou-Beauchamps, Florent Hivert and Nicolas Thiéry, and a number of non-permanent members including postdoctoral fellows, ATER, graduate students, interns and international visiting researchers.

Combinatorics is historically an important research topic of the former **Algo** team of the LRI. It was very weakened by the departure of Jean-Paul Allouche and Sylvie Corteel, but the LRI decided to maintain a strong combinatorics activity by recruiting two professors (Hivert in September 2011 and Thiéry in September 2012). As a consequence, the research subject of the Combinatorics activity recently shifted toward more algebraic aspects.

The main focus of this activity is the interrelation between algebraic structure and algorithms. We plan to work on the following subjects:

- Algebraic structures (Combinatorial Hopf Algebras, Operads, Monoids, ...) related to algorithms;
- Enumerative combinatorics and symbolic dynamic.
- Object oriented software design for modeling mathematics and development of SAGE-COMBINAT;

More precisely, the research project takes place in effective algebraic combinatorics, at the interface of enumerative combinatorics and analysis of algorithms on one hand and symbolic and algebraic computation on the other hand. The objective is twofold: firstly, thanks to vast generalization of the notion of generating series, we hope to give a theoretical framework allowing to study the fine behavior of various algorithms. Reciprocally, the study of those very same algorithms gives a new mean to discover algebraic identities. Those identities have many applications in mathematics, in particular in representation theory but also in physics (mainly statistical physics).

The research relies deeply on computer experimentation and contains as a consequence an important software development part within the SAGE-COMBINAT software project. However, the required level of sophistication, flexibility, and breath of computational tools is reaching a point where large scale collaborative development is critical. The design and collaborative development of such a software is raising research-grade computer science challenges around the modelling of mathematics, the management of large hierarchy of (object oriented) classes, etc.

Those very specific questions also raise more general combinatorial questions. We therefore plan to work on enumerative combinatorics and cellular automaton, in particular on trees.

This activity is conducted with close collaborators in France, Germany, North America, and India.

The Graph Theory activity

The Graph Theory activity involves eight permanent members: Johanne Cohen, Nathann Cohen, Antoine Deza, Selma Djelloul, Evelyne Flandrin, David Forge, Hao Li, Yannis Manoussakis and Reza Naserasr, and a number of non-permanent members including postdoctoral fellows, ATER, graduate students, interns and international visiting researchers.

The main focus is on structural and algorithmic point of views.

The team established expertise includes problems such as finding large cycles in a given graph, graph colorings, covering problems, and extremal graph theory. For example, some team members are particularly interested in Thomassen's conjecture: Every 4-connected line graph is Hamiltonian. Finding sufficient and computationally tractable conditions for a graph to be Hamiltonian is of significant importance from both theoretical and algorithmic viewpoints as Hamiltonicity is an NP-hard problem.

Generalization of such problems has also been recently considered for edge- or vertex-colored graphs. For example, one may look for properly colored spanning trees in an edge- or a vertex-colored graph. Alternatively, one may look for a dominating set in a vertex colored graph having at least one vertex from each color. Beside their theoretical interest, these extensions have applications in areas including biocomputing and web problems.

The recent inclusion of new members to the team has further broadened our research expertise. Signed graphs, which are half way between graphs and 2-edge colored graphs, have proven to be am efficient tool to investigate some of the core problems of graph theory. While we consider extending or relaxing a number of classical problems from graphs and 2-edge colored graphs to signed graphs, we consider some of the most challenging problems in graph theory through the broader perspective of signed graphs. Most of these problems are connected to the celebrated four-color Theorem including (odd) Hadwiger's conjecture and Seymour edge-coloring conjecture of planar graphs. Signed graphs play a special role there by revealing relations between (signed) minors and (signed) homeomorphisms. Furthermore, random signed graph is a notion that has not received much of attention yet, and through this window we strengthen our use of probabilistic methods. In addition, we have recently started an international collaborative research project on homomorphism of vertex-colored graphs with an algorithmic viewpoint.

Many of the questions we consider can be stated in terms of (integer) linear optimization that is an expertise of new members of the team with research interests focusing on the combinatorial, computational, and geometric aspects of linear optimization. In this regard the aim would be to investigate recent results illustrating the significant interconnection between the most computationally successful algorithms for linear optimization and its generalizations, and the geometric and combinatorial structure of the input. Ideally, the deeper theoretical understanding will ultimately lead to increasingly efficient algorithms.

Most of our research collaborations involve French research groups including LaBRI, LIRMM, LIAFA, and LIMOS as well as research groups in Europe, North America, China, Japan, India and South America.

Algorithms for Networked Systems

Algorithms for Networked Systems (ANS) is a research activity that takes place within the **GALaC** team. It has four permanent members, namely Lin Chen, Johanne Cohen, Sylvie Delaët, Fabio Martignon, and a number of non-permanent members including postdoctoral fellows, ATER, graduate students, interns and international visiting researchers.

The research goal of the ANS group is to design efficient modeling, control and performance optimization algorithms especially tailored for networked and distributed systems, as well as their applications. The scientific contributions we expect are therefore both *theoretical*, with the development of new mathematical modeling techniques and proofs, and *applied*, with the development of innovative tools for the optimal planning and resource allocation in cognitive, opportunistic wireless and content-centric networks.

Specifically, the objectives of the ANS group for the next 5 years are:

- To establish theoretical building blocks for the design and optimization of networked systems, including: Control Theory, Game Theory, Distributed Algorithms (Self-stabilization, Fault Tolerance), Discrete Event Simulation systems.
- To design novel, efficient algorithms and protocols based on the developed theoretical framework, and evaluate their performance in practical networking scenarios. This includes: Opportunistic Wireless systems (including, among others, Cognitive Radio, Sensor and Robot networks), Future Internet infrastructures and protocols (Information, Content-Centric Networks), Security in Cyber-physical systems.

More specifically, the challenges we will address are related to *dynamic spectrum aggregation*, which has just emerged in the cognitive radio network field, with many important theoretical and technical problems waiting to be solved. In this context, we plan to (1) develop a theoretical framework characterizing the tradeoff between spectrum and energy efficiencies in spectrum aggregation, and (2) design green dynamic spectrum aggregation mechanisms that jointly optimize the spectrum sensing, spectrum aggregation and access so as to achieve a desired balance from both spectrum and energy perspectives. This research work will be conducted in the framework of an ongoing research project, the Green-Dyspan project (ANR Blanc International II, March 2013-Sep. 2016), in cooperation with Zhejiang University.

Another interesting research field is related to content-centric networks (CCNs), which constitute one of the most promising paradigms for the future Internet. In this field, several research issues are still open, and we plan to (1) devise efficient algorithms to foster resource sharing between network nodes, (2) design optimal resource allocation schemes to plan and manage efficient CCNs in a time-varying context, (3) game theoretical models to address security/privacy issues arising in mobile CCNs, as a basic building block to further support cooperative behaviors. This work will be conducted within the framework of the IUF 5-year project (2013-2018).

We will also study self-stabilization and fault-tolerance properties of different networked systems, like mobile robot networks, wireless inter-networked systems and sensor networks. Common criteria of those systems are the hardness of formal analysis due to huge non-determinism, and likeliness of fault occurrence. Unlike classical fault-tolerance techniques that rely on redundancy and replication (and are hence costly both in terms of memory, computation, and communication usage), self-stabilization is an optimistic way to recover from system faults, and is likely to enable lightweight solutions that are suited to those constrained emerging networks.

Strategy

Our strategy to stabilize the team within its environment and in particular the creating of the Université Paris-Saclay is based on three ongoing actions: the hiring of new young researchers, the creation of the `Séminaire d'algorithmique et de complexité du plateau de Saclay" and the creation of the "MIFOSA" master.

Recruitment The team is expected to recruit a new associate professor (Maître de conférences) in June 2014. The new member is supposed to work in combinatorics and graphs thus further strengthening the synergy between these two activities. Moreover, the LRI decided to hire more young researchers in the GALaC Team within the next five years. We proactively are looking for young researchers (CR CNRS/Maître de Conférences/Postdoc) to hire in order to reinforce all research aeras of the GALaC team. Among other things, our involvement in the Sage project gives us access to a regular source of international candidates.

Séminaire d'algorithmique et de complexité du plateau de Saclay The séminaire was founded in october 2011 by the Algorithmic and Complexity team of the LRI, LIX, PRISM and Supélec. It occurs every two weeks and gather usually more that 20 people. It was initially decided that the hosting will change every years (LRI in 2011, LIX in 2012 and Supélec in 2013). By gathering all the teams working around algorithms, we hope to create a large synergy on the plateau the Saclay. The precise program is available on **www.lix.polytechnique.fr/~bodirsky/seminaire/**.

Master MIFOSA The team leads the creation of the Master 2 MIFOSA which will start in 2015. The goal is to create a Master in theoretical computer science on the "Plateau de Saclay" involving 3 Universities (Evry, Orsay, Versailles) and 5 "Grandes Écoles" (Centrale, Supelec, ENSTA, Télécom ParisTech, Télécom SudParis), with the support of INRIA, Alcatel and EDF. We expect students from all components of the Paris-Saclay university as well as from other international universities. The team will be involved in several courses in Combinatorics, Graphs theory, Algorithms, and Distributed Network Algorithms. We expect that our involvements in this project will let us find and hire future outstanding PhD students.

Algo team publications