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Project-Team MASCOTTE

Algorithms, simulation, combinatorics and optimization for telecommunications

IN COLLABORATION WITH: Laboratoire informatique, signaux systèmes de Sophia Antipolis (I3S)

RESEARCH CENTER
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THEME
Networks and Telecommunications

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Keywords: Graph Theory, Discrete-Event Simulation, Distributed Algorithms, Optical Networks, Peer-to-Peer, Networks, Wireless Networks

1. Members

Research Scientists

Jean-Claude Bermond [Team Leader until march 14, 2011, Research Director (DR), Emeritus, CNRS, HdR]
David Coudert [Team Leader since march 15, 2011, Research Associate (CR), INRIA, HdR]
Frédéric Giroire [Research Associate (CR), CNRS]
Frédéric Havet [Research Associate (CR), CNRS, HdR]
Philippe Mussi [Research Associate (CR), INRIA]
Nicolas Nisse [Research Associate (CR), INRIA]
Stéphane Pérennes [Research Director (DR), CNRS, HdR]

Faculty Members

Christelle Caillouet [Associate Professor UNS, since September 1, 2011]
Olivier Dalle [Associate Professor UNS]
Joanna Moulierac [Associate Professor UNS]
Michel Syska [Associate Professor UNS]

Technical Staff

Luc Hogie [Research Engineer, CNRS (part time), since february 1, 2010]
Grégory Morel [Expert Engineer, ANR, since October 2011]
Van Dan Nguyen [Young graduate engineer, INRIA, since January, 6 2011]

PhD Students

Julio Araújo [MESR, since December 1, 2009, 3rd year]
Nathann Cohen [MENRT, since October 1 2008, defense October 20, 2011]
Sébastien Félix [CIFRE ORANGE LABS, since January 24, 2011, 2nd year]
Alvinice Kodjo [BDE Région/3-ROAM, since October 1, 2011, 1st year]
Aurélien Lancin [CORDI/FP7, since January 1, 2011, 2nd year]
Bi Li [BDO Région/INRIA, since October 1, 2011, 1st year]
Ana Karolinna Maia [Grant CAPES, Brazil, since October 1, 2011, 1st year]
Juan-Carlos Maureira [Grant CONICYT Chile, since February 1, 2008, defense January 21, 2011]
Dorian Mazauric [BDO CNRS/Région PACA, since October 1, 2008, defense November 7, 2011]
Remigiusz Modrzejewski [BDO Région/CNRS, since November 1, 2010, 2nd year]
Ronan Pardo Soares [CORDI-S, since November 22, 2010, 2nd year]
Truong Khoa Phan [MESR, since October 1, 2011, 1st year]
Judicaël Ribault [Contract ANR SPREADS, since January 1, 2008, defense January 20, 2011]
Leonardo Sampaio [Grant CAPES, Brazil, since October 1, 2009, 3rd year]
Issam Tahiri [CORDI/APRF, since November 1, 2009, 3rd year]
Mikaila Toko Worou [CIFRE ORANGE LABS, since November 23, 2009, 3rd year]

Post-Doctoral Fellows

Janna Burman [Chateaubriand, until October 2011]
Gianlorenzo D'Angelo [since September 2011]
František Kardoš [ANR, since October 2011]
Yaning Liu [ANR, since April 1 2011]
Emilio Mancini [ANR, since March 2011]

Administrative Assistants

Sandra Devauchelle [ITA CNRS, (part time)]

Patricia Lachaume [ITA INRIA, (part time)]

2. Overall Objectives

2.1. Overall Objectives

MASCOTTE is a joint team between INRIA Sophia Antipolis Méditerranée and the laboratory I3S (Informatique Signaux et Systèmes de Sophia Antipolis) which itself belongs to CNRS (Centre National de la Recherche Scientifique) and UNS (University of Nice Sophia Antipolis). Its research fields are Algorithmics, Discrete Mathematics, Combinatorial Optimization and Simulation, with applications to telecommunication networks.

The objectives of the MASCOTTE project-team are to design networks and communication algorithms. In order to meet these objectives, the team studies various theoretical tools, such as Discrete Mathematics, Graph Theory, or Algorithmics and develops applied techniques and tools, especially for Combinatorial Optimization and Computer Simulation. In particular MASCOTTE used in the last years both these theoretical and applied tools for the design of various networks, such as WDM, wireless (radio), satellite, overlay, and peer-to-peer networks. This research has been done within various industrial and international collaborations.

This results also in the production of advanced softwares such as GRPH, DRMSim, the MASCOPT library (MASCOTTE optimization), and ambitious software projects such as the OSA (Open Simulation Architecture) Computer Simulation Architecture.

3. Scientific Foundations

3.1. Scientific Foundations

The project develops tools and theory in the following domains: Discrete Mathematics (in particular Graph Theory), Algorithmics, Combinatorial Optimization and Simulation.

Typically, a telecommunication network (or an interconnection network) is modeled by a graph. A vertex may represent either a processor or a router or any of the following: a switch, a radio device, a site or a person. An edge (or arc) corresponds to a connection between the elements represented by the vertices (logical or physical connection). We can associate more information both to the vertices (for example what kind of switch is used, optical or not, number of ports, equipment cost) and to the edges (weights which might correspond to length, cost, bandwidth, capacity) or colors (modeling either wavelengths or frequencies or failures) etc. Depending on the application, various models can be defined and have to be specified. This modeling part is an important task. To solve the problems, we manage, when possible, to find polynomial algorithms. For example, a maximum set of disjoint paths between two given vertices is by Menger's theorem equal to the minimum cardinality of a cut. This problem can be solved in polynomial time using graph theoretic tools or flow theory or linear programming. On the contrary, determining whether in a directed graph there exists a pair of disjoint paths, one from s_1 to t_1 and the other from s_2 to t_2, is an NP-complete problem, and so are all the problems which aim at minimizing the cost of a network which can satisfy certain traffic requirements. In addition to deterministic hypotheses (for example if a connection fails it is considered as definitely down and not intermittently), the project started recently to consider probabilistic ones.

Graph coloring is an example of concept which appears in various contexts: WDM networks where colors represent wavelengths, radio networks where colors represent frequencies, fault tolerance where colors represent shared risk resource groups, and scheduling problems. Another tool concerns the development of new algorithmic aspects like parameterized algorithms.

4. Application Domains

4.1. Application Domains

In the last year the main application domain of the project remained Telecommunications. Within this domain, we consider applications that follow the needs and interests of our industrial partners, in particular ORANGE LABS or ALCATEL-LUCENT BELL-LABS, but also SMEs like 3-ROAM and AVISTO.

MASCOTTE is mainly interested in the design and management of heterogeneous networks. The project has kept working on the design of backbone networks (optical networks, backhaul and mesh (wireless) networks, and peer to peer networks).

The project has also been working on routing algorithms such as dynamic and compact routing schemes in the context of the STREP EULER leaded by ALCATEL LUCENT BELL LABS (Belgium). It also studied the evolution of the routing in case of any kind of topological modifications (maintenance operations, failures, capacity varaitions, etc.). Finally, an emphasis is done on green networks with low power consumption. This work is in collaboration with ORANGE LABS and the SME 3-ROAM and partly supported by the ANR DIMAGREEN.

5. Software

5.1. Grph

Participants: Nathann Cohen, David Coudert, Luc Hogie [correspondant], Aurélien Lancin, Grégory Morel, Issam Tahiri.

Around 20,000 lines of code, developed in Java.

The GRPH project takes over Dipergrafs which was introduced in the activity report of 2010. A drastic change in the model of Dipergrafs justified the name change.

The objective of GRPH is to provide researchers and engineers a suitable graph library for graph algorithms experimentation and network simulation. GRPH is mainly a software library, but it also comes with a set of executable files for user interaction and graph format conversion; as such, it can be used autonomously. Performance and accessibility are the primary targets of the GRPH library. At every stage, it is designed to be efficient in terms of: computation time (use of parallelism, caching, adequate data structures, native code, etc.); memory requirements (use of Java primitives); and portability (it is written in a Java and C). Its model considers mixed graphs composed of (un)directed simple- and hyper-edges. It can handle large dynamic graphs in the order of millions of nodes. GRPH comes with a collection of base graph algorithms which are regularly augmented.

So far, most known users of the GRPH library are part of INRIA and of the FP7 STREP EULER project. GRPH is distributed under the terms of a license defined by its contributors and is available for download. This license allows free usage and access to the source code. See http://www-sop.inria.fr/mascotte/software/grph.

In 2011, GRPH was augmented over Dipergrafs of a number of features suited to its usage within the MASCOTTE research team. These include: addition of numerous graph manipulation methods; introduction of an incidence-list data structure for the representation of graphs; introduction of an adaptive data structure for the representation of sets (based on hash-tables and bit-vectors); integration of implementations of "maximum clique" and "sub-graph isomorphism" algorithms by Christine Solnon (CNRS, INSA Lyon). These sources, written in C, are compiled on-the-fly; integration of implementation of "graph isomorphism" algorithm by Brendan McKay (Australian National University); iteration of implementation of "number of triangles" algorithm by Matthieu Latapy (LIP6); introduction of a bridge to the Mascopt/OpenGVE library; introduction of a bridge to the JUNG library; addition of numerous graph algorithms; introduction of a new layer atop GRPH which allows the representation and manipulation of graph as Java objects, like it is done in other libraries such as Mascopt, Jung, etc.; introduction of an efficient mechanism for the definition of graph properties; addition of graph reporting facilities.

On-going works concern the distributed execution of graph algorithms, a bridge to Sage, and the graphical edition of graphs.

5.2. DRMSim

Participants: David Coudert, Luc Hogie [correspondant], Aurélien Lancin, Nicolas Nisse, Issam Tahiri.

Around 45,000 lines, developed in Java, collaboration between MASCOTTE and researchers in LaBRI (95 % MASCOTTE).

The expansion of the Internet results in a number of issues: BGP (Border Gateway Protocol) starts to show its limits in terms of the number of routing table entries it can manage. More efficient dynamic routing protocols are thus under investigation. However, because deploying under-development routing protocols on the Internet is not practicable at a large-scale, simulation is a necessary step to validate the properties of a newly proposed routing scheme. Unfortunately, the simulation of routing protocols over large networks poses real challenges due to the limited computational capabilities of computers. Existing simulation tools exhibit limitations in terms of the number of nodes they can handle and of the models they propose. This motivated us to conceive and develop DRMSim (Dynamic Routing Model Simulator): a network simulator which addresses the specific problem of large-scale simulations of routing models.

DRMSim relies on a discrete-event simulation engine. It proposes a general routing model which accommodates any network configuration. Aside to this, it includes specific models for Generalized Linear Preference (GLP), and K-chordal network topologies, as well as implementations of routing protocols, including the routing protocol proposed in [99] and lightweight versions of BGP (Border Gateway Protocol).

Recent developments (in 2011) in the DRMSim simulator include the four following elements:

1. The initial framework was composed of a routing model. It now incorporates a system model and a metric model. In addition, the system model now considers the dynamic evolution of the simulated network. This dynamic behavior includes the maintenance operations on the network infrastructure as well as router failures. This model stores the connectivity of routers and links before their failure is simulated. This information is used for the simulation of the recovery procedure. This model takes as its input parameter the distribution of failure probability for both routers and links.

2. The metric model has been fully rewritten and is now geared towards computational performance and flexibility. Taking measures along a discrete-event simulation can be performed in many ways. DRMSim uses a new approach which consists in a metric model listening to the simulation and system models. The user can define its own metrics. Memory and CPU usages depend on which metrics are defined, to which set of routers/links they are applied, how many measures are taken and their computational complexity. It is possible to restrict the model to a small amount of nodes/links by selectors provided as input parameters. At the cost of memory and CPU usage, metrics measures can be stored as time-ordered sequence of values. To reduce the need of resources, a single global measure for each metric can be computed. Finally, metrics can be computed globally on the set of selected entities (links/routers) but also separately for each entity.

3. DRMSim enables the definition of customized simulation scenarios and stateful simulation campaigns.

Commonly, a simulation campaign consists in iterating over the set of combinations of parameter values, calling the simulation function for every combination. These combinations cannot be found randomly nor can they be determined using linear functions. Indeed, most of the time there exist correlations between the parameters involved. Also for performance reasons, the end-user will prefer non-linear (most often logarithmic) evolutions for the values of the parameters. The definition of the set of combinations is strongly linked to the simulated system and the time needed to solve it. DRMSim provides a simulation methodology that describes (programmatically) the way a simulation campaign should be conducted.

The duration of a simulation can be as long as several hours (or days). In the context of a simulation campaign where numerous simulations are executed, it is important that re-starting a simulation campaign that was interrupted does not entail the re-computation of already computed results. In order to do this, DRMSim stores on disk every step of the execution of a simulation campaign.

In a simulation campaign, simulation runs are independent (no simulation depends on the result computed by another simulation). Consequently they can be executed in parallel. Because one simulation is most likely to use large amount of memory and to be multi-threaded, parallelizing the simulation campaign on one single computer is a poor parallelization scheme. Instead, we currently work at enabling the remote parallel execution of several simulation runs, with the same distribution framework that is used in the GRPH library.

4. Finally, DRMSim manipulates graph abstractions, allowing the user to force the use of a library different from the default one, i.e. GRPH.

See also the web page http://www-sop.inria.fr/mascotte/projets/DCR/.

5.3. Mascopt and openGVE

Participant: Michel Syska [correspondant].

Developed in Java.

MASCOPT [98] (MASCOTTE Optimization) is a Java library distributed under the terms of the LGPL license which is dedicated to graph and network processing. MASCOPT includes a collection of Java interfaces and classes that implement fundamental data structures and algorithms. The forthcoming public distribution of MASCOPT will appear under the name of the OPENGVE project, MASCOPT being one implementation of the bridge graph interface (see http://opengve.inria.fr/bridge-graph-interface/apidocs/fr/inria/opengve/bridge/interfaces/Graph.html). The objective is to allow easy integration of different implementations. The applications already written will not be affected. They will have different choices of internal implementation which may lead to better performances for specific issues such as large graphs processing.

The main objective of MASCOPT project is to ease software development in the field of network optimization. Examples of problems include routing, grooming, survivability, and virtual network design. MASCOPT helps implementing a solution to such problems by providing a data model of the network and the demands, classes to handle data and ready to use implementations of existing algorithms or linear programs (e.g. shortest paths or integral multicommodity flow).

A key feature of MASCOPT is to provide a generic linear programming object interface which allows users to program the same way whether the target solver is IBM ILOG CPLEX, GLPK (GNU Linear Programming Kit) or CLP/CBC (accessed through JNI).

MASCOPT has been intensively used in the past within MASCOTTE industrial cooperation programs for experimentation and validation purposes as for example with Alcatel Space Technologies and Orange Labs. Today, the library is used within the framework of the ANR AGAPE to implement FPT algorithms (work done at LIFO).

See also the web page http://www-sop.inria.fr/mascotte/mascopt/.

5.4. Open Similation Architecture (OSA)

Participants: Olivier Dalle [correspondant], Van Dan Nguyen, Judicaël Ribault.

Developed in Java (80%) and XML, AspectJ, etc. Represent the work of about 8 man/year during the last 6 years.

Component-based modeling has many well-known good properties. One of these properties is the ability to distribute the modeling effort amongst several experts, each having his/her own area of system expertise. Clearly, the less experts have to care about areas of expertise of others, the more efficient they are in modeling sub-systems in their own area. Furthermore, the process of studying complex systems using discrete-event computer simulations involves several areas of non-system expertise, such as discrete-event techniques or experiment planning.

The Open Simulation Architecture (OSA) [97] is designed to enforce a strong separation of the end-user roles and therefore, ensure a successful cooperation of all the experts involved in the process of simulating complex systems.

The OSA architecture is also intended to meet the expectations of a large part of the discrete-event simulation community: it provides an open platform intended to support researchers in a wide range of their simulation activities, and allows the reuse and sharing of system models in the simulation community by means of a flexible and generic component model (Fractal).

Many discrete-event simulators are developed concurrently, but with identical or similar purpose. Another goal of OSA is to favor the reuse and integration of simulation software components and models. To favor reuse, OSA uses a layered approach to combine the modeling, simulation, and related concerns, such as instrumentation or deployment. This ability is demonstrated by the successful integration and reuse of third-party components, such as Scave, the analysis module of Omnet++, or a large number of the James II plugins developed by the University of Rostock. OSA is both a testbed for experimenting new simulation techniques and a tool for real case studies.

OSA is Open Source (LGPL) and is available for download on the INRIA forge server http://osa.gforge.inria.fr/.

See also the web page http://osa.inria.fr/.

5.5. SageMath

Participants: Nathann Cohen [correspondant], David Coudert, Leonardo Sampaio.

Developed in Python, Cython, and C++. N. Cohen wrote more than 180 patches and N. Cohen, D. Coudert and L. Sampaio reviewed more than 120 others for inclusion in Sage.

Sagemath is a free open-source mathematics software aiming at becoming an alternative to Maple and Matlab. Initially created by William Stein (Professor of mathematics at Washington University), Sagemath is currently developed by more than 180 contributors around the world (mostly researchers). It has currently more than 200 MB of source code and the graph module consists of 40,000 lines. It was initially of interest for Mascotte because of its large library in Combinatorics and Graph Theory. This year, impressive improvements have been made to this library. In particular, N. Cohen contributed a lot into the following: 1) implementation of a generic interface between Sage and existing (Mixed Integer) Linear Program solvers, 2) implementation of exact algorithms for common Polynomial/NP-Complete graph problems, often through the use of Linear Programs, and 3) improving Sage's documentation by participating to the writing of a french manual on the use of Sage with 10 other french scientists. New patches are in preparation in the group for possible inclusion in Sage.

Sage's Graph and Linear Programing libraries are currently used by Mascotte members to test algorithms or compare their performances, as well as to prove/disprove theoretical conjectures and for teaching purposes in the Master IFI, stream UBINET.

5.6. Utilities

5.6.1. Java4unix

Participant: Luc Hogie [correspondant].

More than 5,000 lines, developed in Java.

Java4unix proposes a development and distribution framework which simplifies the use of Java for UNIX software programming/distribution. Until now, Java could hardly be used for the development UNIX applications because invoking Java applications from the UNIX shell must be done through an explicit call to the Java virtual machine and writing simple things in Java often requires long coding. Java4unix aims at filling those two gaps by providing a UNIX installer for java applications, turning them to standard UNIX application and a framework that UNIX programmers may use to manipulate files/text, etc.

Java4unix includes a module which enables the reporting and automatic releasing of Eclipse Java projects. This module was formely separated from Java4unix and was referred to as EPR.

See also the web page http://www-sop.inria.fr/members/Luc.Hogie/java4unix/.

5.6.2. Jalinopt

Participants: Luc Hogie [correspondant], Grégory Morel.

Developed in Java.

Many mathematical and engineering problems can be expressed as linear programs, and doing so facilitates their resolution. Indeed it is generally more convenient to transform a domain-specific problem into a linear-optimizable one (that can be solved by any solver) rather than writing a complex domain-specific algorithm. In the case of graph theory, problems like flows, minimum vertex cover, maximum stable can be conveniently represented via linear programs.

Jalinopt is a Java toolkit for building and solving linear programs. It consists of a straightforward object-oriented model for linear programs, as well as a bridge to most common solvers, including GLPK and CPLEX.

Altought Jalinopt is inspired by Mascopt and JavaILP, it provides a significantly different model and an utterly different approach to connecting to the solver. In particular this approach, based in inter-process piping, offers better portability, and the possibility to connect (via SSH) to solvers on remote computers.

See also the web page http://www-sop.inria.fr/members/Luc.Hogie/jalinopt/.

5.6.3. JavaFarm

Participant: Luc Hogie [correspondant].

More than 1,500 lines, developed in Java.

JavaFarm is a middleware enabling the distribution of Java applications across farms of servers. Its workflow basically enables an application to locally aggregate code and data into an object, called job that will migrate to another computer, where it will be computed. When a job completes, its result is transferred back to the caller. Among other features, JavaFarm supports futures (asynchronous job executions), thereby enabling parallelization of the distributed code. The design objectives of JavaFarm are to make distribution and parallelism as transparent and easy as possible.

See also the web page http://www-sop.inria.fr/members/Luc.Hogie/javafarm/.

5.6.4. Mascsim

Participants: Luc Hogie [correspondant], Aurélien Lancin, Issam Tahiri.

Around 12,000 lines, developed in Java.

Mascsim is a distributed discrete event simulator whose main target is to be easy to use.

Unlike most discrete-event simulators, the researcher who is using Mascsim is required to provide only the bare minimum material needed for the simulation: a model for the system, a set of events describing what is going on in the system, as well as a set of metrics of interest.

The simulation process is then entirely automatized.

See also the web page http://www-sop.inria.fr/mascotte/software/mascsim/.

5.6.5. P2PVSim

Participant: Remigiusz Modrzejewski [correspondant].

Around 8,000 lines, developed in Python.

P2PVSim is a simple discrete-event simulator created for analyzing theoretical properties of peer-to-peer live video streaming algorithms. Implemented in Python it was designed with clarity and extensibility in mind from the beginning. It is capable of simulating overlays of a few thousands of peers. Multiple control protocols have been implemented. At the same time, a lot of work was put into the performance and scalability aspects of the software. Currently it is meant for simulating overlays of a few thousand peers running multiple control protocols that have been implemented.

6. New Results

6.1. Network Design and Optimization

Participants: Jean-Claude Bermond, Nathann Cohen, David Coudert, Frédéric Giroire, Dorian Mazauric, Joanna Moulierac, Nicolas Nisse, Ronan Pardo Soares, Issam Tahiri.

6.1.1. Backbone and Broadband Networks

Network design is a very wide subject that concerns all kinds of networks. We mainly study telecommunications networks which can be either physical networks (backbone, access, wireless, ...) or virtual (logical) ones. The objective is to design a network able to route a (given, estimated, dynamic, ...) traffic under some constraints (e.g. capacity) and with some quality of service (QoS) requirements. Usually the traffic is expressed as a family of requests with parameters attached to them. In order to satisfy these requests, we need to find one (or many) path(s) between their end nodes. The set of paths is chosen according to the technology, the protocol or the QoS constraints. For instance, optical backbones use the WDM technology to take better advantage of the capacity of the optical fibers often already installed. This is achieved through the multiplexing of several wavelength channels onto the same fiber. In that case a resource allocation is an optical channel, also called lightpath, which includes a path and wavelengths assigned to its links, one per link. If wavelength translation is performed in optical switching, then each channel may be assigned different wavelengths on the links of its path; otherwise the wavelength continuity imposes all the links to have the same wavelength. Of course, two lightpaths sharing a link must use different wavelengths on that link. The design can be done at the conception of the network (i.e. when conceiving a virtual network in MPLS where we have to establish virtual paths) or to adapt the network to changes (failures, new link, updates of routers, variation of traffic, ...). Finally there are various optimization criteria which differ according to the point of view: for a network user they are related to his/her satisfaction (minimizing delays, increasing available bandwidth, ...), while for a network operator, economics criteria like minimizing deployment and operating costs are more important.

This very wide topic is addressed by a lot of academic and industrial teams in the world. Our approach is to attack these problems with tools from Discrete Mathematics.

6.1.1.1. Traffic Grooming

In a WDM network, routing a connection request consists in assigning to this request a route in the physical network and a wavelength. When each request uses at most $1/C$ of the bandwidth of the wavelength, we say that the grooming factor is C. It means that on a given link of the network we can groom at most C requests on the same wavelength. Under this constraint the objective can be either to minimize the number of wavelengths (related to the transmission cost) or to minimize the number of Add/Drop Multiplexers (ADM) used in the network (related to the cost of the nodes). During the last years, we have addressed this problem in various WDM network topologies with the goal of minimizing the total number of required ADMs.

This year, we considered the minimization of the number of ADMs in optical WDM bidirectional rings, considering symmetric shortest path routing and all-to-all unitary requests [24]. We formulate the problem in terms of graph decompositions, and state a general lower bound for all the values of the grooming factor C and N, the size of the ring. We have studied exhaustively the cases $C = 1$, $C = 2$, and $C = 3$, providing improved lower bounds, optimal constructions for several infinite families, as well as asymptotically optimal constructions and approximations. We have also studied the case $C > 3$, focusing specifically on the case $C = k(k + 1)/2$ for some $k \geq 1$. We have also proposed optimal decompositions for several congruence classes of N using the existence of some combinatorial designs.

6.1.1.2. Routing Reconfiguration and its Links with Graph Searching

In production networks, traffic evolution, failures and maintenance operations force to adapt regularly the current configuration of the network (virtual topology, routing of connections). The routing reconfiguration problem in WDM networks is thus to schedule the *migration* of established lightpaths from current routing to a new pre-computed one while minimizing service disruptions. We have shown in the past the relations between this problem and the *graph searching problem* (see also Section 6.4.3).

This year, we have continued studying the tradeoffs between the total number and the number of simultaneous interruptions that occurs during the reconfiguration process, proving in particular that the knowledge of one parameter does not help to optimize the other [28], [15]. We have also started investigating the influence of physical layer impairment constraints on the reconfiguration problem [74]. More precisely, using a new wavelength in a fiber of a WDM network forces to tune or recalibrate all already used wavelengths. We thus model the cost of using a new wavelength with a linear function of the number of already used wavelengths. We have then studied the problem of minimizing the cost of the reconfiguration according to this function. We have shown that this optimization problem is already NP-complete in a two-node network. We have also obtained general bounds and characterized instances for which the problem can be solved in polynomial time. We have additionaly proposed and evaluated heuristics.

6.1.1.3. Green Networking

The minimization of ICT (Information and Communications Technologies) energy consumption has become a priority with the recent increase of energy cost and the new sensibility of public, governments and corporations towards energy consumption. ICT alone is responsible of 2% to 10% (depending on the estimations) of the world power consumption. For example, it is estimated that switches, hubs, routers account for 6 TWh per year in the US.

Several studies exhibit that the traffic load of the routers only has a small influence on their energy consumption. Hence, the power consumption in networks is strongly related to the number of active network elements, such as interfaces, line cards, base chassis, etc. In [78], [15], we have defined and modeled formally the problem of finding a routing that minimizes the (weighted) number of active network elements. We have proved that this problem is not in APX, that is there is no polynomial-time constant-factor approximation algorithm to solve it. We have obtained general bounds for this problem, and bounds for particular topologies such as trees, grids, and cliques. We have also proposed a heuristic algorithm offering good performance on real topologies. Last, we have analyzed the impact of energy efficient routing on the stretch factor and on fault tolerance.

We have also studied potential energy savings in fixed broadband wireless networks [77], [61]. See Section 6.1.2.1 for more details.

6.1.1.4. Xcast6 Treemap Islands

IP multicast is a protocol that deals with group communications with the aim of reducing traffic redundancy in the network. However, due to difficulty in deployment and poor scalability with a large number of multicast groups, IP multicast is still not widely deployed nor used on the Internet. Recently, Xcast6 and Xcast6 Treemap, the two network layer multicast protocols, have been proposed with complementary scaling properties to IP multicast: they support a very large number of active multicast sessions. However, the key limitation of these protocols is that they only support small multicast groups. To overcome this limitation, we have proposed the Xcast6 Treemap Island [96], a hybrid model of Application Layer Multicast (ALM) and Xcast6 that can work for large multicast groups. Our model has several advantages: ease of deployment, efficiency in bandwidth savings, no control message between end-host and router, zero multicast forwarding state at router and no need for a multicast address allocation protocol. In addition, this model is a potential service from which an ISP (Internet Service Provider) can get new revenue. We have shown the feasibility of our model by simulation and comparison with IP multicast and NICE protocols.

6.1.1.5. Time-Dependent Graphs - Applications to Transport Networks

In [70], we focus on time-dependent graphs which seem to be a good way to model transport networks. In the first part, we remind some notations and techniques related to time-dependent graphs. In the second one, we introduce new algorithms to take into account the notion of probability related to paths in order to guarantee travelling times with a certain accuracy. We also discuss different probabilistic models and show the links between them.

Other results on multi-interface networks were obtained outside of MASCOTTE [37], [36], [65], [63], [66], [52], [20].

6.1.2. Wireless Networks

MASCOTTE has conducted an intense research effort on wireless access networks. From the technological and architectural point of view, the field is broad, from mesh (or multi-hop cellular) networks to ad-hoc and sensor networks. Nevertheless, many questions and approaches are generic from an algorithmic and structural prospect. In particular, we have considered three of the most prominent performance metrics for radio networks. Using combinatorial optimization and centralized algorithmic with a network design flavor, fast data gathering, call scheduling, transport capacity and energy consumption of the networks have been studied. Our approach is complementary with those developed in other INRIA project-teams such as PLANETE, MAESTRO, SWING, or POPS. The complementarity has been exploited through a joint Ph.D. between MAESTRO and MASCOTTE [15], through an ANR VERSO project in which MAESTRO, MASCOTTE, and SWING are involved, and through regular collaborations with POPS. At the international level, we cooperate with some groups in renowned research centers such as CTI of Patras in Greece, RWTH Aachen in Germany, Universities of Roma or Salerno in Italy, the Technion Institute in Israël, SFU in Vancouver, Canada, UFC Universidade Federal do Ceará, Fortaleza, Brazil, or the University of Sao Paulo in Brazil. We studied a wide range of issues of wireless networks, from the design of efficient cross-layer medium access, call scheduling and routing techniques to energy efficient optimization. We developed theoretical tools for integrating dynamic caracteristics of the networks in the optimization models, and analyzing and evaluating dynamic networks. Some graph coloring problems motivated by channel assignment in wireless networks are detailed in Section 6.3.

6.1.2.1. Wireless Backhaul

We have investigated network optimization problems related to the design and configuration of fixed wireless microwave backhaul - the portion of the network infrastructure that provides interconnectivity between the access and the core networks. Unlike wired networks, the capacity of a microwave radio link is prone to variations, either due to external factors (e.g., weather) or by the action of the network operator. This fundamental difference raises a variety of new issues to be addressed appropriately. We concentrated on conceiving reliable fixed broadband wireless networks under outage probability constraints [60], [59]. We have developed a joint optimization of data routing and bandwidth assignment that minimizes the total renewal fees of licenses, while handling all the traffic requirements simultaneously. We have proposed a chance-constrained mathematical program taking into account unreliable channel conditions. This approach remains one of the main challenges of modern stochastic programming and it is still considered as very difficult and widely intractable. We have derived integer linear programming (ILP) counterparts for these chance-constrained programs and propose cutset-based valid inequalities to enhance the performance of ILP solvers. Computational results illustrate the price of reliability and present a comparative study on the performance of the different formulations. Moreover, we have been interested in potential energy savings in fixed broadband wireless networks by selectively turning off idle communication devices in low-demand scenarios [77], [61]. We have proposed a mathematical formulation of the problem relying on a fixed-charge capacitated network design (FCCND) problem, which is very hard to optimize. We have derived from this modeling heuristic algorithms producing feasible solutions in a short time. This work was done in collaboration with the SME 3Roam, and partially developed within the scope of the joint project RAISOM (Réseaux de collecte IP sans fil optimisés).

6.1.2.2. Wireless Mesh Networks

We have addressed the problem of computing the transport capacity of Wireless Mesh Networks (WMNs) dedicated to Internet access [26]. Routing and transmission scheduling have a major impact on the capacity provided to the clients. A cross-layer optimization of these problems allows the routing to take into account contentions due to radio interference. We have presented a generic Mixed Integer Linear Programing (MILP) addressing gateway placement, routing, and scheduling optimizations in a WMN. We have then derived new optimization models that can take into account a large variety of radio interference models, and QoS requirements on the routing. We also provide efficient resolution methods that deal with realistic size instances. It allows to work around the combinatoric of simultaneously achievable transmissions and point out a critical region in the network bounding the network achievable capacity. Based upon strong duality arguments, it is then possible to restrict the computation to a bounded area. It allows for computing solutions very efficiently on large networks. We have then extended our models to deal with the dynamic caracteristics of the network [75]. We have proposed a new robust optimization model that considers traffic demand uncertainty, in order to compute an optimal robust routing and bandwidth allocation in WMNs. We have presented a linear program efficiently solved by column generation, and we have quantified the price of robustness, i.e. the additional cost to pay in order to obtain a feasible solution for the robust scheme.

We have additionally investigated on the feasibility of providing network connectivity to vehicles over a predefined trajectory (trains, metros, urban buses, etc.) [14]. The communication between the vehicle and the infrastructure network is based only on WiFi technology. The contributions of this work are two-fold: 1) the horizontal handover (between WiFi access points) and 2) the design and analysis of an infrastructure network (backbone network plus WiFi access network) deployed along the trajectory of the vehicle.

6.1.2.3. Data Gathering

We have studied algorithmic and complexity issues originating from the problem of data gathering in wireless networks [56]. We give an algorithm to construct minimum makespan transmission schedules for data gathering when the communication graph is a tree network, the interference range is *any* integer $m \geq 2$, and no buffering is allowed at intermediate nodes. In the interesting case in which all nodes have to deliver an arbitrary non-zero number of packets, we provide a closed formula for the makespan of the optimal gathering schedule. Additionally, we consider the problem of determining the computational complexity of data gathering in general graphs and show that the problem is weakly NP-complete. On the positive side, we design a simple $(1 + 2/m)$ factor approximation algorithm for general networks. We have also considered the data gathering process in multi-hop wireless sensor networks [76], [57]. Wireless sensors networks (WSNs) are deployed to collect huge amounts of data from the environment. This produced data has to be delivered through sensor's wireless interface using multi-hop communications toward a sink. The position of the sink impacts the performance of the wireless sensor network regarding delay and energy consumption especially for relaying sensors. Optimizing the data gathering process in multi-hop wireless sensor networks is, therefore, a key issue. We have addressed the problem of data collection using mobile sinks in a WSN. We provide a multi-objective optimization framework that studies the trade-off between energy consumption and delay of data collection. This framework provides solutions that allow decision makers to optimally design the data gathering plan in wireless sensor networks with mobile sinks.

6.1.3. P2P Networks

6.1.3.1. Performance Analysis of Distributed Storage Systems

Distributed or peer-to-peer storage solutions rely on the introduction of redundant data to be fault-tolerant and to achieve high reliability. To ensure long-term fault tolerance, the storage system must have a self-repair service that continuously reconstructs lost fragments of redundancy. The speed of this reconstruction process is crucial for the data survival. In [93], we propose a new analytical framework, based on queuing models, to estimate the repair time and the probability of data loss. This model takes into account the correlation of concurrent repairs. The models and schemes proposed are validated by mathematical analysis, extensive set of simulations, and experimentation using the Grid'5000 test-bed platform. Recently, the Regenerating Codes were proposed as an improvement over classical replication and erasure codes to introduce redundancy. These codes make a better use of the available bandwidth when reconstructing the missing information. In [50], we propose a new code based on a hybrid approach, Double Coding, and compare it to existing codes from the point of view of availability, durability and storage space.

6.1.3.2. Well Balanced Designs for Data Placement

In collaboration with MAESTRO. The problem we consider in [88] is motivated by data placement, in particular, data replication in video on-demand systems. We are given a set V of n servers and b files (data, documents). Each file is replicated on exactly k servers. A placement consists in finding a family of b subsets of V (representing the files) called blocks each of size k. Each server has some probability to fail and we want to find a placement which minimizes the variance of the number of available files. It was conjectured that there always exists an optimal placement (with variance better than that of any other placement for any value of the probability of failure). We show that the conjecture is true if there exists a well balanced design, that is a family of blocks, such that each j-element subset of V, $1 \leq j \leq k$, belongs to the same or almost the same number of blocks (difference at most one). The existence of well balanced designs is a difficult problem as it contains as subproblem the existence of Steiner systems. We completely solve the case $k = 2$ and give bounds and constructions for $k = 3$ and some values of n and b.

6.1.3.3. Peer-Assisted Time-shifted Streaming Systems: Design and Promises

Time-shifted streaming (or catch-up TV) allows viewers to watch their TV programs within an expanded time window. In [71], we emphasize the challenging characteristics of time-shifted TV systems that prevent known delivery systems to be used. We model time-shifted TV as multiple-interval graph, then we present a Peer-Assisted Catch-Up Streaming system, namely PACUS, where a set of end users' computers assists the server for the content delivery. We show in particular how the PACUS tracker server can be efficiently implemented for catch-up TV. We demonstrate the benefits of PACUS by simulations. We especially highlight that PACUS reduces the traffic at the server side with the advantages of lightweight and self-adaptive unstructured peer-to-peer systems.

6.2. Simulation and Optimization Tools

Participants: Olivier Dalle, Luc Hogie, Aurélien Lancin, Emilio Mancini, Juan-Carlos Maureira, Philippe Mussi, Van Dan Nguyen, Judicaël Ribault, Issam Tahiri.

The works related to simulation and optimization tools address two kinds of issues: issues related to the development of the tools and their associated methodology, and issues related to the use of these tools in order to investigate a particular problem or assess the performances or properties of a particular system.

Since 2005, MASCOTTE has been developing a discrete event simulation architecture, named OSA, whose aim is to investigate how new software engineering techniques, such as component-based frameworks or Aspect Oriented Programming can help improving the simulation methodology, especially in terms of software reuse [16], [46], [47]. After six years of research development, OSA entered in the process of being diffused in 2011. This process is supported by a two-year INRIA "Development Action" (ADT) funding. This first year was devoted to cleaning the code base and produce a public release with a significant effort placed on user documentation and tutorial (cf http://osa.inria.fr/).

Aside our efforts on the OSA project, we are strongly involved in the USS-SimGrid ANR funded project, whose aim is at developing an efficient simulation platform geared at Grid Computing and very large scale distributed computing architectures. In this project, we worked on two tasks:

- Monitoring and characterization of the workload of large scale distributed applications [68];
- Support for modeling Peer-to-peer applications in the SimGrid simulator (originally designed for modeling grid-computing platforms).

We also pursued our involvement in the Discrete Event Systems Specification (DEVS) standardization effort [81], [82]. This formalism has reached a strong agreement amongst the community, but it still lacks implementation standard. Since OSA is aimed at providing better support for methodology, we consider necessary to support DEVS and participate to this effort. Our particular focus was on techniques and Architecture Description Languages (ADLs) for describing very large models of distributed applications [69].

Regarding our works on simulation studies and application-oriented developments, this year was the conclusion of our effort on the Internet on Rails project [14]. In this project, we studied and designed, both by means of simulations and experimentations, a low cost communication architecture based on IEEE 802.11 WiFi to provide high quality Internet access onboard high speed trains.

6.3. Graph Theory

Participants: Julio Araújo, Jean-Claude Bermond, Nathann Cohen, Frédéric Giroire, Frédéric Havet, František Kardoš, Ana Karolinna Maia, Dorian Mazauric, Remigiusz Modrzejewski, Leonardo Sampaio, Michel Syska.

MASCOTTE principally investigates applications in telecommunications via Graph Theory (see other objectives). However it also studies a number of theoretical problems of general interest. Our research mainly focused on graph coloring and some other problems arising from networks problems.

6.3.1. Graph Coloring

Coloring and edge-coloring are two central concepts in Graph Theory. There are many important and long-standing conjectures in these areas. We are trying to make advances towards such conjectures, in particular Steinberg's conjecture, the List coloring Conjecture and the Acyclic Edge-Coloring Conjecture.

We are also interested in coloring problems arising from some practical problems: improper coloring, $L(p, q)$-labeling, directed star arboricity and good edge-labelling. The first two are both motivated by channel assignment and the last two by problems arising in WDM networks. For many practical problems are posed in a dynamic setting, we study on-line coloring and list coloring.

We also study some other variants of coloring like non-repetitive coloring or frugal coloring.

For all the coloring problems, we also consider the associated algorithmic problem, which consists in designing algorithms for finding the minimum number of colors of a coloring of a given graph. Algorithmic results on graph coloring are presented in Section 6.4.

The most classical notion of coloring (of edges or vertices) is the one of proper coloring, in which we insist on two adjacent elements to have distinct colors. However, it is usual to consider additional constraints,as well as relaxed constraints. For each variant of coloring, one can consider, its list version in which every element x is given a list $L(x)$ of prescribed colors. A graph is said to be *L-colorable* if is has an L-coloring (fulfilling the constraints) such that $x \in L(x)$ for all element x. The *choosability* of a graph G is the smallest integer k for which G has an L-coloring whenever $|L(x)| \geq k$ for all elements x.

6.3.1.1. Coloring Graphs with Few Crossings

The famous Four Color Theorem states that every planar graph can be properly colored with 4 colors and Thomassen Five Color Theorem states that the choosability of every planar graph is at most 5. Hence, a natural question is to ask about the chromatic number and choosability of graphs with few crossings. In [38], we disprove a conjecture of Oporowski and Zhao stating that every graph with crossing number at most 5 and clique number at most 5 is 5-colorable. However, we show that every graph with crossing number at most 4 and clique number at most 5 is 5-colorable. We also show some colorability results on graphs that can be made planar by removing few edges. In particular, we show that if there exists three edges whose removal leaves the graph planar then it is 5-colorable. In [90], we show that every graph with two crossings is 5-choosable. We also prove that every graph which can be made planar by removing one edge is 5-choosable.

Another famous theorem on planar graphs is the one of Grötzsch, which says that every planar graph with no cycle of length 3 can be properly 3-colored. Steinberg's Conjecture (1976) asserts that a graph with no cycles of length 4 or 5 is 3-colorable. Many approaches have been used towards this conjecture. We considered the following one in which, we relax the constraints on the color classes. Instead of insisting on them be independent sets, we allow them to induce a graph with some bounded degree. A graph $G = (V, E)$ is said to be *(i, j, k)-colorable* if its vertex set can be partitioned into three sets V_1, V_2, V_3 such that the graphs $G[V_1], G[V_2], G[V_3]$ induced by the sets V_1, V_2, V_3 have maximum degree at most i, j, k respectively. Under this terminology, Steinberg's Conjecture says that every graph with no cycle of length 4 or 5 is $(0, 0, 0)$-colorable. In [91], we prove that every graph of $\mathcal{F}$ is $(2, 1, 0)$-colorable and $(4, 0, 0)$-colorable.

6.3.1.2. Acyclic, Linear and Frugal Colorings

A classical constraint added to a proper coloring is that at least three colors appears on each cycle, in which case we speak about acyclic coloring. In other words, the graph induced by the elements of any two color classes is a forest. The *acyclic chromatic index* of a graph G, denoted $\chi'_a(G)$ is the minimum k such that G admits an *acyclic edge-coloring* with k colors. The famous Acyclic Edge-Coloring Conjecture asserts that $\chi'_a(G) = \Delta(G) + 2$, where $\Delta(G)$ is the maximum degree of the graph. In [21], we conjecture that if G is planar and $\Delta(G)$ is large enough then $\chi'_a(G) = \Delta(G)$. We settle this conjecture for planar graphs with girth at least 5. We also show that $\chi'_a(G) \leq \Delta(G) + 12$ for all planar G.

Even stronger constraints are the following: a proper coloring of a graph is *2-frugal* (resp. *linear*) if the graph induced by the elements of any two color classes is of maximum degree 2 (resp. is a forest of paths). In [29], we improve some bounds on the 2-frugal choosability and linear choosability of graphs with small maximum average degree.

6.3.1.3. Coloring of Plane Graphs with Constraints on the Faces

We studied several variants of vertex and edge colorings of plane graphs insisting one some constraints on the faces.

A face of a vertex colored plane graph is called *loose* if the number of colors used on its vertices is at least three. The *looseness* of a plane graph G is the minimum k such that any surjective k-coloring involves a loose face. In [35], we prove that the looseness of a connected plane graph G equals the maximum number of vertex disjoint cycles in a dual graph G^* increased by 2. We also show upper and lower bounds on the looseness of graphs based on the number of vertices, the edge connectivity, and the girth of the dual graph. These bounds improve the result of Negami for the looseness of plane triangulations. We also present infinite classes of graphs where the equalities are attained.

A vertex coloring of a 2-connected plane graph G is a *strong parity vertex coloring* if for every face f and each color c, the number of vertices incident with f colored by c is either zero or odd. Czap et al. [Discrete Math. 311 (2011) 512–520] proved that every 2-connected plane graph has a proper strong parity vertex coloring with at most 118 colors. In [34], we improve this upper bound for some classes of plane graphs.

A *facial parity edge coloring* of a connected bridgeless plane graph is such an edge coloring in which no two face-adjacent edges (consecutive edges of a facial walk of some face) receive the same color, in addition, for each face α and each color c, either no edge or an odd number of edges incident with α is colored with c. From Vizing's theorem it follows that every 3-connected plane graph has a such coloring with at most $\Delta^* + 1$ colors, where Δ^* is the size of the largest face. In [33] we prove that any connected bridgeless plane graph has a facial parity edge coloring with at most 92 colors.

A sequence $r_1, r_2, \cdots, r_{2n}$ such that $r_i = r_{n+i}$ for all $1 \leq i \leq n$, is called a *repetition*. A sequence S is called *non-repetitive* if no *block* (i.e. subsequence of consecutive terms of S) is a repetition. Let G be a graph whose edges are colored. A trail is called *non-repetitive* if the sequence of colors of its edges is non-repetitive. If G is a plane graph, a *facial non-repetitive edge-coloring* of G is an edge-coloring such that any *facial trail* (i.e. trail of consecutive edges on the boundary walk of a face) is non-repetitive. We denote $\pi'_f(G)$ the minimum number of colors of a facial non-repetitive edge-coloring of G. In [41], we show that $\pi'_f(G) \leq 8$ for any plane graph G. We also get better upper bounds for $\pi'_f(G)$ in the cases when G is a tree, a plane triangulation, a simple 3-connected plane graph, a hamiltonian plane graph, an outerplanar graph or a Halin graph. The bound 4 for trees is tight.

6.3.1.4. Improper Coloring

In [85] and [48], we study a coloring problem motivated by a practical frequency assignment problem and up to our best knowledge new. In wireless networks, a node interferes with the other nodes the level of interference depending on numerous parameters: distance between the nodes, geographical topography, obstacles, etc. We model this with a weighted graph G where the weights on the edges represent the noise (interference) between the two end-nodes. The total interference in a node is then the sum of all the noises of the nodes emitting on the same frequency. A weighted t-improper k-coloring of G is a k-coloring of the nodes of G (assignment of k frequencies) such that the interference at each node does not exceed some threshold t. The Weighted Improper Coloring problem, that we consider here consists in determining the weighted t-improper chromatic number defined as the minimum integer k such that G admits a weighted t-improper k-coloring. We also consider the dual problem, denoted the Threshold Improper Coloring problem, where given a number k of colors (frequencies) we want to determine the minimum real t such that G admits a weighted t-improper k-coloring. We show that both problems are NP-hard and first present general upper bounds; in particular we show a generalization of Lovász's Theorem for the weighted t-improper chromatic number. We then show how to transform an instance of the Threshold Improper Coloring problem into another equivalent one where the weights are either 1 or M, for a sufficient big value M. Motivated by the original application, we study a special interference model on various grids (square, triangular, hexagonal) where a node produces a noise of intensity 1 for its neighbors and a noise of intensity 1/2 for the nodes that are at distance 2. Consequently, the problem consists of determining the weighted t-improper chromatic number when G is the square of a grid and the weights of the edges are 1, if their end nodes are adjacent in the grid, and 1/2 otherwise. Finally, we model the problem using linear integer programming, propose and test heuristic and exact Branch-and-Bound algorithms on random cell-like graphs, namely the Poisson-Voronoi tessellations.

6.3.1.5. On-line Coloring

Several on-line algorithms producing colorings have been designed. The most basic and most widespread one is the greedy algorithm. The largest number of colours that can be given by the greedy algorithm on some graph. is called its *Grundy number*. Determning the Grundy number of a graph is NP-hard even for P_5-free graphs, while it is poynomial-time solvable for P_4-free graphs. In [19], we define a new class of graphs, namely the fat-extended P_4-laden graphs, which intersects the class of P_5-free graphs and strictly contains the one of P_4-free. We show a polynomial-time algorithm to determine the Grundy number of such graphs. It implies that the Grundy number can be computed in polynomial time for most graph classes defined in terms of containing few P_4's: P_4-reducible, extended P_4-reducible, P_4-sparse, extended P_4-sparse, ...

In [94], we study a game version of greedy coloring. Given a graph $G = (V, E)$, two players, Alice and Bob, alternate their turns in choosing uncolored vertices to be colored. Whenever an uncolored vertex is chosen, it is colored by the least positive integer not used by any of its colored neighbors. Alice's goal is to minimize the total number of colors used in the game, and Bob's goal is to maximize it. The game Grundy number of G is the number of colors used in the game when both players use optimal strategies. It is proved in this paper that the maximum game Grundy number of forests is 3, and the game Grundy number of any partial 2-tree is at most 7. We also gave some complexity results on b-colorings, which is a manner of improving colorings on-line [43].

6.3.1.6. Other Results on Graph Coloring

In [18], we aim at characterizing the class of graphs that admit a good edge-labelling. Such graphs are interesting, as they correspond to set of requests in UPP-digraphs (those in which there is at most one dipath from a vertex to another) for which the minimum number of wavelengths is equal to the maximum load. This implies that the problem can be solved efficiently. First, we exhibit infinite families of graphs for which no good edge-labelling can be found. We then show that deciding if a graph admits a good edge-labelling is NP-complete. Finally, we give large classes of graphs admitting a good edge-labelling: C3 -free outerplanar graphs, planar graphs of girth at least 6, subcubic C3, K2, 3 -free graphs.

A *wheel* is a graph formed by a chordless cycle and a vertex that has at least three neighbors in the cycle. We prove in [83] that every 3-connected graph that does not contain a wheel as a subgraph is in fact minimally 3-connected. We prove that every graph that does not contain a wheel as a subgraph is 3-colorable. We were then told that this result was already proved by Thomassen, though with a different proof.

Gallai-Hasse-Roy-Vitaver Theorem states that every n-chromatic digraph contains a directed path of order n. Let $f(k)$ be the smallest integer such that every $f(k)$-chromatic digraph contains every oriented tree of order k. Burr proved that $f(k) \leq (k-1)^2$ and conjectured $f(k) = 2n - 2$. In [84], we give some sufficient conditions for an n-chromatic digraphs to contains some oriented tree. In particular, we show that every acyclic n-chromatic digraph contains every oriented tree of order n. We also show that $f(k) \leq k^2/2 - k/2 + 1$. Finally, we consider the existence of antidirected trees in digraphs. We prove that every antidirected tree of order k is contained in every $(5k-9)$-chromatic digraph. We conjecture that if $|E(D)| > (k-2)|V(D)|$, then the digraph D contains every antidirected tree of order k. This generalizes Burr's conjecture for antidirected trees and the celebrated Erdős-Sós Conjecture. We give some evidences for our conjecture to be true.

6.3.2. Matchings and Independent Sets

Matchings and independent sets are important substructures which appears in many problems. In particular, color classes of vertex-colorings and edge-colorings are independent sets and matchings, respectively.

In [45], we show that every (sub)cubic n-vertex graph with sufficiently large girth has fractional chromatic number at most 2.2978 which implies that it contains an independent set of size at least $0.4352n$. Our bound on the independence number is valid to random cubic graphs as well as it improves existing lower bounds on the maximum cut in cubic graphs with large girth.

In [39], we show that every cubic bridgeless graph G has at least $2^{|V(G)|/3656}$ perfect matchings. This confirms an old and celebrated conjecture of Lovász and Plummer in the 1970's. This improves the first superlinear bound given in [40].

6.3.3. Hypergraphs

Hypergraphs, also called set systems, are a natural generalization of graphs. In a graph an edge is set of two vertices, while in a hypergraph an edge is a set of any size. It turns out to be an important notion in database theory. A digraph is α-acyclic if it can be reduced to the null hypergraph by succesively removing either a vertex which in at most one edge or an edge included in another. It is one of the possible generalizations of forest to hypergraphs. The α-arboricity of a hypergraph H is the minimum number of α-acyclic hypergraphs that partition the edge set of H. In [23], the α-arboricity of the complete 3-uniform (every edge is a set of 3 vertices) hypergraph is determined completely.

In [80], we generalize the concept of line digraphs to line dihypergraphs. We give some general properties in particular concerning connectivity parameters of dihypergraphs and their line dihypergraphs, like the fact that the arc connectivity of a line dihypergraph is greater than or equal to that of the original dihypergraph. Then we show that the De Bruijn and Kautz dihypergraphs (which are among the best known bus networks) are iterated line digraphs. Finally we give short proofs that they are highly connected.

6.3.4. Miscellaneous

6.3.4.1. Zagreb Indices

The first and second Zagreb indices of a graph are defined by $M_1 = \sum_{v \in V(G)} d(v)^2$ and $M_2 = \sum_{uv \in E(G)} d(u)d(v)$, respectively. They are used in chemistry where it represents properties of molecules. In [17], we present some classes of graphs with prescribed degrees that satisfy $M_1/n \leq M_2/m$, where M_1 and M_2 are the first and second Zagreb indices. We also prove that for any $\Delta \geq 5$, there is an infinite family of graphs of maximum degree Δ such that the inequality is false. Moreover, we give alternative and slightly shorter proof of this inequality for trees and unicyclic graphs.

6.3.4.2. Induced Decomposition

An *induced H-decomposition* of a graph G is a partition $(E_1, \cdots, E_k)$ of its edge set $E(G)$, such that the graph induced by each E_i, $1 \leq i \leq k$, is a copy of H. Bondy and Szwarcfiter asked for the maximum number $ex(n, H)$ of edges in a graph on n vertices which admits an induced H-decomposition. In [13], we prove that for every non-empty graph H, $ex(n, H) = n(n-1)/2 - o(n^2)$.

6.4. Algorithms

Participants: Julio Araújo, Janna Burman, Nathann Cohen, David Coudert, Gianlorenzo d'Angelo, Frédéric Giroire, Frédéric Havet, František Kardoš, Dorian Mazauric, Nicolas Nisse, Stéphane Pérennes, Ronan Pardo Soares, Leonardo Sampaio.

MASCOTTE is also interested in the algorithmic aspects of Graph Theory. In general we try to find the most efficient algorithms to solve various problems of Graph Theory and telecommunication networks.

6.4.1. Coloring Graphs

Almost all graph coloring problems are NP-hard and most of them are even hard to approximate. Hence, to solve them efficiently, we aim at designing general exponential-time algorithms as well as polynomial-time algorithms for special classes. This is examplified by the following results.

6.4.1.1. $L(p, q)$-labeling

An $L(p, q)$-*labeling of* G is an integer assignment f to the vertex set $V(G)$ such that $|f(u) - f(v)| \geq p$, if u and v are adjacent, and $|f(u) - f(v)| \geq q$, if u and v have a common neighbor. Such a concept is a modeling of a simple channel assignment, in which the separation between channels depends on the distance. The goal is to find an $L(p, q)$-labeling f of G with minimum *span* (i.e. $\max\{f(u) - f(v), u, v \in V(G)\}$). It is well known that for all $k \geq 4$, deciding if a graph has an $L(p, 1)$-labeling with minimum span k is NP-complete. In [42], we present exact exponential time algorithms that are faster than existing ones.

6.4.1.2. Counting and Enumerating Total and Edge Colorings

In [89], we are interested in computing the number of edge colorings and total colorings of a graph. We prove that the maximum number of k-edge-colorings of a k-regular graph on n vertices is $k \cdot (k-1!)^{n/2}$. Our proof is constructible and leads to a branching algorithm enumerating all the k-edge-colorings of a k-regular graph using a time $O^*((k-1!)^{n/2})$ and polynomial space. In particular, we obtain a algorithm on time $O^*(2^{n/2}) = O^*(1.4143^n)$ and polynomial space to enumerate all the 3-edge colorings of a cubic graph, improving the running time of $O^*(1.5423^n)$ of the algorithm due to Golovach et al. We also show that the number of 4-total-colorings of a connected cubic graph is at most $3.2^{3n/2}$. Again, our proof yields a branching algorithm to enumerate all the 4-total-colorings of a connected cubic graph.

6.4.1.3. Coloring Graphs of Special Classes

For some coloring problems that are known to be NP-hard for general graphs, we give some polynomial-time algorithms for the restriction to some graph classes. These graph classes defined in terms of forbidden induced subgraphs. In [95], [79], we provide linear algorithms for coloring P_5-free graphs. In [58], we obtain polynomial time algorithms to determine the acyclic chromatic number, the star chromatic number and the harmonious chromatic number of $(q, q-4)$-graphs. Such graphs are those such that no set of at most q vertices induces more than $q-4$ distinct P4's.

6.4.2. Complexity and Computation of Graph Parameters

We used graph theory to model various networks' problems. In general we study their complexity and then we investigate the structural properties of graphs that make these problems hard or easy. In particular, we try to find the most efficient algorithms to solve the problems, sometimes focusing on specific graph classes where the problems are polynomial-time solvable.

6.4.2.1. Path Vertex Cover

A subset S of vertices of a graph G is called a k-path vertex cover if every path of order k in G contains at least one vertex from S. The k-path vertex cover problem consists in finding such a set with minimum cardinality in G. In [25], it is shown that this problem is NP-complete for each $k \geq 2$ while it can be solved in linear-time in trees. The particular case of $k = 3$ is studied in [44], where an exact algorithm is given with running time $O^*(1.5171^n)$ in n-node graphs. In [44], we also design a polynomial time randomized approximation algorithm with an expected approximation ratio of $\frac{23}{11}$ for the minimum 3-path vertex cover.

6.4.2.2. Convexity in Graphs

The geodesic convexity of graphs naturally extends the notion of convexity in euclidean metric spaces. A set S of vertices of a graph $G = (V, E)$ is convex if any vertex on a shortest path between two vertices of S also belongs to S. The convex hull of $S \subseteq V$ is the smallest convex set containing S. Finally, a hull set of a graph is a set of vertices the convex hull of it is V. The hull number of a graph G is the minimum size of a hull set in G. In [86], [49], we prove that computing the hull number is NP-complete in bipartite graphs. We also provide bounds and design various polynomial-time algorithms for this problem in different graph classes as co-bipartite graphs, P_4-sparse graphs, etc.

6.4.2.3. Induced Subdivision in Digraphs

In [51], we consider the following problem for oriented graphs and digraphs: Given an oriented graph (digraph) G, does it contain an induced subdivision of a prescribed digraph D? The complexity of this problem depends on D and on whether H must be an oriented graph or is allowed to contain 2-cycles. We give a number of examples of polynomial instances as well as several NP-completeness proofs.

6.4.2.4. Circuits in Grids

A circuit in a simple undirected graph $G = (V, E)$ is a sequence of vertices $\{v_1, v_2, \cdots, v_{k+1}\}$ such that $v_1 = v_k + 1$ and $\{v_i, v_{i+1}\} \in E$ for $i = 1, \cdots, k$. A circuit C is said to be edge-simple if no edge of G is used twice in C. In [30], we study the following problem: which is the largest integer k such that, given any subset of k ordered vertices of an infinite square grid, there exists an edge-simple circuit visiting the k vertices in the prescribed order? We prove that $k = 10$. To this end, we first provide a counterexample implying that $k < 11$. To show that $k \geq 10$, we introduce a methodology, based on the notion of core graph, to reduce drastically the number of possible vertex configurations, and then we test each one of the resulting configurations with an ILP solver.

6.4.3. Graph Searching, Cops and Robber Games

Pursuit-evasion encompasses a wide variety of combinatorial problems related to the capture of a fugitive residing in a network by a team of searchers. The goal consists in minimizing the number of searchers required to capture the fugitive in a network and in computing the corresponding capture strategy. This can also be viewed as cleaning the edges of a contaminated graph. We investigated several variants of these games.

6.4.3.1. Process Number and Routing Reconfiguration in WDM Networks

Graph searching, where the fuggitive is arbitrary fast and moves simultaneously to the searchers, has been widely studied for its close relationship with graph decompositions. More recently, a variant of graph searching, namely the graph processing game, has been widely studied as a model for the routing reconfiguration in WDM networks (see Section 6.1.1.2). In [32], we give a linear time (resp. polynomial-time) algorithm to recognize graphs (resp., digraphs) with process number at most 2, along with a characterization in terms of forbidden minors, and a structural description. In [31], we give a polynomial (both in terms of time complexity and in the number of exchanged messages) distributed algorithm to compute the process number of trees. By slightly modifying the intial parameter of the algorithm, it also allows to compute various parameters of trees as pathwidth, search number, etc.

6.4.3.2. Cops and Robber Games

The "Cops and Robber Games" are turn-by-turn games where a team of cops purchase a robber in a graph. We investigated two generalizations of the game introduced by Quilliot, Nowakoski and Winkler in 1983. We provided structural characterizations of graphs where one cop is sufficient to capture a fast fugitive able to hide [27]. In particular, one of these characterizations relies on hyperbolicity of the considered graph.

A surprising application of "Cops and Robber"-like games is the problem for a web-browser to download documents in advance while an internaut is surfing on the Web. In [92], we provide a modelling of the prefetching problem in terms of Cops and Robber games. The parameter to be optimized is then the download-speed necessary for the Internaut only accesses to already download webpages. This allows us to provide several complexity results and polynomial-time algorithms in some graph classes.

6.4.4. Distributed Algorithms

We investigated algorithmic problems arising in complex networks like the Internet or social networks. In this kind of networks, problems are becoming harder or impracticable because of the size and the dynamicity of these networks. One way to handle the dynamicity is to provide (distributed) fault tolerant algorithms. Studying the mobile agents paradigm seems to be a promissing approach (somehow related to Cops and Robber in Section 6.4.3) to adress some models of distributed computing. We considered self-stabilizing algoritms for the gathering problem, and algorithms for updating routing tables.

Besides, the more an algorithm uses local information, the easier it is to update/correct the behaviour of the algorithm. In this direction, we investigated communication problems through game theory. We also studied the power of a communication model using only localized information, i.e., we study what can be computed using this communication model.

6.4.4.1. Mobile Agents and Self-stabilization

In [64], we consider a recent model of robot-based computing which makes use of identical, memoryless mobile robots placed on nodes of anonymous graphs. The robots operate in Look-Compute-Move cycles that are performed asynchronously for each robot. In particular, we consider the case of gathering robots on an anonymous ring. We provide a new distributed approach which turns out to be very interesting as it neither completely falls into symmetry-breaking nor into symmetry-preserving techniques.

We address dynamic large scale emerging networks, e.g., mobile sensor (agent) networks. The agents are resource limited and prone to failures. They move almost unpredictably and communicate in pairs. Population Protocol model is a communication model suited for such networks. We use a recently proposed version of this model where every agent is associated with a parameter called Cover Time. Cover Times abstract the interaction characteristics of mobile agents and allow the design of fast converging protocols and the evaluation of their convergence times (this is impossible in the original model). We take advantage of this model and perform first analytical analysis of a data collection protocol used in the ZebraNet project for the wild-life tracking of zebras. We propose alternative data collection protocols for ZebraNet and we analysis their time complexities [72], [53], [54]. To achieve fault-tolerance in population protocols, we develop a generic self-stabilizing transformer [22]. This is an automatic technique to convert a protocol to its self-stabilizing version.

In addition, we address important problems of coordination and synchronization. We present and prove correct two self-stabilizing deterministic protocols solving the classical mutual exclusion problem and the group mutual exclusion one [54].

6.4.4.2. Distributed Update of Routing Tables

In [62], we propose a simple and practical distributed algorithm for computing and updating routing tables for shortest path routing. This algorithm can be combined with every distance vector shortest paths routing algorithm, and allows to reduce the total number of messages sent. We give experimental evidence that it leads to an important gain in terms of the number of messages sent at the price of a little increase in terms of space occupancy per node.

Arc-Flags is a data structure used to speed-up the shortest paths computation in a graph. In [67], we introduce a new data structure, named Road-Signs, which allows us to efficiently update the Arc-Flags of a graph in a dynamic scenario. Road-Signs can be used to compute Arc-Flags, can be efficiently updated and do not require large space consumption for many real-world graphs.

6.4.4.3. Models of Distributed Computation

Since, we need to face both locality and dynamicity issues, we are developing new techniques allowing to obtain global structural information from local (partial) views of the network. In [55], [73], we has investigated the question of determining which graph properties can or cannot be computed using only local information. We consider the following model: each of the n nodes of a graph which only knows its own ID and the IDs of its neighbours is allowed to send a message of $O(logn)$ bits to some central entity, called the referee. We then investigate whether the referee is able to decide some basic structural properties of the network topology G or not. We show that simple questions like, "does G contain a square?", "does G contain a triangle?" or "Is the diameter of G at most 3?” cannot be solved in general [55], [73]. On the other hand, the referee can decode the messages in order to have full knowledge of G when G belongs to many graph classes such as planar graphs, bounded treewidth graphs and, more generally, bounded degeneracy graphs [55], [73]. Following our framework, we are able to simulate asynchronicity of the network. In particular, we have exhibited a hierarchy of problems and distributed models of computation [87].

7. Contracts and Grants with Industry

7.1. ADR HiMa, joint laboratory INRIA / Alcatel-Lucent Bell-labs France, 10/2009 -12/2012

Participants: Jean-Claude Bermond, David Coudert, Frédéric Giroire, Joanna Moulierac.

MASCOTTE is part of the join laboratory INRIA / Alcatel-Lucent Bell-labs France within the ADR HiMa (research action on High Manageability) and works on autonomous dynamic management of virtual topologies.

7.2. Contract APRF (région PACA/FEDER) RAISOM with 3-Roam and Avisto, 05/2009 - 04/2012

Participants: Jean-Claude Bermond, David Coudert, Alvinice Kodjo, Stéphane Pérennes, Issam Tahiri.

On Wireless IP Service Deployment optimization and monitoring.

(http://www-sop.inria.fr/mascotte/projets/raisom/)

7.3. Contract CIFRE

7.3.1. Contract CIFRE with Orange Labs, 11/2009 - 11/2012

Participants: Jean-Claude Bermond, Mikaila Toko Worou.

"Convention de recherche encadrant une bourse CIFRE" on the topic *Outils algorithmiques pour la détection des communautés*.

7.3.2. Contract CIFRE with Orange Labs, 02/2011 - 01/2014

Participants: Jean-Claude Bermond, Sébastien Félix.

"Convention de recherche encadrant une bourse CIFRE" on the topic *Smart Transports: optimisation du trafic dans les villes*.

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR Jeunes Chercheurs DIMAGREEN, 09/2009-08/2012

Participants: David Coudert, Frédéric Giroire, Alvinice Kodjo, Dorian Mazauric, Joanna Moulierac, Truong Khoa Phan, Issam Tahiri.

The objectives of the project DIMAGREEN (DesIgn and MAnagement of GREEN networks with low power consumption) are to introduce and analyze energy-aware network designs and managements in order to increase the life-span of telecommunication hardware and to reduce the energy consumption together with the electricity bill.

(http://www-sop.inria.fr/teams/mascotte/Contrats/DIMAGREEN/index.php)

8.1.2. ANR Blanc AGAPE, 10/2009-09/2013

Participants: Nathann Cohen, David Coudert, Frédéric Havet, František Kardoš, Ana Karolinna Maia, Grégory Morel, Nicolas Nisse, Stéphane Pérennes, Michel Syska.

The project AGAPE (Parameterized and exact graph algorithms) is led by MASCOTTE and implies also LIRMM (Montpellier) and LIFO (Orléans). The aim of AGAPE is to develop new techniques to solve exactly NP- hard problems on graphs. To do so, we envisage two approaches which are closely related ways to reduce the combinatorial explosion of NP-hard problems: moderately exponential exact algorithms and fixed-parameter tractability.

(http://www-sop.inria.fr/mascotte/Contrats/Agape.php)

8.1.3. ANR VERSO ECOSCells, 11/2009-12/2012

Participants: David Coudert, Issam Tahiri.

The ECOSCells (Efficient Cooperating Small Cells) project aims at developing the algorithms and solutions required to allow Small Cells Network (SCN) deployment. The consortium gathers industrial groups, together with 3 SMEs and 6 research institutes: ALCATEL-LUCENT BELL LABS (leader), ORANGE LABS, 3-ROAM, SEQUANS, SIRADEL, INRIA teams MAESTRO, MASCOTTE and SWING, Université d'Avignon et des Pays de Vaucluse, Laboratoire des Signaux et Systèmes / Supelec, LAAS and Eurecom.

(http://perso.citi.insa-lyon.fr/hrivano/contrats/ecoscells.php)

8.1.4. ANR USS-SimGrid, 12/2008-12/2011

Participants: Olivier Dalle, Emilio Mancini.

The USS-SimGrid project aims at Ultra Scalable Simulations with SimGrid. This tool is leader in the simulation of HPC settings, and the main goal of this project is to allow its use in the simulation of desktop grids and peer-to-peer settings.

(http://uss-simgrid.gforge.inria.fr/)

8.1.5. Action ResCom, ongoing (since 2006)

Réseaux de communications, working group of GDR ASR, CNRS. (http://citi.insa-lyon.fr/rescom/)

8.1.6. Action Graphes, ongoing (since 2006)

Action Graphes, working group of GDR IM, CNRS. (http://www.labri.fr/perso/raspaud/pmwiki/pmwiki.php)

8.2. European Initiatives

8.2.1. FP7 Projet

8.2.1.1. EULER

Participants: David Coudert, Aurélien Lancin, Nicolas Nisse, Bi Li.

Title: EULER (Experimental UpdateLess Evolutive Routing)

Type: COOPERATION (ICT)

Challenge: Future Internet Experimental Facility and Experimentally-driven Research

Instrument: Specific Targeted Research Project (STREP)

Duration: October 2010 - September 2013

Coordinator: ALCATEL-LUCENT (Belgium)

Others partners: IBBT (Belgium), UPMC (France), UCL (Belgium), RACTI (Greece), CAT (Spain)

See also: http://www.euler-fire-project.eu/

Abstract: STREP EULER (Experimental UpdateLess Evolutive Routing) is part of FIRE (Future Internet Research and Experimentation) objective of FP7. It aims at finding new paradigms to design, develop, and validate experimentally a distributed and dynamic routing scheme suitable for the future Internet and its evolution. The STREP EULER gathers 7 partners: Alcatel-Lucent Bell (leader) (Antwerp, Belgique), IBBT (Ghent, Belgium), UCL (Louvain, Belgium), RACTI (Patras, Grece), UPC (Barcelona, Spain), UPMC (ComplexNetworks, Paris 6), INRIA (MASCOTTE, GANG, CEPAGE). MASCOTTE is the leader of WP3 on Topology Modelling and Routing scheme experimental analysis.

8.2.2. Collaborations in European Programs, except FP7

8.2.2.1. PICS CNRS (with Charles University, Prague), 01/2009-12/2012

Participants: Nathann Cohen, Frédéric Havet, František Kardoš, Leonardo Sampaio.

On Graph coloring: theoretical and algorithmic aspects.

8.2.2.2. PHC PROCOPE (with Discrete Optimization group of RWTH Aachen University), 01/2011-12/2012

Participants: Christelle Caillouet, David Coudert, Alvinice Kodjo, Issam Tahiri.

"Défis algorithmiques dans les réseaux de communication". The purpose of the project is to exchange expertise between the discrete optimization group of RWTH Aachen University and the MASCOTTE team at INRIA Sophia-Antipolis and to address algorithmic problems in communication networks.

8.3. International Initiatives

8.3.1. INRIA Associate Teams

8.3.1.1. DISSIMINET

Participants: Olivier Dalle, Emilio Mancini, Van Dan Nguyen.

Title: Web-Service approaches for simulation

INRIA principal investigator: Olivier Dalle

International Partner:

Institution: Carleton University (Canada)

Laboratory: Advanced Real-Time Simulation Laboratory

Duration: 2011 - 2014

See also: http://www-sop.inria.fr/members/Olivier.Dalle/wiki/Main/Dissiminet

This Franco-Canadian team will advance research on the definition of new algorithms and techniques for component-based simulation using a web-services based approach. On the one hand, the use of web-services is expected to solve the critical issues that pave the way toward the simulation of systems of unprecedented complexity, especially (but not exclusively) in the studies involving large networks such as Peer-to-peer networks. Web-Service-oriented approaches have numerous advantages, such as allowing the reuse of existing simulators, allowing non-computer experts to merge their respective knowledge, or seamless integration of complementary services (eg. on-line storage and repositories, weather forecast, traffic, etc.). One important expected outcome of such approaches is to improve significantly the simulation methodology in network studies, especially by enforcing the seamless reproducibility and traceability of simulation results. On the other hand, a net-centric approach of simulation based on web-services comes at the cost of added complexity and incurs new practices, both at the technical and methodological levels. The results of this common research will be integrated into the discrete-event distributed simulators of both teams: the CD++ simulator at Carleton University and the simulation middle-ware developed in the MASCOTTE EPI, called OSA, whose developments are supported by an INRIA ADT since January 2011.

8.3.1.2. EWIN

Participants: Julio Araújo, Frédéric Giroire, Frédéric Havet, Ana Karolinna Maia, Nicolas Nisse, Ronan Pardo Soares, Leonardo Sampaio.

Title: Efficient algorithms in WIreless Networks

INRIA principal investigator: Frédéric Havet

International Partner:

Institution: Universidade Federal do Ceara (Brazil)

Laboratory: Laboratorio de Inteligencia Artificial

Duration: 2009 - 2011

See also: http://www-sop.inria.fr/teams/mascotte/equipeassociee/ewin/

The research themes are the design of exact or approximate algorithms for solving problems in networks, in particular wireless networks. The problems that we will consider can be modelled as graph coloring or graph decomposition problems. More specifically, we studied the following problems: channel assignment in radio networks which can be modelled by various graph coloring problems, dynamic routing in wireless networks using microwave links, and routing reconfiguration in MPLS or WDM networks, certain models of which are closely related to graph searching problems and tree and path decompositions.

8.3.1.3. ANR International Taiwan GRATEL, 01/2010 – 12/2013

Participants: Jean-Claude Bermond, Nathann Cohen, Frédéric Havet, František Kardoš, Leonardo Sampaio.

GRATEL (Graphs and Telecomunications) has been started in collaboration with LABRI Bordeaux, UJF Grenoble and three partners in Taiwan: Sun Yat-sen University, the National Taiwan University and Academia Sinica.

(https://gratel.labri.fr/pmwiki.php?n=Main.HomePage)

8.3.2. INRIA International Partners

Montreal, Canada: Collaboration and joint publications with B. Jaumard (Concordia), B. Reed (Mac Gill).

Vancouver, Canada: Visits of J. Yu and J. Peters (SFU Vancouver, Canada) in Mascotte and joint publications.

Santiago, Chile: Reciprocal visits of N. Nisse in Chile and I. Rapaport (Universidad de Chile) and K. Suchan (Universidad Adolfo Ibáñez) in Mascotte. Moreover, there are joint publications.

Odensee, Denmark: Visits of J. Bang-Jensen (University of Southern Denmark). N. Nepomuceno (former PhD in Mascotte) went to University of Southern Denmark for his Post-Doc. Moreover, there are joint publications.

Patras, Greece: Long-term collaboration with University of Patras, D. Coudert spent 3 months there in 2011, joint participation in many european projects.

Salerno, Italy: Visits of L. Gargano and U. Vaccaro (University of Salerno) and joint publications.

8.3.3. Visits of International Scientists

Jørgen Bang-Jensen: University of Southern Denmark, Odensee, Denmark, October 10-October 30, 2011 (3 weeks).

Victor Campos: Universidade Federal do Ceara, Fortaleza, Brazil, November 28 - december 4 (1 week).

Grit Classen: Lehrstuhl II fur Mathematik, RWTH Aachen - Aachen, Germany, September 11-16, 2011 (1 week) and December 12-16 (1 week).

Li Da Tong: National Sun Yat-Sen University, Kiaoshung, Taiwan, November 25 - December 2 (1 week).

Michele Flammini: University of l'Aquila, Italy, June 18 - July 9 (3 weeks).

Fedor V. Fomin: University of Bergen, Bergen, Norway, April 4- April 30, 2011 (1 month) and November 16-18 (Colloquium Morgenstern).

Luisa Gargano: Dipartimento di Informatica ed Applicazioni "Renato M. Capocelli" of the Università di Salerno, Salerno, Italy, July 15- August 31 (1 month 1/2).

Tomas Kaiser: University of West Bohemia, Pilsen, Czech Republic, November 28 - December, 4 (1 week).

Arie Koster: Lehrstuhl II fur Mathematik, RWTH Aachen - Aachen, Germany, September 11-16, 2011 (1 week).

Daniel Kral': Charles University, Prague, Czech Republic, October 17-21, 2011 (1 week);

Manuel Kutschka: Lehrstuhl II fur Mathematik, RWTH Aachen - Aachen, Germany, September 11-16, 2011 (1 week) and December 12-16 (1 week).

Joseph Peters: SFU Vancouver, Canada, May 14 - June, 4 (3 weeks).

Ivan Rapaport: Universidad de Chile, Santiago, Chile, May, 2011 (2 weeks).

András Sebö: G-SCOP, Grenoble, October 19-21, 2011 (3 days).

Karol Suchan: Universidad Adolfo Ibáñez, Santiago, Chile, September 21 - December 28, 2011 (3 months).

Amel Tandjaoui: University of Oran, Algeria, November 7-25, 2011 (3 weeks).

Ugo Vaccaro: Dipartimento di Informatica ed Applicazioni "Renato M. Capocelli" of the Università di Salerno, Salerno, Italy, July 15- August 31 (1 month 1/2).

Gabriel Wainer: Carleton University, Ottawa, Canada, January 19-24 (1 week) and June 13 - July 8 (3 weeks).

Joseph Yu: Abbotsford and SFU, Vancouver, Canada, March 1st - April 15, 2011 (1 month 1/2).

8.3.4. Visits of Mascotte Members to Other Research Institutions

J. Araújo: Visit to Federal University of Ceará, Fortaleza, Brazil (December 22th, 2010 - January 15th, 2011).

J.-C. Bermond: Visit to Montpellier March 30-31.

J. Burman: Visit to LRI, University Paris-Sud 11, Orsay, France, (January 31-February 3, 2011).

N. Cohen: Visit to University of Bergen, Norway (February 12-27, 2011); Visit the National Taiwan University, Taipei, Taiwan (March 9–16, 2011).

D. Coudert: Visit the Research Unit 1 (RU1) of the Research Academic Computer Technology Institute (RACTI), Patras, Greece (January 8 till March 31, 2011); Visit the mathematics department of the National and Kapodistrian University of Athens, Greece (February 23-25, 2011); Visit the mathematics departement of RWTH Aachen, Germany (October 30 till November 4, 2011).

O. Dalle: Visit to Carleton University, Ottawa, Canada (July 5 - August 3 2011).

G. D'Angelo: Visit University of L'Aquila, L'Aquila, Italy (November 5-14 and December 12-15); Visit "Sapienza" University of Rome, Rome, Italy (November 8).

F. Havet: National Taiwan University, Taipei, Taiwan (March 9-12 and 17-18, 2011); National Sun Yat Sen University, Kiaoshung, Taiwan (March 13-16); Federal University of Ceara, Fortaleza, Brasil (April 4-8, 2011 and September 27-October 4, 2011); LIRMM, University Montpellier 2, (February 7-11, 2011 and October 14-15, 2011); LIFO, University of Orléans, (May 18-22, 2011); Lebanese University, Beyruth, Lebanon (May 16-20, 2011).

A. Kodjo: Visit RWTH Aachen University, Germany (December 5-9, 2011).

A. Lancin: Visit to Louvain-la-Neuve University, Belgium, (July 8, 2011).

E. Mancini: Visit to Carleton University, Ottawa, Canada (September 5-October 4-2011).

V. D. Nguyen: Visit to Carleton University, Ottawa, Canada (August 7-September 4 2011).

N. Nisse: Visit to Universidad de Chile, Santiago, Chile, (2 weeks, January 13-31, 2011); Visit to CITI, Lyon, France, (1 week, July 25-29, 2011).

I. Tahiri: Visit RWTH Aachen University, Germany (July 4-15, 2011 and December 5-9, 2011);

8.3.5. Internships

J. Araújo and J.-C. Bermond: supervised the internship of Guillaume Ducoffe (École Polytechnique Universitaire Nice Sophia Antipolis) on Eulerian and Hamiltonian hypergraphs, June 15- August 31 (2 months 1/2).

D. Coudert: supervised the internship of Felipe Menezes Machado (Universidade Federal de Minas Gerais, Belo Horizonte, Brasil) on studying community structures in dynamic graphs, April-June 2011 (3 months 1/2).

J. Moulierac: supervised the internship of Truong Khoa Phan (parcours UBINET master IFI, UNS, France) on Minimization of network power consumption with WAN Optimization, March-August 2011 (6 months).

N. Nisse: supervised the internship of Dang Dinh Khanh (parcours UBINET master IFI, UNS, France) on the study of variants of Cops and Robber Games, March-August 2011 (5 months 1/2).

8.3.6. Participation In International Programs

INRIA FUNCAP (Inria-FAP): ALERTE (ALgorithmes Efficaces pour les Réseaux de TElécommunications), with Pargo Team, Universidade Federal do Ceará, Brazil, accepted in June 2011.

INRIA Conicyt: PhD Grant of J.-C. Maureira supervised by J.-C. Bermond and O. Dalle.

9. Dissemination

9.1. Animation of the Scientific Community

9.1.1. Participation in Committees

J.-C. Bermond: Expert for DRTT, and various projects outside France (Canada, Qatar,...); Responsible of the *Pôle ComRed* of I3S till January 31th; Member of the Ph.D. committee of the University of Marseille; Member of the *comité de sélection des ATER* till march 15; Member of the I3S laboratory committee (until October).

D. Coudert: Member of the *comité du suivi doctoral* of INRIA Sophia Antipolis (since January 2009); Member of INRIA working group GT AER; Member of *comité de sélection 27e section* of UNS, 2011; Member of the scientific board of the GIS ENSL-UNS (CNRS, ENSL, INRIA, UNS) since 2011; Expert for the National Sciences and Engineering Research Council of Canada (NSERC), the Future and Emerging Technologies Open Scheme (FET-Open) European program, and the ANR (ARPEGE, JC-JC, SIMI).

O. Dalle: Member of the *comité de sélection 27e section* of UNS; Member of the CUMIR comittee of INRIA Sophia Antipolis; Expert reviewer for Ministry of Higher Education and Research (MESR) CIR applications (Credit Impot Recherche); Member of the PhD defense committee of P. Vehlo, Univ. Grenoble, July 2011 (reviewer).

F. Havet: Expert for ANR (*Agence Nationale de la Recherche*) and its analogue in Slovakia VEGA; Member of the I3S laboratory committee (until October); External member of the Doctoral Deparment I2S committee (Montpellier); Reviewer of the PhD Theses of V. Campos (Federal University of Ceara, Brasil, September 2011) and S. Ghazal (Lebanese University, Lebanon and University of Lyon I, December 2011); Examiner of the PhD Thesis of Anthony Perez (University of Montpellier 2, November 2011).

J. Moulierac: Member of the *comité de sélection 27e section* of Université de Montpellier II; Member of the CDL (Commission for software development) at INRIA Sophia Antipolis since 2009; Member of the *Conseil de Département* (Department Committee) of IUT Nice since 2007; Responsible of the International stream Ubinet, Master IFI (http://ubinet.unice.fr), until August 2011.

N. Nisse: Member of the *comité de sélection 27e section* of Université de la Méditerranée; member of the *comité de sélection 27e section* of Université de Montpellier II, 2011; co-responsible of the Computer Science course of MPSI, INRIA-Lycée International de Valbonne.

M. Syska: Expert for DRTT PACA; Member of *comité de sélection 27e section* of UNS, 2011 (ATER, "ad-hoc"); Member of DCCE committee ED STIC; Member of the PhD defense committee of Swann Perarnau (University of Grenoble, December 1st 2011).

9.1.2. Editorial Boards

J.-C. Bermond: Combinatorics Probability and Computing, Computer Science Reviews, Discrete Mathematics, Discrete Applied Mathematics, Journal of Graph Theory, Journal Of Interconnection Networks (Advisory Board), Mathématiques et Sciences Humaines, Networks, Parallel Processing Letters the SIAM book series on Discrete Mathematics, Transactions on Network Optimization and Control , Discrete Mathematics, Algorithms and Applications.

D. Coudert: Discrete Applied Mathematics.

F. Havet: Discrete Mathematics and Theoretical Computer Science.

9.1.3. Steering Committees

D. Coudert: Pôle ResCom du GDR ASR du CNRS (since 2005); Rencontres francophones sur les aspects algorithmiques des télécommunications (AlgoTel).

O. Dalle: *ICST Intl. Conf. on Simualtion Tools and Techniques* (SIMUTools).

F. Havet: *Journées Combinatoire et Algorithmes du Littoral Méditerranéen* (JCALM); *Journées Graphes et Algorithmes* (JGA); GT Graphes du GDR IM du CNRS.

9.1.4. Conference Organization

AlgoTel'11: 13mes rencontres francophones sur les Aspects Algorithmiques des Télécommunications, Agay, France, May 2011; Organizing Chairs: F. Giroire and N. Nisse.

9.1.5. Workshop Organization

PADS'2011: 25th ACM/IEEE/SCS Workshop on Principles of Advanced and Distributed Simulation (PADS 2011), Nice, France (June 14-17, 2011). Organized: by O. Dalle, A. Lancin, E. Mancini and I. Tahiri.

CC11: Workshop Cycles and colorings 2011, Nový Smokovec, Slovakia, September 04-09, 2011. Member of the organizing commitee: F. Kardoš.

9.1.6. Participation in Program Committees

C. Caillouet: 13th Workshop on Advances in Parallel and Distributed Computational Models (APDCM2011), Anchorage, Alaska, USA (May 16, 2011).

D. Coudert: 10th International Symposium on Experimental Algorithms (SEA'11), Chania, Greece (May 5-7, 2011); 13es Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel'11), Cap Estérel, France (May 23-26, 2011); 18th International Symposium on Fundamentals of Computation Theory (FCT), Oslo, Norway (August 22-25, 2011).

O. Dalle: Member of International Workshop on SImulation Models and Techniques for Intelligent Mobility (SIMTIM -2011), 2nd International Track on Collaborative Modeling & Simulation - CoMetS'11, DEVS/TMS 2011, Boston, MA, April 2011, Omnet++ Workshop, Barcelona, March 2011.

F. Havet: Journées Graphes et Algorithmes, Lyon, France, (November 16-18, 2011).

N. Nisse: Workshop TERA-NET'11, Toward Evolutive Routing Algorithms for scale-free/internet-like NETworks, Roma, September 19, 2011.

9.2. Participation in Conferences and Workshops

9.2.1. Invited Talks

D. Coudert: Seminar at the MPLA graduate students seminar, University of Athens, Greece (February 25, 2011); Seminar at mathematics department of RWTH Aachen, Germany (November 2, 2011).

F. Kardoš: 46th Czech-Slovak Conference on Graph Theory, Banská Bystrica, Slovakia (June 06-10, 2011). 43th Slovak Mathematicians Conference, Jasná, Slovakia (December 01-04, 2011).

N. Nisse: IMSA Workshop on Algorithms and Randomness, Santiago, Chili, February 2011.

9.2.2. Participation in Scientific Meetings

AGAPE: AGAPE meeting, Montpellier, (February 7-9, 2011). Attended by J. Araújo, A. K. Maia, F. Havet, R. Pardo Soares, S. Pérennes, L. Sampaio (Speaker) and I. Tahiri.

COMRED: *Évaluation du pôle COMRED*, Sophia Antipolis, France (January 19th, 2011). Attended by most of the Mascotte members (speaker: J. Moulierac).

ECOSCELLS: Scientific meeting of ANR Verso ECOSCELLS, Villarceaux, France (June 9, 2011). Attended by D. Coudert.

EULER: Roma, September 20-21, 2011. Attended by A. Lancin, B. Li and N. Nisse.
Interim meeting of the FP7 STREP EULER project, Paris, France (January 20-21, 2011). Attended by D. Coudert and A. Lancin.
Retreat of the FP7 STREP EULER project, St-Raphael, France (May 10-12, 2011). Attended by D. Coudert and A. Lancin.
Annual meeting of FP7 STREP EULER project, Barcelona, Spain (November 7-9, 2011). Attended by D. Coudert and A. Lancin.

FIRE: FIRE Conference co-located with the Future Internet Week, Poznan, Poland (October 26-27, 2011). Attended by D. Coudert.

GRATEL: Mid-term Workshop, Taipei (March 11-12, 2011). Attended by N. Cohen (speaker) and F. Havet (speaker).

GreenDays: GreenDays meeting, Paris, (May 31th - June 1st, 2011). Attended by Y. Liu.

JOR: 8th day on Network Optimization, Paris, France (October 21, 2011). Attended by C. Caillouet.

Journées Nationales du GDR-IM: Paris VI, Paris, France (19-21 January 2011). Attended by N. Cohen.

Mascotte Days: Mascotte project annual seminar, Agay, France (May 26-27, 2011). Attended by most of the MASCOTTE members.

MDSC: Journée du pôle MDSC de l'I3S, Sophia Antipolis (May 23, 2011). Attended by F. Havet.

ResCom: 10th *Journées du Pôle ResCom du GDR ASR*, Paris, France (October 20-21, 2011). Attended by D. Coudert.

STRUCO: LEA STRUCO Kick-off meeting, Paris, (December 8-9, 2011). Attended by F. Havet and F. Kardoš.

USS-SIMGRID: Meeting, Nice, France (Janaury 22, 2011). Organized by O. Dalle, E. Mancini and J. Ribault.

9.2.3. Participation in Conferences

4CCGTA: Fourth International Conference on Combinatorics, Graph Theory, and Applications, Elgersburg, Germany (March 21-25, 2011). Attended by F. Kardoš (speaker).

ADHOCNOW: 10th International Conference on Ad Hoc Networks and Wireless, Paderborn, Germany (July 18-20, 2011). Attended by C. Caillouet (speaker).

AlgoTel'11: 13mes rencontres francophones sur les Aspects Algorithmiques des Télécommunications, Agay, France, May 23-26, 2011. Attended by J. Araújo, J.-C. Bermond, J. Burman (speaker), C. Caillouet (speaker), D. Coudert, F. Giroire, D. Mazauric (speaker), J. Moulierac, N. Nisse, L. Sampaio, R. Pardo Soares and I. Tahiri (speaker).

DEVS/TMS 2011: Workshop DEVS/TMS, colocated with the SpringSim 2011 Conference, Boston, MA, April 2011. Attended by O. Dalle (speaker).

DIPAM-WCGT: DIPAM Workshop on Combinatorics and Graph Theory, Warwick, Great Britain (April 04-07, 2011). Attended by F. Kardoš (speaker).

DISC'11: 25th International Symposium on DIStributed Computing, Roma, September 20-22, 2011. Attended by A. Lancin and B. Li.

EuroComb'11: European Conference on Combinatorics, Graph Theory and Applications, Budapest, Hungary (August 29th - September 2nd, 2011). Attended by J. Araújo (speaker), L. Sampaio and R. Pardo Soares.

GRASTA'11: 4th Workshop on GRAph Searching, Theory and Applications, Dagstuhl, Germany, February 14-18, 2011. Attended by N. Nisse (speaker).

IMSA'11: Workshop on Algorithms and Randomness, Santiago, Chile, January 18th, 2011. Attended by N. Nisse (speaker).

INOC: 5th International Network Optimization Conference, Hamburg, Germany (June 13-16, 201). Attended by I. Tahiri.

IWOCA'11: International Workshop on Combinatorial Algorithms, Victoria, Canda (June 20th - June 22th, 2011). Attended by J. Araújo (speaker).

JGA'11: 13èmes Journées Graphes et Algorithmes, Univ. Claude Bernard, Lyon, France, November 16-18, 2011. Attended by J. Araújo (speaker), F. Havet, F. Kardoš, A. K. Maia (speaker), G. Morel, N. Nisse (speaker) and L. Sampaio (speaker).

JPOC7C: La 7ème édition des Journées Polyèdres et Optimisation, Valenciennes, France (8-10 june 2011). Attended by I. Tahiri.

LAGOS: 6th Latin-american Algorithms, Graphs and Optimization Symposium, Bariloche, Argentina (March 28 - April 1, 2011). Attended by F. Havet (speaker) and A. K. Maia (speaker).

ROADEF 2011: 12ème congrès annuel de la Société française de Recherche Opérationnelle et d'Aide à la décision, Saint-Etienne, France (March 2nd - 4th, 2011). Attended by G. Morel.

TERA-NET'11: Workshop Toward Evolutive Routing Algorithms for scale-free/internet-like NETworks, Roma, September 19, 2011. Attended by D. Coudert, A. Lancin, B. Li and N. Nisse.

Workshop on DSS: Workshop on distributed storage systems, Cesson Sévigné, France (September 19th - September 20th, 2011). Attended by J. Araújo and R. Modrzejewski (speaker).

WSC'11: WinterSim Conference 2011, Phoenix, AZ, USA (December 11-14, 2011). Attended by E. Mancini.

9.2.4. Participation in Schools

9ème JCALM: 9èmes Journées Combinatoire et Algorithmes du Littoral Méditerranéen, Marseille,(February 18, 2011). Attended by J. Araújo, R. Pardo Soares and F. Havet.

10ème JCALM: 10èmes Journées Combinatoire et Algorithmes du Littoral Méditerranéen, Barcelona, Spain, (June 7-8, 2011). Attended by J.Araújo, N. Cohen, D. Coudert, F. Havet, N. Nisse and L. Sampaio.

Grascomp: Summer school on Networking, Louvain-la-Neuve, Belgium, (July 6-7, 2011). Attended by A. Lancin.

JPOC7S: L'école de la 7ème édition des Journées Polyèdres et Optimisation, Valenciennes, France (6-8 june 2011). Attended by I. Tahiri.

Ninth Annual Winter School in Algorithms, Graph Theory and Combinatorics: Geilo, Norway (23-25 February 2011). Attended by N. Cohen (speaker).

Operations research as an asset for development: Ecole de Recherche Operationnelle, Université d'Abomey-Calavi(UAC)/Institut des Mathematiques et Sciences Physiques(IMSP), Porto-Novo, Benin, November, 14-19 2011. Attended by A. Kodjo and M. Toko-Worou.

Sage Days 28: Laboratoire de Mathématiques d'Orsay (Université Paris-Sud 11), Orsay, France (17-19 January 2011). Attended by N. Cohen (speaker).

WSNO: Winter School on Network Optimization, Estoril, Portugal (January 17-21, 2011). Attended by C. Caillouet.

9.2.5. Popularization

Attractiveness: Since April 1, J.-C. Bermond is in charge of the attractiveness of the center INRIA Sophia Antipolis Méditerannée.

Colloquium Montpellier: J.-C. Bermond gave a talk at the Colloquium organized in Montpellier on March 31, 2011.

Colloquium Morgenstern Sophia-Antipolis: J.-C. Bermond gave a talk at the Colloquium organized in Sophia Antipolis on May 12, 2011.

EPU: D. Mazauric gave a talk to the students of Polytech' Nice, on "Compromis pour le problème du reroutage dans les réseaux optiques" at Sophia Antipolis (March 10, 2011).

Fête de la Science: F. Havet presented the stand "Mathématiques" at Rians, France (October 12-16, 2011).

Goûter des Sciences: F. Havet presented "Maths et magie", Rians, France (February 12, 2011).

Science et Culture au Lycée: F. Havet gave two conferences "Graph theory and networks" and "Researcher as a job" in Lycée du Rempart, Marseille, November 24, 2011.

SUP'COM: D. Mazauric gave a talk to the students of SUP'COM, on "Reconfiguration du routage dans les réseaux optiques" at Sophia Antipolis (July 12, 2011).

9.3. Teaching

Licence:

- ASR5 - Networks, 150h, Level L1, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Introduction to Operating Systems, 40h, Level L1, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Informatique, 20h, Level L1 (classe préparatoire MPSI), Lycée International de Valbonne.
- IT Tools, 32h, Level L1, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Programmation fonctionnelle (Scheme), 18h, Level L1, UFR Sciences, University of Nice Sophia Antipolis.
- Database and advanced information system, 36h, Level L2, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Operating Systems : Advanced Programming, 63h, Level L2, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Algorithmique et Programmation, 35h, Cycle Initial Polytechnique 2, École Polytech'Nice, University of Nice Sophia Antipolis.
- Mathématiques discrètes, 64h, Level L3, Ecole Polytech'Nice, University of Nice Sophia Antipolis.
- Advanced Networks, 15h, Level L3, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Object-Oriented Programming, 54h, L3, Licence Miage, Université de Nice, France.
- Graph Theory, 18h, Level L3, Mathematics Department, RWTH Aachen, Germany.
- Introduction to Algorithms, 36h, Level L3, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Bash Scripting, 15h, Level L3, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.

- Linux Systems Administration, 24h, Level L3, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.
- Algorithmique et complexité, 25h, Level L3, IUT Nice Côte d'Azur, University of Nice Sophia Antipolis.

Master:
- Théorie des graphes, 24h, M1 PENSUNS, University of Nice Sophia Antipolis.
- Combinatoire des graphes, 25h, Level M2, Master MDFI, Université de la Méditerranée - Faculté des sciences de Luminy.
- Probabilistoc method, 18h, Master 2 Mathematics, Lebanese University, Beyruth, Lebanon.
- Algorithms for telecommunications, 42h, Level M2, Master IFI (international stream Ubinet), University of Nice Sophia Antipolis.

9.3.1. Administration

Collaboration INRIA-Lycée International de Valbonne: N. Nisse is co-responsible of the Computer Science course of MPSI.

IUT Nice Côte d'Azur: M. Syska is responsible of the Computer Science Department of IUT since september 2011.

Ubinet, Master IFI: J.-C. Bermond is member of the scientific committee.
J. Moulierac was responsible of the International stream Ubinet, Master IFI (http://ubinet.unice.fr), until August 2011.
F. Giroire is responsible of the Internships within international stream Ubinet, Master IFI (http://ubinet.unice.fr), since October 2011.

International Master 1: J.-C. Bermond is member of the scientific committee of the international track of the M1.

9.3.2. PhD & HdR

PhD:

Nathann Cohen, *Three years of graphs and music: some results in graph theory and its applications*, Université de Nice Sophia Antipolis, October 20, 2011, F. Havet.

J.-C. Maureira, *Internet on rails*, Université de Nice Sophia Antipolis, January 21, 2011, J.-C. Bermond and O. Dalle.

D. Mazauric, *Optimisation discrète dans les réseaux de télécommunication: reconfiguration du routage, routage efficace en énergie, ordonnancement de liens et placement de données*, Université de Nice Sophia Antipolis, November 7, 2011, P. Nain and J.-C. Bermond.

J. Ribault, *Reuse and Scalability in Modeling and Simulation Software Engineering*, Université de Nice Sophia Antipolis, January 20, 2011, O. Dalle.

PhD in progress:

3rd year:

J. Araújo, *Dynamic network routing*, since December 2009, J.-C. Bermond, C. Linhares Sales and F. Giroire.

L. Sampaio, *Algorithmic aspects of graph colorings*, since November 2009, F. Havet.

I. Tahiri, *Optimisation dans les réseaux de collecte IP sans fils*, since November 2009, D. Coudert.

M. Toko Worou, *Outils algorithmiques pour la détection des communautés*, since November 2009, J.-C. Bermond and J. Galtier.

2nd year:

S. Félix, *Smart transports : optimisation du trafic dans les villes*, since January 2011, J.-C. Bermond and J. Galtier.

A. Lancin, *Study of network properties for efficient routing algorithms*, since January 2011, D. Coudert.

R. Modrzejewski, *Systèmes pair-à-pair de partage de données*, since November 2010, S. Pérennes and F. Giroire.

R. Pardo Soares, *Routing reconfiguration in WDM networks*, since November 2010, D. Coudert and N. Nisse.

1st year:

A. Kodjo, *Design and optimization of multi-operators wireless backhaul networks*, since October 2011, D. Coudert.

B. Li, *Study of Internet model and its properties for efficient routing algorithms*, since October 2011, D. Coudert and N. Nisse.

A. K. Maia, *Partitions of directed graphs*, since September 2011, F. Havet.

T. K. Phan, *Design and Management of networks with low-power Consumption*, since October 2011, D. Coudert and J. Moulierac.

10. Bibliography

Major publications by the team in recent years

[1] E. ALTMAN, P. NAIN, J.-C. BERMOND. *Distributed Storage Management of Evolving Files in Delay Tolerant Ad Hoc Networks*, in "INFOCOM 2009", Rio De Janeiro, Brazil, April 2009, p. 1431 - 1439, http://dx.doi.org/10.1109/INFCOM.2009.5062059.

[2] J.-C. BERMOND, F. ERGINCAN, M. SYSKA. *Line Directed Hypergraphs*, in "Quisquater Festschrift", D. NACCACHE (editor), Lecture Notes in Computer Science, Springer-Verlag, Berlin Heidelberg, 2011, vol. 6805, p. 25-34.

[3] C. CAILLOUET, S. PÉRENNES, H. RIVANO. *Framework for Optimizing the Capacity of Wireless Mesh Networks*, in "Computer Communications", 2011, vol. 34, n^{o} 13, p. 1645-1659 [*DOI :* 10.1016/J.COMCOM.2011.03.002], http://hal.inria.fr/inria-00572967/en.

[4] I. CARAGIANNIS, A. FERREIRA, C. KAKLAMANIS, S. PÉRENNES, H. RIVANO. *Fractional Path Coloring in Bounded Degree Trees with Applications*, in "Algorithmica", 2010, vol. 58, n^{o} 2, p. 516-540, http://dx.doi.org/10.1007/s00453-009-9278-3.

[5] N. COHEN, D. COUDERT, D. MAZAURIC, N. NEPOMUCENO, N. NISSE. *Tradeoffs in process strategy games with application in the WDM reconfiguration problem*, in "Theoretical Computer Science (TCS)", August 2011, vol. 412, n^{o} 35, p. 4675-4687, http://dx.doi.org/10.1016/j.tcs.2011.05.002.

[6] D. COUDERT, P. DATTA, S. PÉRENNES, H. RIVANO, M.-E. VOGE. *Shared Risk Resource Group: Complexity and Approximability issues*, in "Parallel Processing Letters", June 2007, vol. 17, n^{o} 2, p. 169-184.

[7] O. DALLE, E. MANCINI. *Traces Generation to Simulate Large-Scale Distributed Applications*, in "Winter Simulation Conference", Phoenix, AZ, United States, S. JAIN, R. R. CREASEY, J. HIMMELSPACH, K. P. WHITE, M. FU (editors), 2011, http://hal.inria.fr/inria-00634620/en/.

[8] F. V. FOMIN, P. FRAIGNIAUD, N. NISSE. *Nondeterministic Graph Searching: From Pathwidth to Treewidth*, in "Algorithmica", 2009, vol. 53, n^{o} 3, p. 358-373, http://www.springerlink.com/content/42g5tp1588w89186/.

[9] F. GIROIRE. *Order statistics and estimating cardinalities of massive data sets*, in "Discrete Applied Mathematics", 2009, vol. 157, n^{o} 2, p. 406-427, http://dx.doi.org/10.1016/j.dam.2008.06.020.

[10] F. GIROIRE, D. MAZAURIC, J. MOULIERAC, B. ONFROY. *Minimizing Routing Energy Consumption: from Theoretical to Practical Results*, in "IEEE/ACM International Conference on Green Computing and Communications (GreenCom'10)", Hangzhou, China, 2010, 8.

[11] D. GONÇALVES, F. HAVET, A. PINLOU, S. THOMASSÉ. *Spanning galaxies in digraphs*, in "European Conference on Combinatorics, Graph Theory and Applications (Eurocomb 2009)", Bordeaux, France, Electronic Notes on Discrete Mathematics, September 2009, vol. 34, p. 139–143.

[12] F. HAVET, M. KLAZAR, J. KRATOCHVÍL, D. KRATSCH, M. LIEDLOFF. *Exact algorithms for L(2,1)-labelling*, in "Algorithmica", 2011, vol. 59, n^{o} 2, p. 169–194.

Publications of the year

Doctoral Dissertations and Habilitation Theses

[13] N. COHEN. *Some results in graph theory and its applications*, Ecole doctorale STIC, Université de Nice-Sophia Antipolis, October 2011, http://tel.archives-ouvertes.fr/tel-00645151/fr/.

[14] J.-C. MAUREIRA BRAVO. *Internet on Rails*, Ecole doctorale STIC, Université de Nice Sophia-Antipolis, January 2011, http://hal.inria.fr/tel-00594951/en.

[15] D. MAZAURIC. *Optimisation discrète dans les réseaux de télécommunication: reconfiguration du routage, routage efficace en énergie, ordonnancement de liens et placement de données*, Ecole doctorale STIC, Université de Nice Sophia-Antipolis, November 2011, http://tel.archives-ouvertes.fr/tel-00643513/fr/.

[16] J. RIBAULT. *Reuse and Scalability in Modeling and Simulation Software Engineering*, Ecole doctorale STIC, Université de Nice Sophia-Antipolis, January 2011, http://tel.archives-ouvertes.fr/tel-00604014/en/.

Articles in International Peer-Reviewed Journal

[17] V. ANDOVA, N. COHEN, R. ŠKREKOVSKI. *Graph Classes (Dis)satisfying the Zagreb Indices Inequality*, in "MATCH Commun. Math. Comput. Chem.", 2011, vol. 65, n^{o} 3, p. 647-658.

[18] J. ARAÚJO, N. COHEN, F. GIROIRE, F. HAVET. *Good edge-labelling of graphs*, in "Discrete Applied Mathematics", 2011, In press [*DOI :* 10.1016/J.DAM.2011.07.021], http://hal.inria.fr/inria-00383343_v4/.

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[23] J.-C. BERMOND, Y. M. CHEE, N. COHEN, X. ZHANG. *The α-Arboricity of Complete Uniform Hypergraphs*, in "SIAM Journal on Discrete Mathematics", 2011, vol. 25, n^o 2, p. 600-610.

[24] J.-C. BERMOND, X. MUÑOZ, I. SAU. *Traffic Grooming in Bidirectional WDM Ring Networks*, in "Networks", 2011, vol. 58, n^o 1, p. 20-35, http://dx.doi.org/10.1002/net.20410.

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