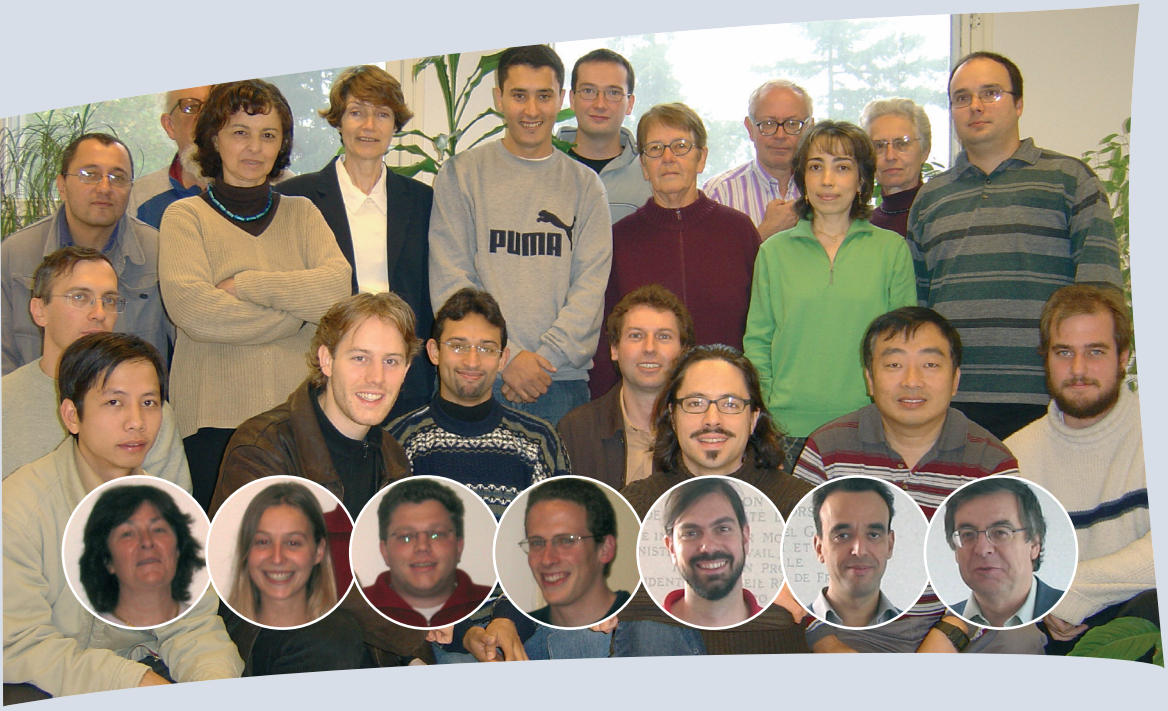
Graph Theory and Fundamental Aspects of Communications

équipe Théorie des Graphes et Fondements des Communications

Responsable : Pierre Fraigniaud

L'équipe fut l'une des composantes initiales du LRI, lors de sa création il y a plus de trente ans. Ses principaux domaines d'études sont la théorie structurelle des graphes et la recherche opérationnelle. Ses domaines d'applications sont la conception de réseaux de télécommunication et d'algorithmes de communication. Grâce à ses compétences en théorie des graphes, l'équipe s'intéresse également à des problèmes provenant d'autres domaines de l'informatique, comme l'informatique distribuée, l'algorithmique discrète, et le calcul parallèle. L'équipe est très active et très productive, comme en témoigne sa longue liste de publications scientifiques dans des journaux ainsi que dans les actes de conférences, la participation de ses membres à de nombreux comités de programmes de conférences, et leurs nombreuses invitations dans des rencontres et séminaires internationaux.

L'équipe a une approche plutôt fondamentale des problèmes scientifiques. Cependant, ceci ne se fait pas au détriment de collaborations industrielles, comme en témoignent plusieurs participations à des projets RNRT, ainsi qu'une participation à un projet européen IST. Le recrutement comme professeur d'Abdel Lisser (en provenance de France Telecom R&D), et celui de David Forge comme maître de conférences, a permis à l'équipe d'investir de nouveaux champs d'études comme la théorie des matroïdes et la programmation mathématique. Ces recrutements ne font cependant que compenser les départs de deux membres actifs de l'équipe en 1999 et 2000 : celui de Dominique Sotteau, actuellement attachée scientifique à l'ambassade de France au Canada, et celui de Dominique Barth, actuellement professeur à l'université de Versailles. De plus, trois membres de l'équipe ont pris leur retraite ces deux dernières années : Odile Favaron, Marie-Claude Heydemann, et Maryvonne Mahéo. L'équipe leur souhaite de profiter au mieux de leur nouvelle vie. Cependant, lorsque l'on constate qu'O. Favaron a, à elle seule, cosigné plus de 30 articles parus dans des revues ces quatre dernières années, on mesure l'impact de ces départs sur le fonctionnement scientifique de l'équipe.



Graph Theory and Fundamental Aspects of Communications

Head: Pierre Fraigniaud

As one of the founding members of LRI, the group goes back more than 30 years. Today, it tackles problems from structural Graph Theory and Operational Research, with applications to network design and network provisioning. Thanks to its expertise in graph theory, the group also addresses problems coming from other fields of computer science, such as distributed computing, discrete algorithms, and parallel computing. The group is very active and productive, as witnessed by its long list of publications in international journals and conference proceedings, by the participation of its members in many conference program committees, and by numerous invitations to international conferences and seminars.

The group addresses problems that are mostly of fundamental flavor. Nevertheless, we also collaborate with industry, as illustrated by several participations in national RNRT projects and one european IST project. Over the 2000-2004 period, the appointments of Abdel Lisser, who left France Telecom R&D, as professor, and of David Forge as assistant professor, enabled the group to investigate new domains: matroid theory, mathematical programming, etc. These appointments came however after two productive group members left in 1999-2000: Dominique Sotteau, now Scientific Officer at the French Embassy in Canada, and Dominique Barth, now professor at Versailles university. In addition, three group members retired in 2003 and 2004: Odile Favaron, Marie-Claude Heydemann, and Maryvonne Mahéo. The group wishes them happiness in their new life. However, considering that Odile Favaron alone co-authored more than 30 journal articles over the past four years, one can easily understand that these departures will create a real overthrow in the scientific life of the group.

Research Group Members

Personnel as of 01/01/2004

Full time faculty			
Name	*First Name*	*Position**	*Institution*
BERTHOME	Pascal	MC	IUT Orsay
DELORME	Charles	MCHC	Université Paris XI
DJELLOUL	Selma	MC	IUT Fontainebleau
FAYARD	Didier	PR1	IUT Orsay
FLANDRIN	Evelyne	PR2	IUT Paris V
FORGE	David	MC	Université Paris XI
FRAIGNIAUD	Pierre	DR2	CNRS
HEYDEMANN	Marie-Claude	PR1	IUT Orsay
KOUIDER	Mekkia	MCHC	Université Paris XI
LI	Hao	CR1	CNRS
LISSER	Abdel	PR2	Université Paris XI
MAHEO	Maryvonne	MCHC	Université Paris XI
SACLE	Jean-François	MC	Université Paris XI

Doctoral students			
BENAJAM	Wadie	ATER	Université Paris XI
DANG NGOC	Frédéric	D	Grant France Telecom R&D
FAIK	Taoufik	ATER	Université Paris XI
GANCARZEWICZ	Grzegorz	D	Grant France/Poland
GASTAL	Lynda	AM	IUT Sceaux
GAURON	Philippe	AM	IUT Orsay
ILCINKAS	David	AM	Supélec
NGUYEN	Le Huy	D	Grant CNRS

Temporary personnel			
CADA	Roman	Post-doc	Grant Université Paris XI
FAVARON	Odile	Associated	Université Paris XI
MENG	Jixiang	Invited Prof.	Grant Xinjiang University

** See the glossary for acronyms.*

Long term visitors

Name	*First Name*	*Nationality*	*Institution*	*Arrival*	*Departure*	*Funding*
BACSÓ	Gabor	Hungarian	Acad. of Sciences (Budapest)	01/07/02	31/07/02	Invited Prof. Paris XI
BARRIÈRE	Eulalia	Spanish	UPC (Barcelona)	26/06/00	31/07/00	PICASSO
CADA	Roman	Czech	Univ. of Plzen	02/07/00	15/07/00	BARRANDE
DUCKWORTH	William	Australian	Macquarie Univ. (Sydney)	15/09/02	29/09/02	ARC/CNRS
EL SAHILI	Amine	Lebanese	Univ. of Beyrouth	03/06/02	08/07/02	Assistant Prof.
FOMIN	Fedor	Norwegian	Univ. of Bergen	10/01/04	17/01/04	ACI PairAPair
GAIVORONSKI	Alexei	Norwegian	Univ. of Trondheim	05/05/04	05/06/04	Invited Prof. Paris XI
GENEST	François	Canadian	Univ. of Montréal	15/11/03	30/11/03	EGIDE
HENNING	Michael	South African	Univ. of Natal	01/07/02	31/07/02	Invited Prof. Paris XI
HOANG	Chinh	Canadian	Waterloo Univ. (Ontario)	05/07/01	29/07/01	Invited Prof. Paris XI
HU	Zhiquan	Chinese	Central China Normal Univ.	24/06/02	30/06/03	MAE
KRISTIANSEN	Petter	Norwegian	Univ. of Bergen	17/02/03	21/02/03	
MANS	Bernard	Australian	Univ. Macquarie (Sydney)	31/01/00	30/06/00	CNRS/ARC
				15/09/02	29/09/02	CNRS/ARC
MARCZYK	Antoni	Polish	Acad. of Science (Krakow)	01/10/00	30/10/00	POLONIUM
ORDAZ	Oscar	Venezuelian	Univ. Centrale	01/08/01	31/08/01	
PELC	Andrzej	Canadian	UQO (Gatineau)	20/03/04	26/03/04	ACI PairAPair
RASJBAUM	Sergio	Mexican	Univ. of Mexico	13/05/04	20/05/04	INRIA Grand Large
ROSENBERG	Arnold	American	UMass (Amherst)	29/01/00	31/05/00	CNRS “Poste rouge”
RYJÁČEK	Zdenek	Czech	Univ. of Plzen	02/07/00	15/07/00	BARRANDE
SHPARLINSKI	Igor	Australian	Univ. Mcquarie (Sydney)	17/01/01	31/01/01	CNRS/ARC
SHU	Jinlong	Chinese	Eastern China Normal Univ.	25/10/01	25/10/02	Grant Chinese Gov.
TUZA	Zsolt	Hungarian	Acad. of Sciences (Budapest)	14/06/00	30/06/00	CNRS/Acad Sc.
TVRDIK	Pavel	Czech	Tech. Univ. (Prague)	15/02/00	04/03/00	
VESTERGAARD	Preben	Danish	Aalborg Univ.	02/07/00	18/07/00	
				01/06/03	30/06/03	Invited Prof. Paris XI
WOŹNIAK	Mariusz	Polish	Acad. of Science (Krakow)	01/10/00	30/10/00	POLONIUM
				01/10/01	25/10/01	POLONIUM
				01/04/02	30/06/02	Invited Prof. Paris V

Group evolution

Some remarkable facts about the evolution of the research group:

- In July 2000, Nicolas Hanusse was appointed as Assistant Professor (MC). He left LRI one year later to become CNRS Research Scientist (CR) at LaBRI (Université de Bordeaux).
- In July 2001, Abdel Lisser was appointed as Professor (PR), after leaving France Telecom R&D. Since then, he is the leader of the “Optimization” sub-team.
- In July 2003, David Forge was appointed as Assistant Professor (MC), and joined the “Graph Theory” team.

The latter two arrivals balance two departures at the end of the 90’s: Dominique Sotteau (DR CNRS), now scientific officer at the French embassy in Canada, and Dominique Barth (MC), now Professor at Université Versailles Saint-Quentin (PRiSM laboratory).

Three group members retired in 2003 and 2004: Odile Favaron (MC), Marie-Claude Heydemann (PR), and Maryvonne Mahéo (MC). As one can notice from the list of publications, these retirements will eventually have a significant impact on the scientific production of the group (Odile Favaron was still *collaborateur bénévole* in 2003-2004). Therefore,

the group expects to appoint new members in the coming years, for each of its teams: Graph Theory, Optimization, and Information Dissemination (e.g., in the domain of Dynamic Networks).

The number of Ph.D. defenses in the group was relatively low in 2000-2004. However, the number of Ph.D. students in the group increased in recent years (and two more will start in 2004), and several theses will be defended during the next two years. Finally, no Habilitation has been defended during 2000-2004, but two Assistant Professors will defend their Habilitation in 2005 or 2006.

Research description

GraFComm is organized in two research teams: *Graph Theory* and *Communication and Network Design*. The former is devoted to the study of fundamental problems in graph theory, while the latter focuses on various types of applications in network design and network provisioning (including information dissemination, routing, protocol for mobile agents, etc.).

The cross-fertilization between these two teams is ensured by our group seminar (supervised by Mekkia Kouider), occurring once a week, and during which members of GraFComm, or their visitors, present their most recent results.

Graph Theory Team

- *Participants: Hao Li (leader), Charles Delorme, Selma Djelloul, Odile Favaron, Evelyne Flandrin, David Forge, Marie-Claude Heydemann, Mekkia Kouider, Maryvonne Mahéo, Jean-François Saclé.*
- *Ph.D. Students: Taoufik Faik, Grzegor Gancarzewicz.*

As one of the founding members of LRI, the Graph Theory team goes back more than 30 years. The long list of results obtained by its members has earned the team an international reputation in several topics in graph theory. Motivated by the fact that a graph is a discrete topological structure that can be used to model and study large collections of problems in various areas of computer science (algorithms, logic, telecommunication, computer architecture, combinatorial optimization, etc.), the Graph Theory team conducts advanced research in the structural properties of graphs.

During the 2000-2004 period, the team carried out research in fundamental problems of graph theory. The appointment of David Forge in 2003 allowed the team to extend its competence to include matroid theory. The team focused on several core areas of extremal graph theory, and graph structure theory. Its work is very fruitful, as illustrated by almost 100 publications in international journals during the 2000-2004 period. Members of the team were able to solve important conjectures that were suggested by graph theorists of international renown, and that had been widely studied for many years. In particular, the team achieved important advances in various problems on cycles, colourings, factors, algebraic graph theory, matroids, domination theory, etc. The team collaborated with colleagues from all over the world, leading to many joint publications.

In the following, the description of the main contributions of the team are grouped in four research areas:

- Hamiltonian graph theory;
- Factoring, covering, and decomposition;
- MinMax parameters;
- Algebraic aspects;

Hamiltonian graph theory

The *Hamilton* problem is one of the core problems in graph theory. The *circumference* of a graph, i.e., the length of a longest cycle, is a natural and important generalization of Hamilton cycles. It is NP-hard to compute the circumference of a graph, and thus much work in the literature has focused on obtaining lower bounds for arbitrary graphs, or for some specific classes of graphs. One of the most basic and important foundation of extremal Hamiltonian theory is the famous result by Dirac (1952): the circumference of a graph is at least twice its minimum degree. As a consequence, if the degree of every vertex is at least half the total number of vertices, then the graph is Hamiltonian. Woodall conjectured in 1975 that if a 2-connected graph of order n has at least $n/2+k$ vertices of degree at least k, then its circumference is at least $min\{n,2k\}$. This conjecture is one of the fifty open problems listed in the famous book *Graph Theory with Applications* (Bondy and Murty, 1976). One important contribution of the team was to prove Woodall's conjecture. In collaboration with Roland Häggkvist, Cristina Bazgan and Mariusz Wozniak, the team also obtained several results about the length of the longest cycles, and the length of the longest paths, in graphs having half their vertices with a "large" degree.

Along another way to generalize Dirac's result, Ore (1960) derived a famous sufficient condition for hamiltonicity, based on the sum of the degrees of any pair of independent vertices. This condition was generalized by members of the team in 1991 (in collaboration with Jung) into a condition on the sum of the degrees of any triple of independent vertices. Under various conditions on the sum of the degrees of any four independent vertices, the team also derived many results about hamiltonicity and about the existence of a maximum dominating cycle, i.e., a maximum cycle C such that every edge has at least one extremity in C.

The team also focused on the existence of cycles of various lengths. In particular, a graph is *pancyclic* if it contains cycles of all lengths, from 3 to the order n of the graph. We derived several results about pancyclicity, in particular sufficient conditions for a bipartite graph to contain all even cycles. *Cyclability* and *pancyclability* are two important generalizations of hamiltonicity and pancyclicity, respectively. The team investigated the stability, under Bondy-Chvátal's closure and Ryjáček's closure, of cyclability and pancyclability properties, for a given subset of vertices. In particular, the team derived refinements of the closure concept by considering local structures of subsets of vertices. This allowed us to obtain new sufficient degree conditions for cyclability.

Key references:

[55] R. Faudree, E. Flandrin, M. Jacobson, J. Lehel, and R. Schelp. Even cycles in graphs with many odd cycles. *Graphs and Combinatorics*, 16:399-410, 2000.

[108] H. Li. On a conjecture of Woodall. *Journal of Combinatorial Theory B*, 86:172-185, 2002.

Factor, covering and decomposition

A vast research area in graph theory is to decompose or to cover a graph using simpler structures. In several contexts (e.g., network design) such decompositions allow simplifying algorithms. In this domain, the team focused on the existence of spanning subgraphs, either regular (***k***-factors), or of bounded degrees (***[a,b]***-factors). Additional conditions, such as connectivity or degree parity, may even be required. An important contribution of the team is solving a conjecture by Kano about connected ***[a,b]***-factors, and their minimum degree. On the other hand, the team disproved another conjecture by Kano involving the stability and the connectivity of a graph. However, by reformulating this latter conjecture, the team extended sufficient conditions implying the existence of a ***b***-tree (i.e. a ***[1,b]***-factor) to sufficient conditions implying the existence of connected ***[a,b]***-factors.

The team also derived sufficient conditions for the existence of partitions into elementary cycles. Alternatively, the team has studied the minimum number of cycles ***c(G)*** required to cover the vertices. In particular, by considering the size of the neighbourhood of pairs or triples of vertices the team has obtained bounds on ***c(G)***.

It is well known that every strong tournament contains a Hamiltonian cycle. An important contribution of the team in the framework of tournaments, in collaboration with Chen and Gould, is to answer to a question asked by Bollobás in the 80's: Given a positive integer ***k***, what is the least integer ***g(k)*** so that all but a finite number of ***g(k)***-connected tournaments contain ***k*** vertex-disjoint cycles that span the vertices?

Last but not least, the team focuses on Gallai's famous conjecture (1960), about the decomposition of the edges of a graph into a minimum number of paths. For about 30 years, the only known bound was ***3n/4*** (due to Lovász), where ***n*** is the order of the graph. The team improved this bound to ***2n/3*** for any graph, and proved that this bound is sharp for disconnected graphs consisting of triangles.

Key references:

[20] G. Chen, R. Gould, and H. Li. Partitionning vertices of a tournament into independent cycles. *Journal of Combinatorial Theory B*, 83:213-220, 2001.

[38] N. Dean and M. Kouider. Gallai's conjecture in disconnected graphs. *Discrete Mathematics*, 213:43-54, 2000.

[98] M. Kouider and M. Mahéo. 2-edge-connected [2,k]-factors in graphs. *Journal of Combinatorial Mathematics and Combinatorial Computing*, 35:89-95, 2000.

MinMax parameters

MinMax parameters are often involved in computing whether a graph satisfies certain properties. They are also often considered for searching specific structures, for partitioning a graph, or for assigning weights to the vertices or the edges of a graph in order to satisfy some specific properties. In fact, many maximum and minimum graph parameters have *minimum maximal* and *maximum minimal* counterparts. Most often the terms "minimum" and "maximum" refer to the cardinality of a subset, or a partition, of the vertices, and the notions of maximality and minimality are related to partial orders on subsets of vertices. For instance, the independent domination number is the minimaximal counterpart of the independence number, where the partial order is set-inclusion.

MinMax parameters are hard to compute. Thus, the team essentially focuses on:

- Deriving sharp bounds,
- Establishing connections between different MinMax parameters,
- Characterizing families of graphs for which two parameters are equal (or close), and
- Analyzing the impact of adding or deleting an edge.

The general concept of *domination* intuitively refers to the ability to reach all the vertices of the graph from a subset of vertices (the dominating set). This concept has a large number of variants, depending on various types of motivations. For instance, one can impose conditions on the structure of the dominating set (total domination, paired domination, etc.), on the way the vertices must be dominated (multiple domination, distance-*k* domination, secure domination, etc.), or simultaneously on both (double domination). The team widely contributed to this field, with roughly 25 references in the attached bibliography. In particular, members of the team have proved a relation between a specific MinMax parameter (namely the *upper irredundancy*) and both independence and chromatic numbers.

The *achromatic number* is the maximinimal counterpart of the *chromatic number* for a certain partial order defined on the set of partitions of the vertices. This parameter has been studied for more than forty years. In 1998, a refinement of this partial order gave rise to a new parameter, called *b-chromatic number*. Members of the team have studied this new parameter. In particular, they characterized classes of graphs for which the chromatic and the b-chromatic numbers are equal for every induced subgraph.

Key references:

[5] G. Bacsó and O. Favaron. Independence, irredundance, degrees and chromatic number in graphs. *Discrete Mathematics*, 259:257-262, 2002.

[68] O. Favaron and M. A. Henning. Paired domination in claw-free cubic graphs. *Graphs and Combinatorics*, to appear.

[203] C. Hoang and M. Kouider. b-coloring of sparse graphs. Technical report, W.Laurier University, 2002.

Algebraic aspects

The team studied several algebraic aspects of graph theory, such as matroids, graph spectrum, Cayley graphs, etc.

Matroid theory was introduced in the 30's as a common generalization of linear algebra and graph theory. Since then, this theory has found applications in many branches of theoretical computer science, as well as inapplied and pure mathematics. In their study of the topology of hyperplane arrangements, and of their complements, Orlik and Solomon (1980) proved that the matroid of an arrangement catches some information on their topology via a specific structure, called now the Orlik-Solomon algebra. For these reasons, these algebras have been intensively studied in the last twenty years, using both algebraic and combinatorial methods. An important contribution of the team is related to the study of the Orlik-Solomon algebra, as well as some other related algebras (e.g., the Orlik-Terao algebra, the Cordovil algebra, etc.). In particular, the team provided several very simple combinatorial proofs of various results that were already known, but proved using non-combinatorial arguments. Matroid theory is also very central in combinatorial studies, like graph theory and optimization (see the recent book "Combinatorial Optimization" by A. Schrijver). Hence, not surprisingly, the team also focused on combinatorial problems, e.g., orienta-

tions on graphs, by using matroids and oriented matroids as a tool.

The *spectrum* of graphs is a concept that has been used since the 50's (in particular by A. Hoffman) as a tool for proving the non-existence of graphs with too stringent conditions on regularity and diameter. In combination with optimization techniques, e.g., semidefinite programming, this concept provides rather efficient methods for bounding graph parameters such as independence number, chromatic number, max-cut, and, to a lesser extend, connectivity. Graphs with different spectra are certainly not isomorphic, but the converse is a source of problems that have been deeply investigated by the team.

Cayley graphs are graphs constructed from a group. These graphs have highly symmetrical properties, and, for this reason, they have found many applications in several areas of computer science, for they include hypercubes, toroidal meshes, wrapped FFT-graphs (or Butterflies), etc. Based on the notion of Cayley graphs, and using other algebraic objects, e.g., association schemes, the team investigated the construction of large graphs, e.g., voltage graphs, with specific symmetry properties. In fact, graph symmetry is by itself a wide field of investigations, e.g., determining a non-trivial symmetry in a given graph, with applications to algorithm design, e.g., routing.

Key references:

[33] R. Cordovil and D. Forge. Diagonal bases in Orlik-Solomon type algebras. *Annals of Combinatorics*, 7:247-257, 2003.

[40] C. Delorme. Spectra and cuts. *Australasian Journal of Combinatorics*, 26:183-191, 2002.

[41] C. Delorme. Laplacian eigenvalues and fixed size multisections. *Discrete Mathematics*, 276:149-159, 2004.

[45] C. Delorme and J. Gómez. Some new large compound graphs. *European Journal of Combinatorics*, 23(5):539-547, 2002.

Communication and Network Design Team

- *Participants: Pierre Fraigniaud (leader), Pascal Berthomé, Didier Fayard, Nicolas Hanusse (2000-2001), Abdel Lisser.*
- *Ph.D. Students: Ignacio Alvarez-Hamelin, Wadie Benajam, Moaiz Ben Dhaou, Lynda Gastal, Philippe Gauron, David Ilcinkas.*

The *Communication and Network Design* team tackles problems occurring in network design and network provisioning. These activities are split into two sub-teams, characterized by the fundamental tools used for solving problems rather than by the nature of the considered problems. The *Optimization* sub-team focuses its activities on the design of sophisticated mathematical optimization techniques. The *information dissemination* sub-team focuses its activities on the design and analysis of discrete and/or distributed algorithms, using tools borrowed from graph theory and combinatorics.

Obviously, these two sub-teams have lots to share. The evolution of the research activities of one of the members of the group (Pascal Berthomé), moving from the information dissemination sub-team to the optimization sub-team illustrates the close interactions between the two parts of the communication and network design team.

Optimization

- *Participants: Abdel Lisser (leader), Pascal Berthomé, Didier Fayard.*
- *Ph.D. Students: Wadie Benajam, Moaiz Ben Dhaou, Lynda Gastal.*

The research topics tackled by the Optimization sub-team were strongly influenced by Prof. Abdel Lisser, who joined the GraFComm research group in 2001, from France Telecom R&D. Since 2001, the topics studied by the sub-team are closely related to recent advances in telecommunication network, especially concerning synchronous and optical wired backbone networks. Recently, the team initiated a new research direction, on Frequency Assignment problems in wireless GSM networks. Telecommunication network design problems vary according to the technologies, and to the numerous strategies of the telecommunication companies. This gives rise to a variety of new combinatorial optimization problems, in particular routing and survivability. In order to tackle such problems, the Optimization sub-team considered models and methods in the deterministic as well as stochastic frameworks. Specifically, the team focused on the following problems:

1/ Multicommodity flow models,
2/ SDP relaxations,
3/ Robust and Stochastic combinatorial optimization, and
4/ Resource assignment and multi-terminal flow problems.

Multicommodity flow models

The sub-team studied different formulations of *multicommodity netflow* problems, e.g., node-arc formulation and path formulation. Our main contributions are the design and implementation of several algorithms for solving minimum cost multicommodity netflow (MCNF) problems. MCNF problems are widely used in different areas of optimization, especially, as far as telecommunication is concerned, with applications to routing, survivability, availability, etc. In the domain of telecommunication network optimization, MCNF problems take the form of large integer linear programming problems. The Optimization sub-team considered both 0-1 integer variables and continuous formulations of these problems. In the two cases, different relaxations were studied and implemented, such as linear relaxations and Lagrangian relaxations. The sub-team solved large MCNF problems, with several million variables and constraints. This is considered among the largest solved instances of the problem. The sub-team also studied direct methods, as well as decomposition approaches. Using several decomposition methods, the sub-team extended the models to capture survivability issues, in order to solve real-world problems. In particular, specific decomposition methods, such as Kelly's or Analytic Center Cutting Plane, were used to reduce the size of the linear problems. This is considered pioneering work for deriving lower bounds on survivability optimization problems.

SDP relaxations

We have shown that semi-definite programming relaxations (SDP) provide tight lower bounds for several combinatorial optimization problems. We studied several SDP relaxations for several combinatorial problems, among which telecommunication clustering problems, frequency assignment problems, and quadratic assignment problems. For clustering problems, we proposed both linear and SDP relaxations for the equipartition problem, and presented numerical results for large real-world instances. In parallel with our research on wired network, we studied different relaxations for the frequency assignment problem. We proposed several semi-definite programming relaxations using advanced cutting-plane techniques from combinatorial optimization, and we solved medium-sized, real-world problems using algorithms based on SDP cutting plane.

Robust and Stochastic combinatorial optimization

The MCNF problems studied above are deterministic. We extended our work on network design problems by introducing uncertainty. We mostly studied two approaches. First, we studied recent robust optimization techniques, and we tackled the robust shortest path problem. Uncertainty was modelled by the underlying graph, and we solved the problem for some specific families of graphs (we proposed theoretical results, as well as numerical ones). Second, modelling uncertainty by means of stochastic programming, we studied variants of stochastic MCNF problems. Uncertainty was there expressed by demand (or commodity) random variables. We studied different distribution functions, and we modelled the problem by a two-stage mixed integer program that we solved by combining different methods from combinatorial optimization and stochastic programming. Combinatorial stochastic programming is a very recent research area, and little has been done from a computational point of view. Our work is in fact among the very first to deal with network design problems.

Resource assignment and multi-terminal flow problems

The Optimization sub-team also considered other types of problems such as task mapping and resource allocation for multi-point communications. For these problems, mathematical programming approaches have been used successfully, and approximation algorithms and heuristics have been proposed. Some polynomial solutions have even been exhibited in specific cases. The sub-team also investigated flow theory. In particular, we have studied multi-terminal flow problems, where the capacity of the edges is subject to variations. A deep understanding of the so-called "Gomory-Hu cut tree method" allowed us to provide new (simple) algorithms.

Key references:

[4] C. Andrade, A. Lisser, G. Plateau, and N. Maculan. Telecommunication network capacity design for uncertain demand. *Computational Optimization and Applications*, 29:129-147, 2004.

[19] P. Chardaire and A. Lisser. Simplex and interior point specialization algorithms for solving non-oriented multicommodity flow problems. *Operations Research*, 2:260-276, 2002.

[113] A. Lisser and F. Rendl. Telecommunication clustering using linear and semidefinite programming. *Mathematical Programming*, 95(1):91-101, 2003.

[118] M. Bendhaou and D. Fayard. *Optimisation Combinatoire*, chapter Assignment Problems. Hermes, to appear.

[134] P. Berthomé, M. Diallo, and A. Ferreira. Generalized parametric multi-terminal flows problem. In *Graph Theoretical Concepts in Computer Science (WG)*, LNCS 2880, pages 71-80, 2003.

Information dissemination

- *Participants: Pierre Fraigniaud (leader), Pascal Berthomé, Nicolas Hanusse.*
- *Ph.D. Students: José Ignacio. Alvarez-Hamelin, Philippe Gauron, David Ilcinkas.*

Although of fundamental nature, the problems addressed by the Information Dissemination sub-team followed the evolution of network technologies at the turn of the new century. While during most the 90's, very high computational power was explored in the framework of parallel multi-computer systems, it is now believed that decentralized, loosely coupled systems are much better candidates in terms of storage, computation, and cost. In addition, the evolution of telecommunications in terms of both technology (high speed networks, wireless links, ad hoc networks, etc.) and services (Web, peer-to-peer, glob-

al computing, etc.) introduced new problems, and/or required new solutions adapted to the decentralized nature of both the systems and the applications. As a consequence, the activities of the Information Dissemination sub-team are now mostly concentrated on understanding the fundamental complexity of problems that naturally occur in large decentralized systems of various types, from Internet and the Web, to ad hoc and peer-to-peer networks. The Information Dissemination sub-team mostly focused its activities on the following problems:

1/ Routing problems,
2/ Peer-to-peer network design and Small Worlds properties,
3/ Protocol design for mobile agents, and
4/ Group-communications in arbitrary topologies.

In each of these topics, our research is *not* directly driven by the technology. Instead, the goal of the sub-team is to identify the limits of different network technologies (optical, radio, etc.) and systems (Internet, peer-to-peer, mobile agents, etc.), and to propose new applications that may in turn motivate the need for new hardware or software technologies.

Monsieur Jourdain does routing too!

Molière, *The Bourgeois Gentleman*, Act 2, Scene 4:
— M. Jourdain: Oh, really? So when I say: "Nicole bring me my slippers and fetch my nightcap" is that routing?
— Philosophy Master: Most clearly.

While this may be an exaggeration, routing is definitely at the core of today's approach to Information Dissemination. It has relationships with fundamental notions in theoretical computer science and discrete mathematics as well as numerous implications in various scientific fields, from networking to sociology. We present three examples to illustrate this claim.

Routing obviously plays a central role in data communication. Perhaps more surprisingly, it also has applications to key problems in distributed computing. For instance, we have shown that a network supporting shortest paths interval routing allows broadcast and leader election to be performed in linear message complexity [84]. This link between compact routing and distributed computing answers a question raised by D. Peleg (Weizmann Institute) and is of growing interest in the community.

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Routing is also related to central notions in graph theory, such as minor theory. For instance, minimizing the header size for oblivious routing in unreliable networks is a minor-closed problem. In this context, we have shown that deterministic routing in planar networks requires headers that are at least $\boldsymbol{log(tw)}$ bits long, where $\boldsymbol{tw}$ is the tree width of the network [83]. An important consequence of this result is to close a conjecture on meshes by F. Fich (University of Toronto).

Finally, routing provides a framework for investigations in social sciences. For instance, Kleinberg's model is widely accepted as a good model for the "six degrees of separation" among individuals found by the social psychologist Milgram in the 1960's. However, this model does not capture the impact of the number of routing criteria, e.g., occupation or location, which has been shown by sociologists to have a strong empirical effect. We have recently designed a new model taking the number of criteria into account [146]. Under this model, the performance of greedy routing better fits experimental observations.

Routing

Routing encompasses such diverse problems as analyzing message transfers between endpoints in a communication network, interactions between social entities, lookup strategies in fully decentralized peer-to-peer systems and data transfers between facilities in a transportation network (see sidebar). The sub-team focuses mostly on *compact routing*, i.e., the design of routing strategies requiring a limited amount of memory-space at the routers. Other fields of investigations are routing in ad hoc networks (802.11, Bluetooth, etc.), and routing in all-optical networks (cf. the European project DAVID).

Peer-to-peer network design and Small Worlds properties

The peer-to-peer (P2P) paradigm is opposed to the client-server paradigm. In P2P systems, all users play the same role and are both clients and servers. Fully decentralized P2P systems require sophisticated lookup strategies based on dynamically maintained overlay networks. The sub-team significantly contributes to this scientific domain, in particular via the design of the so-called D2B network based on the *de Bruijn* graph. Closely related to this field, the sub-team also studies social networks, experimenting with "small world" properties. In particular, the team recently proposed a new model enhancing Kleinberg's model, and capturing the "six degrees of separation" phenomenon in a more accurate way.

Protocol design for mobile entities

The team investigates the behaviour (in terms of capabilities and limits) of software agents and physical robots moving in networks. Specifically, the team focuses on problems such as *graph exploration* and *graph searching*, motivated by various problems occurring in network security, e.g., capturing of an intruder, or resource discovery. The contributions of the team are either impossibility results, e.g., the impossibility to explore all networks with a finite group of finite automata, even if the network is planar and has a small degree, or bounds on the size of a group of agents searching for an intruder under specific constraints. The group also investigates the impact of anonymity on the capabilities of software agents, for complex tasks such as rendezvous, election, or labelling.

Group-communications in arbitrary topologies

The sub-team carried on its traditional activities on protocol design for group communications, including one-to-all broadcasting and all-to-all broadcasting. However, the subteam followed the recent evolution of this topic, either guided by the advances in the design of approximation algorithms, or by the evolution of the technology. The sub-team mainly focused on (1) the design of approximation algorithms for broadcasting in distance-invariant models, e.g., one-hop optical networks, (2) the design of multicast protocols taking the self-similar nature of the Internet traffic into account, and (3) the design of group communication protocols for a cluster of clusters of...of clusters of workstations.

Key references:

[7] L. Barrière, P. Fraigniaud, L. Narayanan, and J. Opatrny. Robust position-based routing in wireless ad hoc networks with irregular transmission ranges. *Wireless Communications and Mobile Computing*, 3(2):141-153, 2003.

[49] K. Diks, P. Fraigniaud, E. Kranakis, and A. Pelc. Tree exploration with little memory. *Journal of Algorithms*, 51(1):38-63, 2004.

[139] P. Fraigniaud. Approximation algorithms for minimum-time broadcast under the vertex-disjoint paths mode. In *9th Annual European Symposium on Algorithms (ESA)*, LNCS 2161, pages 440-451, 2001.

[142] P. Fraigniaud and C. Gavoille. Routing in trees. In *28th International Colloquium on Automata, Languages and Programming (ICALP)*, LNCS 2076, pages 757-772. Springer, 2001.

[146] P. Fraigniaud, C. Gavoille, and C. Paul. Eclecticism shrinks even small worlds. In *23rd ACM Symp. on Principles of Distributed Computing (PODC)*, pages 169-178, 2004.

Research Perspective

In the short and mid-term, the GraFComm group will continue its activities in Graph Theory and Optimization, with specific emphasis on the following topics.

The group aims at investigating the theory of *dynamic networks*. Such networks appear in several scientific domains, including computer science (Web, peer-to-peer, etc.), network engineering (ad hoc, satellite, etc.), sociology, biology, etc. They are characterized by the continuous and possibly brutal evolution of their topologies: nodes can join and leave at any time, links can be established or removed dynamically, etc. After having led the CNRS working group (Action Spécifique) DYNAMO, the group now leads a European COST Action proposal on Algorithmic and Structural Aspects of Dynamic Networks.

The appointment of Prof. Abdel Lisser has reinforced the group's activities in optimization and network design. We anticipate future growth, not only in GraFComm but also throughout LRI, since the number of formal and informal inter-group collaborations on this topic is growing in the lab.

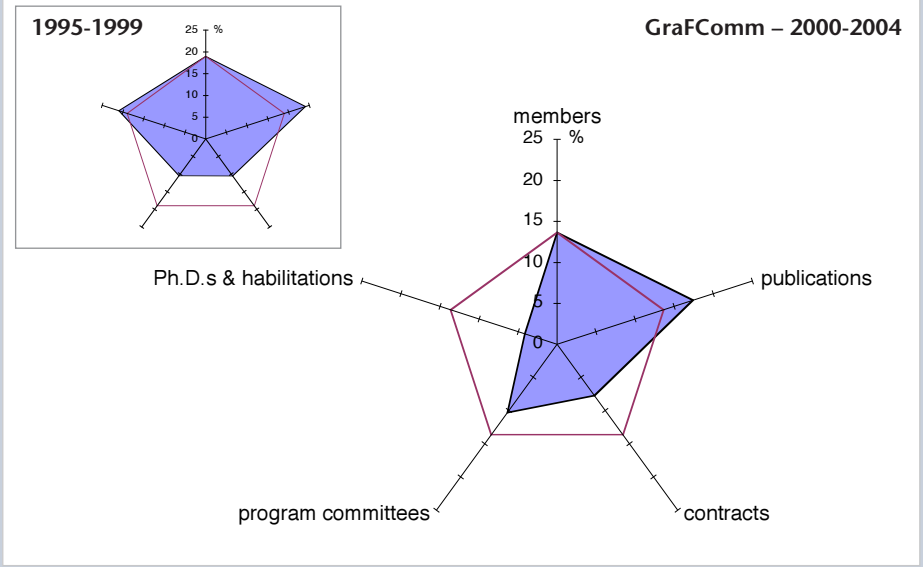
Finally, the group will address new problems in Graph Theory. Some group members are currently focusing on aspects of minor theory, e.g., graph-decomposition, for its links to logic and algorithmic. A GraFComm member is currently preparing her habilitation on this topic, and the group strongly supports the development of such new activities in the graph theory team.

Highlights

The group covers a vast area of Computer Science, as witnessed by the variety of its scientific contributions in both journals and conferences: from Graph Theory and Combinatorics (J. of Graph Theory, J.C.T. B, Discrete Maths, WG, etc.) to Parallel and Distributed Computing (PODC, SPAA, DISC, etc.), from Algorithms (SODA, ESA, etc.) to Operational Research (Mathematical Programming, Operations Research, etc.), from fundamental aspects (STACS, ICALP, MFCS, etc.) to networks (CCCN, IFIP Networking, etc.).

The important contributions of the group to the scientific fields mentioned above, both quantitatively (roughly 150 journal and conference publications) and qualitatively (the journals and conferences listed above are among the very best in their respective domains) have earned the group an international reputation, as shown by the large number of invited presentations at conferences and seminars. The number of participations in conference program committees (as members or as chair) is significant, especially when considering that conferences in graph theory and optimisation often have small committees that select submissions based on short (half a page) abstracts.

The two radar views below show that despite a significant improvement in the amount of contract funding, it remains only 50% of what could be expected according to the size of the group. The Graph Theory team had difficulties finding contracts in 2000-2004 because very few institutional support was eligible for structural graph theory. The most important difference between the two plots is the number of Ph.D.s defended. The group suffered greatly from the decay in the number of students in the masters program (DEA) at the end of the 90s. The number of Ph.D. students in the group is however getting back to normal, with 10 students at the end of 2004.



Radar views display a synthetic view of the activity of the group over the 1995-1999 and 2000-2004 periods, by means of five statistics:
• Size of the group at the end of the period (01/01/1999, 01/01/2004),
• Number of publications (peer-reviewed journals, books, book chapters, major international conferences),
• Annualised amount in Euro of new contracts and grants,
• Number of participations in program committees (national and international), and,
• Number of defended Ph.D.s and habilitations.

These statistics are displayed as a percentage with respect to the overall laboratory, together with a reference line corresponding to the size of the group. Data points outside the reference line show above-average performance whereas those inside the line show below-average performance, relative to the laboratory.

As with any statistics, these data must be interpreted carefully. In particular, they are not a direct measure of relative quality of the groups within the laboratory, because different research areas place different values and offer different opportunities with respect to these five measures.

Honors

Prizes and awards

- Mekkia Kouider was distinguished by the Journal of Graph Theory for her paper *Stability and (a,b)-factors*, for which she received a 1-year free subscription to the journal.

Keynote addresses

- Odile Favaron, invited keynote speaker, *South African International Graph Theory Conference*, Itala, South Africa, June 18-22, 2001. Title: "Domination related parameters in claw-free graphs".
- Odile Favaron, invited keynote speaker, *18th miniconference on Discrete Mathematics and Operational Research*, Clemson, USA, October 15-18, 2003. Title: "t-colorings and s-complete t-colorings of graphs".
- Pierre Fraigniaud, invited keynote speaker, *9th Colloquium on Structural Information and Communication Complexity* (SIROCCO), Andros, Greece, June 10-12, 2002. Title: "Mobile Entities in Networks".
- Pierre Fraigniaud, invited keynote speaker, *5th Rencontres Francophones sur les aspects Algorithmiques des Télécommunications* (AlgoTel), Banyuls-sur-mer, May 12-14, 2003. Title: "Réseaux dynamiques pour les sytèmes pair-à-pair".
- Hao Li, invited keynote speaker, *CAS International Conference on Graph Theory and Combinatorics, Kunming*, China, June 2001. Title: "On Woodall's conjecture".
- Hao Li, invited keynote speaker, *International Conference on Graph Theory and Combinatorics*, Taipei, Taiwan, June 2002. Title: "Pancyclic and Pancyclability".
- Hao Li, invited keynote speaker, *First Chinese National Conference on Graph Theory and Combinatorics*, Ulmuqi, China, August 2004. Title: "Vertex-distinguishing proper edge colorings of graphs".

Steering Committees

- Pierre Fraigniaud is member of the Steering Committee of the series of *Symposia on Theoretical Aspects of Computer Science* (STACS), since 2003. STACS 2005 will be the 22nd edition.
- Pierre Fraigniaud is member of the Steering Committee of the series of *ACM Symposia on Parallelism in Algorithms and Architectures* (SPAA), since September 2002. SPAA 2005 will be the 17th edition.
- Pierre Fraigniaud is member of the Steering Committee of the series of *Colloquia on Structural Information and Communication Complexity* (SIROCCO), since June 2001. SIROCCO 2005 will be the 12th edition.

Other honors

- Hao Li was acknowledged in the *Math Reviews* journal for his paper "On a conjecture of Wooddall" in JCT B, 2002 [108]. Quoting from the editorial: "This paper is the most beautiful that has appeared in the last 3 years in the Journal of Combinatorial Theory, Series B".

The following GraFComm members were invited to foreign universities (with their local and/or travel expenses fully covered):

- Odile Favaron: Univ. of Victoria, Canada, 2 weeks July 2001; UNISA, South Africa, 2 weeks April 2002; Univ. of Clemson, USA, 10 days Oct 2003.
- Pierre Fraigniaud: Carleton Univ., Ottawa, Canada, 3 months Oct-Dec 2000; Concordia Univ., Montreal, Canada, 6 months Jan-June 2001; Weizmann Inst., Israel, 1 week April 2004; ETH Zurich, Swiss, 2 weeks Feb 2000, and 1 week Feb 2004; UQO, Canada, 2 weeks Sept 2004, 2 weeks Jan 2003, and 2 weeks Jan 2002; Univ. of Bergen, 1 week Nov 2003, and 1 week June 2004.
- Hao Li: Hungarian Academy of Sciences, 6 weeks, 2003; Chinese Academy of Sciences, 1 month in 2003, 2 months in 2004; City University of Hong Kong, 10 days in 2002; Lanzhou University, China, 1 week in 2001, 2003, and 2004; Eastern China Normal University, 2 weeks in 2004.
- David Ilcinkas: Weizmann Inst., Israel, 1 week April 2004; UQO, Canada, 3 weeks Sept 2004, and 2 weeks Jan 2004.
- Mekkia Kouider: AGH, Krakow, Poland, 2 weeks, 2000; Univ. of Aalborg, Denmark, 3 weeks 2002 and 1 week 2004; Univ. W. Laurier, Waterloo, Canada, 2 weeks, 2004; Univ. of Rio, Brazil, 3 weeks, 2002.

Evaluation of research

Editorial boards

- *AKCE International Journal of Graphs and Combinatorics*: Hao Li and Odile Favaron, members since 2004.
- TOCS, *Theory of Computing Systems*: Pierre Fraigniaud, member since Jan 1st, 2003.
- JOIN, *Journal of Interconnection Networks*: Pierre Fraigniaud, member since March 2002.
- DM&TCS, *Discrete Mathematics and Theoretical Computer Science*: Pierre Fraigniaud, member until 2001.
- 4OR, *Quarterly Journal of the Belgian, French and Italian Operations Research Societies*: Abdel Lisser, member since 2002.

Program committees

Chair:

- DISC, *19th Conference on Distributed Computing*, 2005: Pierre Fraigniaud, Program Chair.
- SPAA, *13th ACM Symp. on Parallel Algorithms and Architectures*, July 4-6, 2001, Greece: Pierre Fraigniaud, Program Chair.
- SIROCCO, *8th Colloquium on Structural Information and Communication Complexity*, June 27-29, 2001, Vall de Nuria, Spain: Pierre Fraigniaud, Program co-Chair (with F. Comellas, UPC, Barcelona).

Member (international events):

- WAE, *4th Int. Workshop on Efficient and Experimental Algorithms*, May 10-13, 2005, Santorini Island, Greece: Pierre Fraigniaud.
- WG, *31st Int. Workshop on Graph-Theoretical Concepts in Computer Science*, Metz, France, June 2005: Pierre Fraigniaud.
- *Graph Theory 2004*, Conference in Memory of Claude Berge, Paris, July 5-9, 2004: Charles Delorme.
- DISC, *18th Int. Symposium on Distributed Computing*, Amsterdam, Netherlands, October 4-8, 2004. Pierre Fraigniaud.
- MASS, *1st IEEE Conference on Mobile Ad-hoc and Sensor Systems*, October 24-27, 2004, Fort Lauderdale, Florida, USA. Pierre Fraigniaud.
- DIALM-POMC, *1st and 2nd Joint Workshop on Foundations of Mobile Computing*, San Diego, USA, Sept. 19, 2003, and Philadelphia, USA, Oct. 1, 2004. Pierre Fraigniaud (twice).
- DIWANS, *1st Workshop on Dependability Issues in Wireless Ad Hoc Networks and Sensor Networks*, Florence, Italy, June 29, 2004. Pierre Fraigniaud.
- FUN, *3rd Int. Conference on Fun with Algorithms*, May 26-28, 2004, Isola d'Elba, Italy. Pierre Fraigniaud.
- WMAN, *4th Int. Workshop on Algorithms for Wireless, Mobile, Ad Hoc and Sensor Networks*, April 30, 2004, Santa Fe, New Mexico, USA. Pierre Fraigniaud.
- EuroPar, *9th European Conference on Parallel and Distributed Computing*, August 26-29, 2003, Klagenfurt, Austria. Pierre Fraigniaud.
- STACS, *20th Symposium on Theoretical Aspects of Computer Science*, Berlin, Germany, Feb. 27-March 1, 2003. Pierre Fraigniaud.
- WADS, *7th and 8th Workshop on Algorithms and Data Structures*, Providence, USA, August 8-10, 2001, and Ottawa, Canada, July 30-August 1, 2003. Pierre Fraigniaud (twice).
- SIROCCO, *10th Colloquium on Structural Information and Communication Complexity*, June 20-22, 2000, L'Aquila, Italy and June 18-20, 2003, Umea, Sweden. Pierre Fraigniaud (twice).
- IPDPS, *1st and 3rd Int. Parallel and Distributed Processing Symposium*, Cancun, Mexico, May 01-04, 2000, and Fort Lauderdale, USA, April 15-19, 2002. Pierre Fraigniaud.

- SPAA, *12th ACM Symposium on Parallel Algorithms and Architectures*, Bar Harbor, USA, July 09-13, 2000. Pierre Fraigniaud.
- ICPP, *16th Int. Conferemce on Parallel Processing*, Toronto, Canada, August 21-24, 2000. Pierre Fraigniaud.
- ISPAN, *5th Int. Symposium on Parallel Architectures, Algorithms and Networks*, Dallas, USA, Dec. 7-9, 2000. Pierre Fraigniaud.

Member (national events):

- AlgoTel, *2nd and 6th Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications*, May 26-28, 2004, Batz-sur-mer, France: Pierre Fraigniaud.
- RenPar, *14th Rencontres Francophones du Parallélisme*, Hammamet, Tunisie, April 9-13, 2002: Pierre Fraigniaud.

Evaluation committees and invited expertise

International:

- National Natural Science Foundation of China (NSFC): Hao Li, invited expert.
- Science and Engineering Research Canada (NSERC): Marie-Claude Heydemann and Pierre Fraigniaud, referees.

National:

- National research program on global computing, *ACI GRID, Globalisation des Ressources Informatiques et des Données*: Pierre Fraigniaud, member of the Scientific Committee (2001-2003).
- National research program on global computing, *GRID 5000*: Pierre Fraigniaud, member of the Scientific Committee since April 2004.
- *Laboratoire d'Informatique, de Modélisation et d'Optimisation des Systèmes* (LIMOS), Clermont-Ferrand: Pierre Fraigniaud, member of its last Evaluation committee.

Other evaluation activities

- Reviewer for Ph.D. dissertation: Charles Delorme (7), Pierre Fraigniaud (8), Marie-Claude Heydemann (1), Abdel Lisser (4);
- AMS, *American Mathematical Society*: Odile Favaron, referee.
- SAMS, *South African Mathematical Society*: Odile Favaron, referee.
- French-Algerian bilateral projects: Mekkia Kouider, referee.
- Eastern China Normal University: Hao Li, consultant professor since July 2003.

Volunteer professional service

Management positions in scientific organisations

- National network on Architecture, Networks, Systems and Parallelism (GdR ARP), Transversal Action TAROT *Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications*: Pierre Fraigniaud, chair until June 2001. Under his supervision was created the AlgoTel series of conferences (*Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications*).
- National network on Algorithms, Languages and Programming (GdR ALP), Action *Algorithmique de Graphes*: Odile Favaron, member of the selecting committee until 2003.
- CNRS Working Group on dynamic networks (*Action Spécifique Dynamo*), in collaboration with LIAFA (Paris), LIP (Lyon), INRIA project Mascotte (Sophia-Antipolis), INSA Lyon, and UTC (Compiègne): Pierre Fraigniaud, chair **(http://www.lri.fr/~pierre/dynamo/).**

Working groups

- The "Communication and network design" team is heavily involved in all activities of the Transversal Action *TAROT, Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications* of the national network *GdR ARP*.
- The "Graph Theory" research team participates in the activities of the Action *Algorithmique de Graphes* of the national network *GdR ALP*.

In addition, GraFComm was involved in two CNRS working groups (*Actions Spécifiques*):

- *Algorithmique pour les grands graphes*, in collaboration with LaBRI (Bordeaux, leader), LIX (Palaiseau), LIRMM (Montpellier), LIP (Lyon), Leibniz (Grenoble), IRIN (Nantes), and INRIA project Hipercom (Rocquencourt).
- *Algorithmes distribués et applications*, in collaboration with LIAFA (Paris, leader), IRISA (Rennes), LIP6 (Paris), ID (Grenoble), and EPFL (Lausanne).

Other professional service

- IWIN, *International bi-annual Workshop on Interconnection Networks*: Pierre Fraigniaud, member of the Steering Committee since 1995.
- AlgoTel, *Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications*: Pierre Fraigniaud, member of the Steering Committee since 1999.
- *Robert Faure Prize*, a French Operations Research award from ROADEF: Abdel Lisser, member of the selecting committee in 2000.
- Every year, the "Graph Theory" team organizes a *Graph theory day* under the supervision of Mekkia Kouider.

Contracts and grants

Type	*Scientific Director*	*Project Name*	*Funding institution*	*Managing institution*	*Dates*	*Duration (months)*	*Total €*
RNRT	D. Barth	ROCOCO	MENRT	Paris XI	2000-01		34 266
RNRT	D. Barth	ROM	MENRT	Paris XI	2000-01		34 193
IST	P. Berthomé	DAVID	UE	CEPHYTEN	2000-03		69 654
PICS	P. Fraigniaud	Circulant Networks	CNRS DRI	CNRS	2000-02		14 329
AS	P. Fraigniaud	Dynamo	CNRS STIC	CNRS	2002-03		7 500
AS	P. Fraigniaud	Grands graphes	CNRS STIC	CNRS	2002-03		7 350
ACI	P. Fraigniaud	PairAPair	MENRT	CNRS	2003-06		46 154
PICS	Hao Li	Progress in graphs	EGIDE	CNRS	2000-01		4 573
Industry	A. Lisser	Frequency Assignment	FT R&D	CEPHYTEN	2002-04		105 000
BQR	A. Lisser	Routage Robuste	Paris XI	Paris XI	2004		11 706
BQR	E. Flandrin		Paris XI	Paris XI	2001		4 573

Note: See the glossary for acronyms.

Summary of each scientific project and main results

ROCOCO

Research project funded by national network on telecommunications research (*RNRT*), 1999-2001.

Scientific directors for LRI: Dominique Barth and Pascal Berthomé.

Partners: ILOG, France Telecom R&D (Sophia Antipolis), INRIA (Grenoble), and LRI (Paris XI).

The objective of this project was to study the interactions between two optimization techniques: constraint programming and operational research.

http://www.telecom.gouv.fr/rnrt/projets/pres_d107_ap99.htm

ROM

Research project funded by national network on telecommunications research (*RNRT*), 1999-2001.

Scientific directors for LRI: Dominique Barth and Pascal Berthomé

Partners: Alcatel CIT (Marcoussis), France Telecom R&D (Lannion), Institut National des Télécommunications (Evry), and LRI (Paris XI).

The objective of this project was to study the feasibility of a high-speed WDM all-optical router for service differentiation. Main publications: [88, 133]. ROM was part of the kernel for the constitution of the IST European project "DAVID".

http://www.telecom.gouv.fr/rnrt/projets/prom.htm

DAVID

European project (*IST Program*), 2000-2003.
Scientific director for LRI: Pascal Berthomé.

Partners: 15 industrial and academic partners, among which Alcatel (France and Germany), Institut National des Télécommunications (Evry), University of Bologna (Italy), Research Center COM (Denmark).

The objective of the project was to propose a packet-over-WDM network solution, covering the entire spectrum from MAN to WAN, and including traffic engineering capabilities, as well as network management. Main publications: [175].

http://david.com.dtu.dk.

Circulant Networks

CNRS Program for international scientific cooperation (*PICS*), 2000-2002.
Scientific director for LRI: Pierre Fraigniaud

Partners: Macquarie University (Sidney), LaBRI (Bordeaux), and LRI (Paris XI).

The objective of this project was the analysis of the algorithmic and structural properties of circulant networks. This academic project led to several publications, among which [84] and [128].

Dynamo

CNRS working group (*Action Spécifique*), 2002-2003.
Scientific director: Pierre Fraigniaud.

Partners: LIAFA (Paris VII), LIP (ENS Lyon), LRI (Paris XI), Mascotte (I3S/INRIA), Ares (INSA-Lyon/INRIA), and Heudiasyc (UTC).

The objective of this action was the algorithmic and structural analysis of dynamic networks (Web graph, Internet, ad hoc networks, peer-to-peer systems, etc.). This project was the basis for the constitution of a European COST project on this topic, led by LRI, and which should be formally accepted in the fall of 2004.

http://www.lri.fr/~pierre/dynamo/

Grands graphes

CNRS working group (*Action Spécifique*), 2002-2003.
Scientific director for LRI: Pierre Fraigniaud.

Partners: Hipercom (INRIA), LRI (Paris XI), LIX (Polytechnique), LIRMM (Montpellier), LIP (ENS Lyon), Leibniz (IMAG), LaBRI (Bordeaux), IRIN (Nantes).

The objective of this action, led by André Raspaud (LaBRI), was the design of algorithms for large complex networks such as the Web or Internet. The "PairAPair" project (see below) and the Dynamo project (see above) came out of this group.

http://www.labri.fr/Perso/~hanusse/Grandsgraphes/

PairAPair

Project funded by national program (*ACI*), 2003-2006.

Scientific director for LRI: Pierre Fraigniaud.

Partners: LRI (Paris XI), LaBRI (Bordeaux), Hipercom (INRIA), and Gyroweb (INRIA).

The objective of this on-going project, led by Laurent Viennot (Gyroweb), is to analyse peer-to-peer systems from different points of view: from the models and the algorithms, to the design of the protocols and their analysis.

http://gyroweb.inria.fr/pairapair/

Progress in graphs

CNRS Program for international scientific cooperation (*PICS*), 1998-2001.

Scientific director for LRI: Hao Li.

Partners: LRI (Paris XI), Univ. of Memphis, and Vanderbilt Univ.

The main purpose of this project was to build a data-base about the recent progress in graph theory, in particular as far as cycle problems are concerned. For that purpose, members of the project visited the main research centers in this field to collect information.

Frequency Assignment

Industrial Project funded by France Telecom, 2002-2003.

Scientific director: Abdel Lisser.

Partners: France Telecom R&D, Belfort.

The objective of this project was to model the Frequency Assignment problem, to study and to compute tight lower bounds using semidefinite programming relaxations. This industrial project yields several ongoing publications and conference presentations, among which [170, 172], and [171].

Routage robuste

University grant (*BQR, Bonus Qualité Recherche*), 2004.

Scientific director: Abdel Lisser.

Partners: LRI (GraFComm and I&A), France Telecom R&D (Belfort).

This project addressed the design of robust routing protocols in telecommunication networks. Its objectives were to study and model "uncertainty" for routing problems. Theoritical studies as well as numerical experiments were performed using different approaches.

Other projects

Abdel Lisser kept the responsability of the RNRT project *PORTO* until 2001. This project began in 1999 when he was still at France Telecom R&D. Partners: Alcatel CIT (Marcoussis), France Telecom R&D (Issy Les Moulineaux), INRIA (Nice, mascotte team). The objective of the project was to study and design methods and planning strategies for SDH and WDW backbone networks. The main result is an optical network optimization tool.

http://www.telecom.gouv.fr/rnrt/projets/pporto.htm

Collaborations

Cooperation agreements

- Laboratory of Graph Theory, Combinatorics and Networks, Academy of Mathematics and System Sciences, Chinese Academy of Sciences: Hao Li, co-director, in charge of international cooperation, since 2004. The lab. director is Prof. Xiaodong Hu.
- CNRS Program for internation scientific cooperation (PICS), *Database design for graph theoretical results*, between Université Paris-Sud, CNRS (H. Li) and the universities of Memphis (B. Bollabas) and Vandebilt (M. Plummer), USA, 1998-2001.
- POLONIUM Integrated action, *Extremal problems in graphs and networks*, between Université Paris-Sud (E. Flandrin) and Akademia Gorniczo-Hutnicza, Poland (M. Wozniak). Grant: 3.200 euros, 2004.
- BARRANDE Integrated action, *Structural properties of graphs and hamiltonicity*, between Université Paris-Sud (E. Flandrin) and Zapadoceska Universita, Czech Republic (Z. Ryjacek). Grant: 2.990 euros, 2004.
- PICASSO Integrated action, *Algorithms for systems of mobile agents* between Universtié Paris-Sud (P. Fraigniaud) and UPC Barcelona (E. Barrière). Grant: 2.847 euros/year, 2002-2003.
- ARC-CNRS Collaboration, *Algorithmic and structural properties of Circulant networks* between LRI (P. Fraigniaud), LaBRI (C. Gavoille), and Macquarie University, Sydney (B. Mans). Grant: 36.000 FF/year for the French side, 2000-2002.

Collaborations leading to joint publications

GraFComm actively collaborates with the following foreign universities:

Canada

- Université du Québec en Outaouais, Canada (A. Pelc);
- University of Ottawa, Canada (P. Flocchini);
- Carleton University, Ottawa, Canada (N. Santoro and E. Kranakis);
- Concordia University, Montreal, Canada (L. Narayanan and J. Opatrny);
- University of Victoria, Canada (E. Cockayne, C. Mynhardt);
- University W. Laurier, Waterloo, Canada (C. Hoang).

USA

- Clemson University, USA (W. Goddard, S. Hedetniemi, R. Laskar);
- Vandebilt University, USA (M. Plummer);
- University of Memphis, USA (D.Schelp);
- Univ. of Massachussets at Amherst, USA (A. Rosenberg).

Western Europe

- University of Bergen, Norway (F. Fomin);
- UPC Barcelona, Spain (J. Gómez, D. Thilikos);
- RWTH, Aachen, Germany (D. Rautenbach);
- Discrete Maths Institute, Bonn, Germany (D. Rautenbach);
- University of Kagenfurt, Austria (F. Rendl);
- University of East Anglia, UK (P. Chardaire);
- University of Geneva, Switzerland (J.-P. Vial);
- Instituto Superior Tecnico, Lisbon, Portugal (R. Cordovil);
- University of Aalborg, Denmark (P. Vestergaard);

Central and Eastern Europe

- Hungarian Academy of Sciences (E. Gyori);
- AGH, Krakow, Poland (M. Wozniak and A. Marczyk);
- University of West Bohemia, Czech Republic (Z. Ryjacek);
- University of Varsaw, Poland (Z. Lonc).

South America

- Universidad Centroccidental Lisandro Alvarado, Venezuela (I. Marquez);
- Universidad Central de Venezuela, Venezuela (O. Ordaz);
- Universidad Simón Bolívar, Venezuela (D. Quiroz and S. Gonzalez);
- Instituto Pedagógico de Caracas, Venezuela (M.-T. Varela);
- University of Rio de Janeiro, Brazil (S. Klein, N. Maculan);
- University of Fortaleza, Brazil (R. Castro de Andrade).

China

- Chinese Academy of Science (Q.-Y. Yan and F. Tian);
- Eastern China Normal University (J.-L. Shu);
- Yunan University, China (J.-P. Li).

Other

- Natal University and UNISA, South Africa (C. Mynhardt, P. Grobler, M. Henning);
- Macquarie University, Sydney, Australia (B. Mans);
- University of Beyrouth, Lebanon (A. El Sahili);
- Weizmann Institute, Israel (D. Peleg);
- University of Blida, Algeria (M. Blidia, M. Chellali).

Dissemination and technology transfer

Summer schools, tutorials, invited seminars

Invited seminars:

- Odile Favaron, *Meeting in honor of Lutz Volkmann 60th birthday*, AWTH Aachen, January 9, 2004. Title: "Total and paired domination in graphs and claw-free graphs".
- Odile Favaron, *Journée scientifique en l'honneur de C. Benzaken*, Grenoble, France, Sept. 6, 2002. Title: "Domination totale dans les graphes".
- Odile Favaron, *series of seminars in South Africa*, Stellenbosch, Pretoria, April 2002. Title: "Bounds on the upper irredundance parameter".
- David Forge, *AMS Spring conference*, Louisiana State University, Baton Rouge, USA, 2003. Title: "Some results on OS algebras".
- David Forge, Conference *Combinatorics in Oporto*, Porto, Portugal, 2003. Title: "A walk through OS algebras".
- Pierre Fraigniaud, *Franco-Japanese Workshop on Computer Science*, Tokyo, Dec 2001. Title: "Graph exploration".
- Pierre Fraigniaud, *University of Massachusetts*, Amherst, USA, Feb 2001. Title: "Approximation algorithms for broadcasting".
- Hao Li gave more than 24 invited seminars in various universities from China and USA (Purdue, Memphis, etc.).
- Mekkia Kouider, *University of Rio*, Brazil, 2002. Title: "On factorization of graphs".
- Mekkia Kouider, *University of Aalborg*, Denmark, 2004. Title: "Survey on (a,b)-factors of graphs".
- Abdel Lisser, *9es journées d'optimisation*, 2000. Title: "Capacitated Fixe charge multicommodity flow problems".

Tutorials:

- Pierre Fraigniaud, tutorial at *31st LIAFA Spring School on Theoretical Computer Science*, May 4-8, 2003, Porquerolles, France. Title: "Dynamic Networks for Peer-to-Peer Systems".
- Pierre Fraigniaud, tutorial at the *LIX Fall School on Optimisation and Telecom*, Sept. 25-26, 2003, France. Title: "Network exploration".

Other dissemination and technology transfer

- Charles Delorme maintains a table of the current largest known (Δ,D)-graphs.

Training and education (doctoral and post-doctoral)

Defended doctorates		
Name	*Date defended*	*Current position*
VALENCIA PABON Mario	01/12/00	Assistant Professor at Univ. de los Andes, Bogotá, Colombia
ALVAREZ-HAMELIN José Ignacio	20/12/02	Post-doc Institut de physique théorique (PXI)
BEN DHAOU Moaiz	18/12/03	Manager Thalensys S.A.

Graduate courses

- DEA Informatique Distribuée: *Dissémination de l'Information*, Pascal Berthomé (1999-2001), Pierre Fraigniaud (1999-present).
- DEA Informatique Distribuée: *Optimisation de Réseaux de Télécommunications à Très Haut Débit*, Pascal Berthomé (2002-present), Abdel Lisser (2002-present).
- DEA Paris VI: *Optimisation des Réseaux et Applications aux Télécommunications*, Abdel Lisser (2000-present).

Publications

International peer-reviewed journals

[1] A. Ainouche and M. Kouider. Cycles in partially squared graphs. *Graphs and Combinatorics*, 17(1-9), 2001.

[2] J. I. Alvarez-Hamelin and N. Schabanel. An internet graph model based on trade-off optimization. *European Physical Journal B, special issue on "Applications of networks"*, 38(2):231-237, 2004.

[3] D. Amar, M. El Kadi Abderrezzak, and E. Flandrin. Cyclability and pancyclability in bipartite graphs. *Discrete Mathematics*, 236:3-11, 2001.

[4] C. Andrade, A. Lisser, G. Plateau, and N. Maculan. Telecommunication network capacity design for uncertain demand. *Computational Optimization and Applications*, 29:129-147, 2004.

[5] G. Bacsó and O. Favaron. Independence, irredundance, degrees and chromatic number in graphs. *Discrete Mathematics*, 259:257-262, 2002.

[6] P. Balister, A. Kostochka, H. Li, and R. Schelp. Balanced edge colorings. *Journal of Combinatorial Theory B*, 90:3-20, 2004.

[7] L. Barrière, P. Fraigniaud, L. Narayanan, and J. Opatrny. Robust position-based routing in wireless ad hoc networks with irregular transmission ranges. *Wireless Communications and Mobile Computing*, 3(2):141-153, 2003.

[8] D. Barth and P. Berthomé. Periodic gossiping in commuted networks. *Theory of Computing Systems*, to appear.

[9] D. Barth, P. Berthomé, and J. Cohen. The eulerian stretch of a network topology and the ending guarantee of a convergence routing. *Journal of Interconnection Networks*, 5(2):93-109, 2004.

[10] D. Barth, P. Fragopoulou, and M.-C. Heydemann. Uniform emulations of cartesian-product and Cayley graphs. *Discrete Applied Mathematics*, 116:37-54, 2002.

[11] C. Bazgan, A. Harkat-Benhamdine, H. Li, and M. Woźniak. A note on the vertex-distinguishing proper colorings of graphs with large minimum degree. *Discrete Mathematics*, 236:37-42, 2001.

[12] C. Bazgan, A. Harkat-Benhamdine, H. Li, and M. Woźniak. Partitionning vertices of 1-tough graph into paths. *Theoritical Computer Sciences*, 263:255-261, 2001.

[13] C. Bazgan, H. Li, and M. Woźniak. On the Loebl-Komlós-Sós conjecture. *Journal of Graph Theory*, 34:269-276, 2000.

[14] P. Berthomé, A. Ferreira, B. Maggs, S. Perennes, and C. Plaxton. Sorting-based selection algorithms for hypercubic networks. *Algorithmica*, 26:237-254, 2000.

[15] P. Berthomé, T. Hagerup, I. Newman, and A. Schuster. Self-simulation for the passive optical star. *Journal of Algorithms*, 34:128-147, 2000.

[16] S. Brandt, O. Favaron, and Z. Ryjáček. Closure and stable hamiltonian properties in claw-free graphs. *Journal of Graph Theory*, 34(1):30-41, 2000.

[17] R. Cada, E. Flandrin, H. Li, and Z. Ryjáček. Cycles through given vertices and closures. *Discrete Mathematics*, 276:65-80, 2004.

[18] M. Cai, E. Flandrin, and H. Li. On quasifactorability in graphs. *Discrete Mathematics*, 233:85-92, 2001.

[19] P. Chardaire and A. Lisser. Simplex and interior point specialization algorithms for solving non-oriented multicommodity flow problems. *Operations Research*, 2:260-276, 2002.

[20] G. Chen, R. Gould, and H. Li. Partitionning vertices of a tournament into independent cycles. *Journal of Combinatorial Theory B*, 83:213-220, 2001.

[21] T. Chich, J. Cohen, and P. Fraigniaud. Unslotted deflection routing: a practical and efficient protocole for multi-hop optical networks. *IEEE/ACM Transaction on Networking*, 9(1):47-59, 2001.

[22] E. J. Cockayne, O. Favaron, W. Goddard, P. J. Grobler, and C. M. Mynhardt. Changing upper irredundance by edge addition. *Discrete Mathematics*, 266:185-193, 2003.

[23] E. J. Cockayne, O. Favaron, P. J. Grobler, C. M. Mynhardt, and J. Puech. Generalised Ramsey numbers with respect to classes of graphs. *Ars Combinatoria*, 59:279-288, 2001.

[24] E. J. Cockayne, O. Favaron, P. J. Grobler, C. M. Mynhardt, and J. Puech. Ramsey properties of generalised irredundant sets in graphs. *Discrete Mathematics*, 231:123-134, 2001.

[25] E. J. Cockayne, O. Favaron, and C. M. Mynhardt. Irredundance-edge-removal-critical graphs. *Utilitas Math.*, 60:219-228, 2001.

[26] E. J. Cockayne, O. Favaron, and C. M. Mynhardt. Total domination in claw-free cubic graphs. *Journal of Combinatorial Mathematics and Combinatorial Computing*, 43:219-225, 2002.

[27] E. J. Cockayne, O. Favaron, and C. M. Mynhardt. Secure domination, weak roman domination and forbidden subgraphs. *Bull. Inst. Combin. Appl.*, 39:87-100, 2003.

[28] E. J. Cockayne, O. Favaron, and C. M. Mynhardt. On (i-)-edge-removal-critical graphs. *Discrete Mathematics*, 276:111-125, 2004.

[29] E. J. Cockayne, O. Favaron, and C. M. Mynhardt. Total domination in K_r-covered graphs. *Ars Combinatoria*, 71:289-303, 2004.

[30] E. J. Cockayne, O. Favaron, C. M. Mynhardt, and J. Puech. A characterisation of (γ-i)-trees. *Journal of Graph Theory*, 34(4):277-292, 2000.

[31] J. Cohen, P. Fraigniaud, and C. Gavoille. Recognizing Knödel and Fibonacci graphs. *Discrete Mathematics*, 250:41-62, 2002.

[32] J. Cohen, P. Fraigniaud, and M. Mitjana. Polynomial time algorithms for minimum-time broadcast in trees. *Theory of Computing Systems*, 35(6):641-665, 2002.

[33] R. Cordovil and D. Forge. Diagonal bases in Orlik-Solomon type algebras. *Annals of Combinatorics*, 7:247-257, 2003.

[34] R. Cordovil and D. Forge. A note on tutte polynomials and Orlik-Solomon algebras. *European Journal of Combinatorics*, 24:1081-1087, 2003.

[35] R. Cordovil and D. Forge. Quadratic Orlik-Solomon algebras of graphic matroids. *Matematica Contemporanea*, 25:25-32, 2003.

[36] R. Cordovil and D. Forge. Gröbner and diagonal bases in Orlik-Solomon type algebras. *Cubo*, to appear.

[37] R. Cordovil, D. Forge, and S. Klein. How is a chordal graph like a supersolvable binary matroid? *Discrete Mathematics*, to appear.

[38] N. Dean and M. Kouider. Gallai's conjecture in disconnected graphs. *Discrete Mathematics*, 213:43-54, 2000.

[39] C. Delorme. Presentations of groups generated by transpositions. *Discrete Mathematics*, 236:59-64, 2001.

[40] C. Delorme. Spectra and cuts. *Australasian Journal of Combinatorics*, 26:183-191, 2002.

[41] C. Delorme. Laplacian eigenvalues and fixed size multisections. *Discrete Mathematics*, 276:149-159, 2004.

[42] C. Delorme, O. Favaron, and D. Rautenbach. On the Randic index. *Discrete Mathematics*, 257(1):29-38, 2002.

[43] C. Delorme, O. Favaron, and D. Rautenbach. On the reconstruction of the degree sequence. *Discrete Mathematics*, 259:293-300, 2002.

[44] C. Delorme, O. Favaron, and D. Rautenbach. Closed formulas for the numbers of small independent sets and matchings and an extremal problem for trees. *Discrete Applied Mathematics*, 130:503-512, 2003.

[45] C. Delorme and J. Gómez. Some new large compound graphs. *European Journal of Combinatorics*, 23(5):539-547, 2002.

[46] C. Delorme, S. Gonzales, O. Ordaz, and M. T. Varela. Barycentric sequences and barycentric Ramsey numbers-stars. *Discrete Mathematics*, 277:45-56, 2004.

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[48] C. Delorme, O. Ordaz, and D. Quiroz. Some remarks on Davenport constant. *Discrete Mathematics*, 237:119-128, 2001.

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[50] S. Djelloul and M. Kouider. On weighted mean distance. *Australasian Journal of Comb.*, 23:181-195, 2001.

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[52] Y. Egawa, H. Enomoto, R. Faudree, H. Li, and I. Schiermeyer. Two-factors each component of which contains a specified vertex. *Journal of Graph Theory,*, 43(3):188-198, 2003.

[53] M. El Kadi Abderrezzak and E. Flandrin. New sufficient conditions for bipancyclic bipartite graphs. *Discrete Mathematics*, to appear.

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[59] O. Favaron, E. Flandrin, H. Li, and Z. Ryjáček. Clique covering and degree conditions for hamiltonicity in claw-free graphs. *Discrete Mathematics*, 236:65-80, 2001.

[60] O. Favaron and P. Fraisse. Hamiltonicity and minimum degree in 3-connected claw-free graphs. *Journal of Combinatorial Theory Series B*, 82(2):297-305, 2001.

[61] O. Favaron, G. Fricke, W. Goddard, S. M. Hedetniemi, S. T. Hedetniemi, P. Kristiansen, R. C. Laskar, and D. Skaggs. Offensive alliances in graphs. *Discussiones Mathematicae-Graph Theory*, 24:263-275, 2004.

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[63] O. Favaron, T. W. Haynes, and S. T. Hedetniemi. Domination subdivision numbers in graphs. *Utilitas Math.*, to appear.

[64] O. Favaron, T. W. Haynes, S. T. Hedetniemi, M. A. Henning, and D. J. Knisley. Total irredundance in graphs. *Discrete Mathematics*, 256(1-2):115-127, 2002.

[65] O. Favaron, T. W. Haynes, and P. J. Slater. Distance-k independent domination sequences. *Journal of Combinatorial Mathematics and Combinatorial Computing*, 33:225-237, 2000.

[66] O. Favaron, S. T. Hedetniemi, S. M. Hedetniemi, and D. F. Rall. On k-dependent domination. *Discrete Mathematics*, 249:83-94, 2002.

[67] O. Favaron and M. A. Henning. Upper total domination in claw-free graphs. *Journal of Graph Theory*, 44(2):148-158, 2003.

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[70] O. Favaron, M. A. Henning, J. Puech, and D. Rautenbach. On domination and annihilation in graphs with claw-free blocks. *Discrete Mathematics*, 231:143-151, 2001.

[71] O. Favaron, M. Mahéo, and J.-F. Saclé. The Randic index and other Graffiti parameters of graphs. *MATCH - Commun. Math. Comput. Chem.*, 47:7-23, 2003.

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[83] P. Fraigniaud and C. Gavoille. Header-size lower bounds for end-to-end communication in memoryless networks. *Computer Network*, to appear.

[84] P. Fraigniaud, C. Gavoille, and B. Mans. Interval routing schemes allow broadcasting with linear message-complexity. *Distributed Computing*, 14(4):217-229, 2001.

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[87] P. Fraigniaud and J. Peters. Minimum linear gossip graphs and maximal linear (Δ,k)-gossip graphs. *Networks*, 38(3):150-163, 2001.

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[93] M.-C. Heydemann, N. Marlin, and S. Perennes. Complete rotations in cayley graphs. *Europ. J. Combinatorics*, 22:179-196, 2001.

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tion networks. *Investigation Operativa*, 9(1-2):21-47, 2000.

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National peer-reviewed journals

[117] O. Favaron. From irredundance to annihilation: a brief overview of some domination parameters of graphs. *Saber (Venezuela)*, 32(2):64-69, 2000.

Book chapters

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[119] P. Chardaire and A. Lisser. *Encyclopedia of Optimization*, volume 4, chapter Non-oriented multicommodity flow problems, pages 92-97. Kluwer Academic Publisher, 2001.

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Major international peer-reviewed conferences

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cayley colored digraphs. In *8th Annual European Symposium on Algorithms (ESA)*, LNCS 1879, pages 76-87. Springer, 2000.

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