INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Mascotte

Méthodes Algorithmiques, Simulation et Combinatoire pour l'OpTimisation des TElécommunications

Sophia Antipolis - Méditerranée

Theme : Networks and Telecommunications

Activity Report

2009

Table of contents

MASCOTTE is a joint team between INRIA Sophia Antipolis - Méditerranée and the laboratory I3S (Informatique Signaux et Systèmes Sophia Antipolis) which itself belongs to CNRS (Centre National de la Recherche Scientifique) and UNS (University of Nice-Sophia Antipolis).

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

1. Team

Research Scientist

Jean-Claude Bermond [Team Leader, Research Director (DR), CNRS, HdR]
David Coudert [Team Vice-Head, Research Associate (CR), INRIA]
Frédéric Giroire [Research Associate (CR) CNRS]
Frédéric Havet [Research Associate (CR) CNRS, HdR]
Philippe Mussi [Research Associate (CR), INRIA since September 1 2009]
Nicolas Nisse [Research Associate (CR), INRIA since September 1 2009]
Stéphane Pérennes [Research Associate (CR) CNRS]
Bruce Reed [Research Director (DR) CNRS, on leave at Mc Gill U., Montréal since September 1 2009]
Hervé Rivano [Research Associate (CR) CNRS]

Faculty Member

Olivier Dalle [Associate Professor UNS]
Joanna Moulierac [Associate Professor UNS]
Michel Syska [Associate Professor UNS]

External Collaborator

Afonso Ferreira [Research Director (DR) CNRS (on leave at COST Office, Brussels), HdR]

Technical Staff

Fabrice Peix [Expert Engineer, ANR SPREADS, till June 30 2009]
Luc Hogie [Expert Engineer, Contract DCR Alactel-Lucent Belgium, since March 1 2009]

PhD Student

Julio Araujo [MENRT, since December 1 2009, 1st year]
Nathann Cohen [MENRT, since October 1 2008, 2nd year]
Cristiana Gomes [Grant Brazil, since September 1 2006, defense December 1 2009]
Juan-Carlos Maureira [Grant CONICYT Chile, since February 1 2008, 3rd year]
Dorian Mazauric [BDO CNRS/Région PACA, since October 1 2008, 2nd year]
Christelle Molle [Grant DGA/CNRS, since October 1 2006, till September 30 2009, defense October 29 2009]
Julian Monteiro [CORDI, since October 1 2007, 3rd year]
Napoleão Nepomuceno [BDE Région/3-ROAM, since December 1 2007, 3rd year]
Brice Onfroy [Contract ANR DIMAGREEN, since October 1 2009, 1st year]
Patricio Reyes Valenzuela [Grant CONICYT Chile, since February 1 2006, till August 31 2009, defense August 05 2009]
Judicael Ribault [Contract ANR SPREADS since January 1 2008, 3rd year]
Leonardo Sampaio [Grant Brazil, since October 1 2009]
Ignasi Sau-Valls [BDO CNRS/Région, since October 1 2006, till October 31 2009, defense October 16 2009]
Issam Tahiri [Contract RAISOM Région PACA, since November 1 2009]

Post-Doctoral Fellow

Luc Hogie [Post Doc INRIA, till February 28 2009]
Nicolas Nisse [PostDoc INRIA, till August 31 2009]
Gianpiero Monaco [PostDoc INRIA, since November 1 2009]

Visiting Scientist

Jorgen Bang-Jensen [University of Southern Denmark, Odensee, Denmark, October 3-29, 2009 (4 weeks)]

Luisa Gargano [Salerno Italy, July 1 - August 31 2009 (2 months)]
Ugo Vaccaro [Salerno Italy, July 1 - August 31, 2009 (2 months)]
Joseph Yu [S.F.U. Vancouver, Canada, February 24- May 22, 2009 (3 months)]

Administrative Assistant

Sandra Devauchelle [ITA CNRS, (part time)]
Patricia Lachaume [ITA INRIA, (part time)]

2. Overall Objectives

2.1. Introduction

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 or 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 year both these theoretical and applied tools for the design of various networks, such as WDM, wireless (radio), satellites, 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 the MASCOPT library (MASCOTTE optimization), and ambitious software projects such as the OSA computer Simulation Architecture.

2.2. Highlights of the year

Last year Mascotte has strongly increased both its international and industrial collaborations.

International Collaborations: besides its long standing European collaboration (inside the IST/FET europeean project AEOLUS or bilateral ones), and the associated team with S.F.U. (Canada), a new associated team EWIN with the Universidade Federal do Ceará (Fortaleza, Brazil) has been started.

Industrial collaborations: MASCOTTE has joined the common laboratory INRIA / Alcatel-Lucent Bell-Labs (participation in the ADR HiMa on autonomous dynamic management of virtual topologies). MASCOTTE has also got a contract with Alcatel-Lucent Bell-Labs on dynamic compact routing. MASCOTTE got a financial support of the *région PACA* to work with two SME's (3-Roam and Avisto) on wireless IP backhaul networks (project RAISOM).

ANR: Four new ANR have been accepted in 2009: AGAPE (on parametrized and exact algorithms); DIMAGREEN (on design and management of green networks), ECOSCells (on efficient cooperating small cells) and GraTel with Taiwan (on graphs for telecommunications).

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 hypothesis (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 tool 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 parametrized algorithms. A school has been organized on this topic and the research will be conducted under the ANR project AGAPE.

Theoretical results are described after, with more emphasis on those of Graph Theory (Section 6.5) and algorithmic aspects (Section 6.6).

4. Application Domains

4.1. Application Domains

For 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 SME's like UBISTORAGE or 3-ROAM.

MASCOTTE is mainly interested in the design of heterogeneous networks. The project has kept working on the design of backbone networks in particular optical ones (see Section 6.1) but also on wireless access networks (see Section 6.2) and on overlay (Peer to peer) networks (see Section 6.3), in particular inside the European FET project AEOLUS.

Part of these research is done within the join laboratory INRIA-Alcatel-Lucent Bell-Labs, (participation in the ADR HiMa on autonomous dynamic management of virtual topologies and within the ANR ECOSCells leaded by Alcatel-Lucent Bell-Labs). MASCOTTE has also a contract with Alcatel-Lucent Bell-Labs, on dynamic compact routing. An emphasis is put on green networks with low power consumption financed with the ANR DIMAGREEN. We have also developed two cooperations with SMEs. The first one is on data storage in peer-to-peer networks with the SME UBISTORAGE within the ANR SPREADS (Safe P2P reliable Architecture for Data Storage). The second one is on backhaul networks with the SME 3-ROAM,and is funded by the *région PACA* project RAISOM (Wireless IP Service Deployment optimization and monitoring)

5. Software

5.1. Prototype Software

- MASCOPT **and** OPENGVE (http://www-sop.inria.fr/mascotte/mascopt/)
  Participants: Fabrice Peix, Michel Syska.

  MASCOPT [122] is a free 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 in january 2010 under the name of the OPENGVE project, MASCOPT being one implementation of the bridge graph interface [R. Correa, 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 not have to be rewritten but will have different choices of internal implementation. This may lead to better performances for specific issues such as large graphs processing.

  The main objective of MASCOPT (MASCOTTE Optimization) 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 implementation of existing algorithms or linear programs (e.g. shortest paths or integral multicommodity flow).

  A generic linear programming interface 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 intensively been used within MASCOTTE industrial cooperation programs for experimentation and validation purposes: with Alcatel Space Technologies on the design of fault-tolerant on-board network satellites, on the optimization of the access layer and planning of satellite communication and with Orange Labs on the design of telecommunication backbone networks.

  Another cooperation at INRIA Sophia Antipolis Méditerranée is the use of MASCOPT by the Aoste team.
- **OSA**: an Open Component-based Architecture for Discrete-Event Simulations. (http://osa.inria.fr/wiki/)
  Participants: Olivier Dalle, Fabrice Peix, Judicael Ribault.

  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) [121] 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 developped 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/.

- **Dipergrafs** (http://www-sop.inria.fr/members/Luc.Hogie/dipergrafs/)
  Participants: Luc Hogie, Issam Tahiri.

  The Dipergrafs project proposes a Java framework for the manipulation of directed hypergraphs. Briefly, a directed hypergraph consists in a set of directed links, each link connecting a set of vertices to another set of vertices. In other words, a directed hypergraph is a graph in P(E). Hypergraphs are used into the fields of network modeling, rational databases, semantic web, expert systems, route planning. In particular, the design objectives of Dipergrafs are to make it particularly useful in the context of network simulation.

  Briefly Dipergrafs: has a vertex-oriented design (in opposite to node-oriented design), that is the graph is seen as a collection of relations between nodes; imposes no constraint on the type of nodes and vertices (in opposite to frameworks which oblige to follow a certain structure, leading tp a lack of flexibility); provides implementations for common graph operations : navigation (paths, connected components, shortest paths, hop-exploring, etc), graph queries, graph metrics (radius, density, degrees, distance/adjacency/incidence matrices, etc), distributions of vertex metrics; is mostly usable through a small set of Java classes (in opposite to frameworks whose utilization requires the knowledge of numerous classes); features graph input/output mechanisms, allowing persistence, serialization, etc; does not feature any graph rendering tool. Instead bridges to external products dedicated to rendering are provided; comes with a set of composeable topology generator allowing to quickly instantiate the desired topology.

  Dipergrafs is extensively used in the DRMSim project, in which it enables the modeling and simulation of large backbone networks.

- **DRMSim**: (http://www-sop.inria.fr/mascotte/projets/DCR/)
  Participants: Luc Hogie, Issam Tahiri, David Coudert.

  The expansion of the Internet routing system results in a number of research challenges, in particular, the Border Gateway Protocol (BGP) starts to show its limits amongst others in terms of the number of routing table entries it can dynamically process and control. Dynamic routing protocols showing better scaling properties are thus under investigation. However, because deploying under-development routing protocols on the Internet is not practicable at a large-scale (due to the size of the Internet topology), simulation is an unavoidable step to validate the properties of a newly proposed routing scheme. Unfortunately, the simulation of inter-domain routing protocols over large networks (order of tens of thousands of nodes) poses real challenges due to the limited memory and computational power that computers impose. Existing simulation tools exhibit limitations in terms of the number of nodes they can handle and in the models they propose. This motivated us for conceiving and developing an adequate network simulator call DRMSim (Dynamic Routing Model simulator) which addresses the specific problem of large-scale simulations of (inter-domain) routing models on large networks.

  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 GLP, and K-chordal network topologies, as well as implementations of routing protocols, including the NSR routing protocol and lightweight versions of BGP. More features will be further incorporated into the simulator. In particular, they address the challenge of simulation of larger networks (order of 10k nodes), the next step is to propose new routing algorithms, including state-of-the-art ones, to enhance the code, and to go further with distributed simulation campaigns.

  DRMSim is developped in cooperation with LaBRI (Laboratoire Bordelais de Recherche en Informatique, Bordeaux, France).

6. New Results

6.1. Backbone Networks

Participants: Jean-Claude Bermond, Nathann Cohen, David Coudert, Frédéric Giroire, Dorian Mazauric, Gianpiero Monaco, Joanna Moulierac, Napoleão Nepomuceno, Nicolas Nisse, Stéphane Pérennes, Hervé Rivano, Ignasi Sau-Valls.

Network design is a very wide subject that concerns all kinds of networks. For telecommunications networks it 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, which consists of a path and a wavelength assigned on each link along the path, and is called a *lightpath*. If wavelength translation is performed in optical switching, then to each channel may be assigned different wavelengths on each link along the path; otherwise the wavelength continuity constraint must be satisfied on all links along the path. 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 considered by a lot of academic and industrial teams in the world. Our approach is to attack these problems with tools from Discrete Mathematics and to consider mainly telecommunications networks. This approach is shared by other teams in Europe, most of them being part of European projects IST FET AEOLUS (where MASCOTTE is leader of sub-project *SP2 Resource management*) and COST 293 Graal (where MASCOTTE is leader of working group *WG-A broadband and optical networks*). Outside Europe, many teams have also this approach and sometimes we have direct collaborations with them: Vancouver (EA RESEAUXCOM), Montréal, Fortaleza (EA EWIN),...

6.1.1. Traffic Grooming

In a WDM network, routing a connection request consists in assigning it 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. That means that on a given edge of the network we can groom at most C requests on the same wavelength. With this constraint the objective can be either to minimize the number of wavelengths (related to the transmission cost) or minimize the number of Add/Drop Multiplexers (ADM) used in the network (related to the cost of the nodes).

We have first addressed the problem of traffic grooming in WDM rings or paths with All-to-All uniform unitary traffic. The goal is to minimize the total number of ADMs required. We have shown that this problem corresponds to a partition of the edges of the complete graph into subgraphs, where each subgraph has at most C edges (where C is the grooming factor) and where the total number of vertices has to be minimized. Using tools of graph and design theory, we optimally solved the problem for practical values and infinite congruence classes of values for a given C. We give optimal constructions on unidirectional rings when $C \geq N(N-1)/6$ and when $C = 3, 4, 5, 6, 12$, on paths when $C = 2$, and bidirectional rings when $C = 1, 2, 3$ and $C = k(k+1)/2$ ($k \geq 1$) for infinite congruence classes [102], and propose an approximate construction for all-to-all traffic on unidirectional rings for any value of C, and on bidirectional rings for $C = 2, 3$ [102]. We also showed how to improve lower bounds by using refined counting techniques, and how to determine the maximum number of connections which can be established in a path of size N or in a DAG.

Then, we have also studied the all-to-all traffic grooming on unidirectional rings with grooming factor C and with the extra constraints that the traffic between a subset of vertices must be served with grooming factor C'. We provided optimal constructions for $C = 4$ and $C' = 1, 2, 3$ [96].

Furthermore, we refined the complexity analysis of the problem for general traffic requirement and established the first in-approximability result on traffic grooming using a study of the complexity (including parametrized complexity) [24]. We have provided an approximation algorithm for ring and path networks with approximation factor of $O(n^{1/3} \log^2 n)$, independent of the grooming factor. Moreover, we have proposed an *a priori* placement of ADMs in unidirectional WDM rings allowing to satisfy any set of requests with bounded degree d (a node is source or destination of at most d requests) [75].

Moreover, we studied the traffic grooming on the path with online traffic and distributed routing algorithm. We have shown how to design the best possible virtual topologies (assignment of ADMs to wavelengths), independently of the routing algorithm and for any bounded degree traffic instances. We have in particular analyzed the performances of distributed greedy routing algorithms [101].

We also studied the placement of optical add/drop multiplexers (OADM) that allows adding or dropping wavelengths from/to an optical fiber. For this problem, we provided a 4-approximation algorithm for general instances on unidirectional path, and improved approximation factors for particular instances [64].

Finally, in [92] we survey the main results obtained on traffic grooming, including complexity and hardness results, optimal constructions, approximation algorithms, ILP formulations and heuristic algorithms.

6.1.2. Reconfiguration in WDM Networks

In production networks, traffic evolution, failures and maintenance operations force to adapt regularly the current configuration of the network (virtual topology, routing of connections). In this context, we have developed tools to switch connections one after the other from a pre-computed routing to another with limited service disruptions. We thus concentrated on the reoptimization phase of the network, or *migration* of the routing. We have modeled this problem as a scheduling problem in a dependency digraph that may contains cycles, the *process number*, and then established some similarities and differences with two other known problems: the *pathwidth* and a particular *graph searching problem*. Dependency cycles are broken through the use of temporary routes or temporary disruptions (called “agents” in the model) that have to be minimized. We have proved that the problem is NP-complete and difficult to approximate in general, characterized the classes of (di)graphs that can be processed with at most two agents, and proposed distributed algorithms for computing this parameter and other graph invariants in trees. We proposed a heuristic algorithm that performs better and faster than previous proposals, and investigated the problem with the extra constraints that some connections should never be interrupted (particular service level agreement) [58], [88]. We also studied tradeoffs between the total number of interruptions and the maximum number of concurrent interruptions, proving in particular that the knowledge of one parameter does not help to optimize the other [104].

We have extended our study to the case in which connections use only a fraction of the bandwidth of a link. In [59], [108] we proved that deciding whether it exists a scheduling of the rerouting of connection requests without traffic interruption is NP-complete even if requests use the third of the bandwidth of a link.

6.1.3. All-Optical Label Switching, AOLS

All-Optical Label Switching (AOLS) is a promising technology that performs packet forwarding without any optical-electrical-optical conversions, thus speeding up the forwarding. However, the cost of this technology requires limiting the number of labels needed to ensure the forwarding when routing a set of requests using GMPLS technology. In particular, this prevents the usage of label swapping techniques.

We have studied the routing problem in this context using label stacking techniques. We have formalized the problem by associating to each routing strategy a logical hypergraph, called a hypergraph layout, whose hyperarcs are dipaths of the physical graph, called tunnels in GMPLS terminology. We defined a cost function for the hypergraph layout, depending on its total length plus its total hop count. Minimizing the cost of the design of an AOLS network can then be expressed as finding a minimum cost hypergraph layout. In [100], [51], we prove hardness results for the problem, namely for general directed networks we prove that it is

NP-hard to find a $C \log n$-approximation, where C is a positive constant and n is the number of nodes of the network. For symmetric directed networks, we prove that the problem is APX-hard. These hardness results hold even if the traffic instance is a partial broadcast. On the other hand, we provide approximation algorithms, in particular an $O(\log n)$-approximation for symmetric directed networks. We focussed on the case where the physical network is a directed path, providing a polynomial-time dynamic programming algorithm first for one source [50], [98], and then for a fixed number k of sources running in time $O(n^{k+2})$ [99].

We have also considered label-stripping techniques that allow reducing further the overall number of labels but at the cost of increasing the stack size and so waste bandwidth. We proposed a heuristic algorithm performing tradeoffs between the stack size and the waste of bandwidth [85].

6.1.4. Regenerator placement in WDM networks

The transmission of an optical signal in a fiber causes small phase shifting and power loss forcing to regenerate the signal after a certain distance (e.g. 1000km). We have investigated the problem of minimizing the number of locations to place the regenerators in a WDM network [63] in various settings: limited or unlimited number of regenerators per site, routing given or not, general and particular topologies. In each setting, we established the complexity and in-approximability of the problem, and provided approximation algorithms and exact polynomial time algorithms whenever possible.

6.2. Wireless Access Networks

Participants: Jean-Claude Bermond, David Coudert, Afonso Ferreira, Jérôme Galtier, Luisa Gargano, Cristiana Gomes, Dorian Mazauric, Christelle Molle, Julian Monteiro, Napoleão Nepomuceno, Nicolas Nisse, Stéphane Pérennes, Patricio Reyes, Hervé Rivano, Ugo Vaccaro, Joseph Yu.

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 viewpoint.

In particular, we have studied three of the more prominent performance metrics for radio networks. Using combinatorial optimization and centralized algorithmic with a network design flavor, transport capacity and energy consumption of the networks have been studied. Using distributed algorithmic with a protocol flavor, fast data gathering and call scheduling are investigated. Our approach is complementary with those developed in other INRIA project-teams such as PLANETE, MAESTRO, SWING (ex ARES) or POPS. The complementarity has been exploited through an ARC collaboration with ARES and POPS, a joint Ph.D. between MAESTRO and MASCOTTE and, recently, an ANR VERSO project in which MAESTRO, MASCOTTE and SWING are involved.

At the international level, our researches are comparable and collaborative with some groups in renowned research centers such as CTI of Patras in Greece, 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 and energy efficient optimization, to the development of theoretical tools for analyzing and evaluating dynamic networks. Some graph coloring problems motivated by channel assignment in wireless networks are detailed in Section 6.5 and the optimization techniques and wireless simulation tools that we have developed are also cited in Section 6.4.

6.2.1. Transport capacity of wireless access networks

The specific challenges of multihop wireless networks lead to a strong research effort on efficient protocols design where the offered capacity is a key objective. More specifically, the routing strategy largely impacts the network capacity, i.e. the throughput offered to each flow.

In these settings, [15] focuses on optimizing the capacity of wireless mesh networks defined as the fair throughput offered to each flow. In order to get theoretical bounds on the network performances, we develop optimization models integrating the cross-layer characteristics of radio communications. More precisely, we study the joint routing and scheduling problem. We develop, for the linear relaxation of the problem, a resolution method based on the column generation process. We derive a linear formulation which focuses on the transport capacity available on the network cuts. We prove the equivalence of the models, and adapt the resolution method into a cross line and column generation process. Through tests, we point out a contention area located around the mesh gateways which constraints the network capacity. These results are applied to a quantitative study of the effects of acknowledgments on the capacity. We then present a stability study of a protocol which routes a traffic injected arbitrarily. We improve existing results by showing the stability even if the total traffic injected is a maximum flow. All this research work has been implemented in the open-source library MASCOPT (Mascotte Optimisation) dedicated to network optimization problems.

[68] deals with the rate allocation problem for downlink in a Multi-hop Cellular Network. A mathematical model is provided to assign transmission rates in order to reach an optimal and fair solution. We prove and valid experimentally that under some conditions that are often met, the problem can be reduced to a single-hop cellular network problem.

[79] is dedicated to a specific work about the impact of the MAC layer type on the capacity of the network. Using linear programming models, we compare the capacity of a network with MAC link per link acknowledgment to the case where the acknowledgments are done by the transport layer (TCP like).

[46] provides a complete framework based on linear programming to compute upper and lower bounds on the capacity of a CSMA-CA based network according to a physical topology and a given routing protocol. This framework is itself independent of the network topology and the routing protocols, and provides therefore a relevant tool for comparing them. We apply our models to a comparative analysis of a well-known flat routing protocol OLSR against two main self-organized structure approaches, VSR and localized CDS.

6.2.2. Minimizing the energy consumption

[60], [89] investigate the problem of determining feasible radio configurations in fixed broadband wireless networks, focusing on power efficiency. Under this scenario, a power-efficient configuration can be characterized by a modulation constellation size and a transmission power level. Every link holds a set of power-efficient configurations, each of them associating a capacity with its energy cost. We introduce a joint optimization of data routing and radio configuration that minimizes the total energy consumption while handling all the traffic requirements simultaneously. An exact mathematical formulation of the problem is presented. It relies on a minimum cost multicommodity flow with step increasing cost functions, which is very hard to optimize. We then propose a piecewise linear convex function, obtained by linear interpolation of power-efficient points, that provides a good approximation of the energy consumption on the links, and present a relaxation of the previous formulation that exploits the convexity of the cost functions. This yields lower bounds on the total energy expenditure, and finally heuristic algorithms based on the fractional optimum are employed to produce feasible configuration solutions. Our models are validated through extensive experiments, and the results testify the potentialities behind this novel approach.

[116], [84] focuses on the energy consumption of *ad-hoc* and sensor networks through the viewpoint of congestion. Congestion not only causes packet loss and increases queueing delay, but also leads to unnecessary energy consumption. Two types of congestion can occur: node-level congestion, which is caused by buffer overflow in the node, or link-level congestion, when wireless channels are shared by several nodes arising in collisions. A measure of link-level congestion in static wireless ad-hoc and sensor networks randomly deployed over an area is studied. The measure of congestion considered is the inverse of the greatest eigenvalue of the adjacency matrix of the random graph. This measure gives an approximation of the average quantity of wireless links of a certain length on the network. We survey the results to find this measure in Bernoulli random graphs. We use tools from random graph and random matrix theory to extend this measure on Geometric random graphs.

6.2.3. Fast data gathering

Several works of MASCOTTE have dealt with gathering (data collection) in wireless multi hop networks when interferences constraints are present.

[17] concerns the study of the algorithmic and the complexity of the gathering communications in radio networks. The goal is to find the minimum number of steps needed to achieve such a gathering and design algorithms achieving this minimum. For special topologies such as the path and the grid, we have proposed optimal or near optimal solutions. We also considered the systolic (or continuous) case where we want to maximize the throughput (bandwidth) offered to each node.

[87], [103], [52] suppose that the time is slotted and that during one time slot (step) each node can transmit to one of its neighbor at most one data item. Each device is equipped with a half duplex interface; so a node cannot both receive and transmit simultaneously. During a step only non interfering transmissions can be done. In other words, the non interfering calls done during a step will form a matching. Under these settings, the best known algorithm, in terms of the makespan or completion time, in grid networks was a multiplicative 1.5-approximation algorithm. In such topologies, we give a very simple +2 approximation algorithm and then a more involved +1 approximation algorithm. Moreover, our algorithms work when no buffering is allowed in intermediary nodes, i.e., when a node receives a message at some step, it must transmit it during the next step.

[25] considers interference constraint modeled by a fixed integer $d \geq 1$, which implies that nodes within distance d in the graph from one sender cannot receive messages from another node. We give protocols and lower bounds when the network is a path and the destination node is either at one end or at the center of the path. These protocols are shown to be optimal for any d in the first case, and for $1 \leq d \leq 4$, in the second case.

6.2.4. Distributed call scheduling

Distributed call scheduling in wireless networks is a challenging problem to tackle. Indeed, even when interferences are not considered, computing an optimal call scheduling with local information is still an open question.

[114] investigates the problem of routing packets between undifferentiated sources and sinks in a network modeled by a multigraph. A distributed and local algorithm that transmits packets hop by hop in the network is provided and its behaviour is studied. At each step, a node transmits its queued packets to its neighbours in order to optimize a local gradient. This protocol is thus greedy since it does not require to record the history about the past actions, and lazy since it only needs informations of the neighborhood. We prove that this protocol is however optimal in the sense that the number of packets stored in the network stays bounded as soon as the sources injects a flow that another method could have exhausted. We therefore reinforce a result from the literature that worked for differentiated suboptimal flows.

[86] considers a weaker stability objective but coping with interferences. Two distributed algorithms are provided ensuring stability under a random packet arrival process. These algorithms improve on existing algorithms since they work under any binary interference model and under the cost of a constant length control phase.

In [86] [120], we have investigated the problem of distributed transmission scheduling in wireless networks. Due to interference constraints, "neighboring links" cannot be simultaneously activated, otherwise transmissions will fail. Here, we consider any binary model of interference. We assume that traffic is single-hop and that time is slotted. We suppose also random arrivals on each link during each slot. We design a fully distributed local algorithm with the following properties: it works for any arbitrary binary interference model; it has a constant overhead (independent of the size of the network and the values of the queues); and it needs no knowledge. Indeed contrary to other existing algorithms, we do not need to know the values of the queues of the “neighboring links”, which are difficult to obtain in a wireless network with interference. We also give sufficient conditions for stability under Markovian assumptions. The performance of our algorithm (throughput, stability) have been investigated and compared via simulations to that of previously proposed schemes.

6.2.5. Routing in evolving graphs

The assessment of routing protocols for mobile wireless networks is a difficult task, because of the networks dynamic behavior and the absence of benchmarks. However, some of these networks, such as intermittent wireless sensors networks, periodic or cyclic networks, and some delay tolerant networks (DTNs), have more predictable dynamics, as the temporal variations in the network topology can be considered as deterministic, which may make them easier to study. Recently, a graph theoretic model, the evolving graphs was proposed to help capture the dynamic behavior of such networks, in view of the construction of least cost routing and other algorithms. The algorithms and insights obtained through this model are theoretically very efficient and intriguing. However, there were no study about the use of such theoretical results into practical situations.

In [29], we analyze the applicability of the evolving Graph Theory in the construction of efficient routing protocols in realistic scenarios. Using the NS2 network simulator to first implement an evolving graph based routing protocol, we then use it as a benchmark when comparing the four major ad hoc routing protocols (AODV, DSR, OLSR and DSDV). Interestingly, our experiments show that evolving graphs have the potential to be an effective and powerful tool in the development and analysis of algorithms for dynamic networks, with predictable dynamics at least. In order to make this model widely applicable, however, some practical issues still have to be addressed and incorporated into the model, like adaptive algorithms. We also discuss such issues in this paper, as a result of our experience.

6.2.6. Fast IEEE 802.11 Handover for High Speed Vehicles

Providing a continous connection with a terrestrial backbone network from a vehicle moving at high speeds is still an open issue. Various options have already been considered and still being studied such as UMTS, WiMax, LEO Satellites, and so on. Despite some of these having already been implemented and commercially exploited (eg. satellite connexions on trains), most fail to offer a sufficiently reliable service to their customers over long periods of travel time (UMTS/3G) or suffer from a limited ability to support a large number of simultaneous users (satellites). Let's consider the case of trains. Ideally, on-board customers want a full-time connection of their laptop to a regular WiFi network, such that they don't need an additional device, and they want that network to provide a continuous and reliable connection to the Internet. Furthermore, many other devices onboard trains could benefit of such a continuous and reliable connection (eg. security cameras, broadcasting service, etc.), but these devices do not necessarily rely on TCP/IP. In [76], [115], we introduce a new system that allows fast handover between an on-board, fast moving IEEE 802.11 device and a series of 802.11 Access Points regularly placed along the road or track. This new device, called Spiderman, seamlessly alternates connections on two radio channels in order to hide the standard WiFi scanning and association delays. Another noticeable property of this new system is that it is fully implemented withen the OSI layer 2, which means that it does not depend on upper layers mobility mechanisms (in particular TCP/IP). A prototype of this system is currently under testing.

6.3. Application/Overlay Networks

Participants: Jean-Claude Bermond, Olivier Dalle, Afonso Ferreira, Frédéric Giroire, Julian Monteiro, Stéphane Pérennes.

6.3.1. P2P Storage Systems

Traditional means to store data are dedicated servers or magnetic tapes. These solutions are reliable but expensive. Recently, hard disks and bandwidth have become cheaper and widely available, allowing new forms of data storage on distributed, peer-to-peer (P2P) architectures. To achieve high durability, such P2P systems encode the user data in a set of redundant fragments and distribute them among the peers. These systems are cheap to operate, but their highly distributed nature raises questions about reliability, durability, availability, confidentiality, and routing of the data. An abundant literature exists on the topic of P2P storage systems. Several efforts to build large-scale self-managing distributed systems have been done, among others, Intermemory, Ocean Store, Freenet, PASTRY, CFS, Total Recall. However, few analytical models have been proposed to estimate the behavior of the system (the data durability, resource usage, e.g., bandwidth) and understand the trade-offs between the system parameters. Furthermore, in almost all these models, the behavior of a single block is modeled and the block failures are considered independent. We showed that this assumption can lead to severe errors of estimation on the behavior of a system subject to peer failures [61]. Therefore the need of new more complex analytical models to describe the systems. Part of MASCOTTE's work on this topic is done inside the ANR SPREADS project.

In P2P storage systems, peers fail continuously, hence, the necessity of self-repairing mechanisms to achieve high durability. In [90], [61], we propose and study analytical models that assess the bandwidth consumption and the probability to lose data of storage systems that use erasure coded redundancy. We show by simulations that the classical stochastic approach found in the literature, that models each block independently, gives a correct approximation of the system average behavior, but fails to capture its variations over time. These variations are caused by the simultaneous loss of multiple data blocks that results from a peer failing (or leaving the system). We then propose a new stochastic model based on a fluid approximation that better captures the system behavior. In addition to its expectation, it gives a correct estimation of its standard deviation. This new model is validated by simulations.

In [111], [67], we study the impact of different data placement strategies on the system performance when using erasure codes redundancy schemes. We compare three policies: two of them local, in which the data are stored in logical neighbors, and the other one global, in which the data are spread randomly in the whole system. We focus on the study of the probability to lose a data block and the bandwidth consumption to maintain enough redundancy. We use simulations to show that, without resource constraints, the average values are the same no matter which placement policy is used. However, the variations in the use of bandwidth are much more bursty under the local policies. When the bandwidth is limited, these bursty variations induce longer maintenance time and henceforth a higher risk of data loss. Finally, we propose a new external reconstruction strategy and a suitable degree of locality that could be introduced in order to combine the efficiency of the global policy with the practical advantages of a local placement.

In [47], we focus on a class of distributed storage systems whose content may evolve over time. Each component or node of the storage system is mobile and the set of all nodes forms a delay tolerant (ad hoc) network (DTN). The goal of the paper is to study efficient ways for distributing evolving files within DTNs and for managing dynamically their content. We consider both the cases when (a) nodes do not cooperate and (b) nodes cooperate. The objective is to find file management policies (rules specifying when a node may send a copy of a file) which maximize some system utility functions under a constraint on the resource consumption. Both myopic (*static*) and state-dependent (*dynamic*) policies are considered, where the state of a node is the age of the copy of the file it carries. For scenario (a), we find the optimal static (resp. dynamic) policy which maximizes a general utility function under a constraint on the number of transmissions within a slot. In particular, we show the existence of a threshold dynamic policy. In scenario (b) we study the stability of the system (aging of the nodes) and derive an (approximate) optimal static policy. We then revisit scenario (a) when the source does not know parameter N (node population) and q (node meeting probability) and derive a stochastic approximation algorithm which we show to converge to the optimal static policy found in the complete information setting.

6.3.2. Framework for the Analysis of Distributed Systems

Besides the complexity in time or in number of messages, a common approach for analyzing distributed algorithms is to look at their assumptions on the underlying network. In [54], we focus on the study of such assumptions in dynamic networks, where the connectivity is expected to change, predictably or not, during the execution. Our main contribution is a theoretical framework dedicated to such analysis. By combining several existing components (local computations, graph relabellings, and evolving graphs), this framework allows to express detailed properties on the network dynamics and to prove that a given property is necessary, or sufficient, for the success of an algorithm. Consequences of this work include (i) the possibility to compare distributed algorithms on the basis of their topological requirements, (ii) the elaboration of a formal classification of dynamic networks with respect to these properties, and (iii) the possibility to check automatically whether a network trace belongs to one of the classes, and consequently to know which algorithm should run on it.

6.3.3. Network Security

In collaboration with Intel Research Berkeley, MASCOTTE worked on methods for providing security to end hosts in typical enterprise environments. The research is focused on making end host security customizable and adaptable by exploring design profiles based on the end host's communication traffic and using these for anomaly detection.

In [66], we describe a method, on individual end-hosts, to detect command and control (C&C) traffic of a botnet (i.e., a set of devices controlled by a malicious entity). We introduce the notion of destination traffic atoms which aggregate the destinations and services that are communicated with. We then track the persistence (a measure of temporal regularity) of new destination atoms not already whitelisted, to identify suspicious C&C destinations. Importantly, our method does not require any a-priori information about destinations, ports, or protocols used in the C&C, nor do we require payload inspection. We evaluate our system using extensive user traffic traces collected from an enterprise network, along with collected botnet traces. We demonstrate that our method correctly identifies a botnet's C&C traffic, even when it is very stealthy, doing so with a very low false positive rate.

In [49], we study the impact of today's IT policies, defined based upon a monoculture approach, on the performance of endhost anomaly detectors. This approach leads to the uniform configuration of Host intrusion detection systems (HIDS) across all hosts in an enterprise networks. We assess the performance impact this policy has from the individual's point of view by analyzing network traces collected from 350 enterprise users. We uncover a great deal of diversity in the user population in terms of the tail behavior, i.e., the component which matters for anomaly detection systems. We demonstrate that the monoculture approach to HIDS configuration results in users that experience wildly different false positive and false negatives rates. We then introduce new policies, based upon leveraging this diversity and show that not only do they dramatically improve performance for the vast majority of users, but they also reduce the number of false positives arriving in centralized IT operation centers.

Estimating the number of distinct flows in a data stream has many applications in network monitoring and network security. For instance, one can count the number of distinct flows on a traffic to detect Denial of Service attacks. In [32], a new class of algorithms to estimate the cardinality of very large multisets using constant memory and doing only one pass on the data is introduced. It is based on order statistics rather than on bit patterns in binary representations of numbers. Three families of estimators are analyzed. They attain a standard error of using M units of storage, which places them in the same class as the best known algorithms so far. The algorithms have a very simple internal loop, which gives them an advantage in terms of processing speed. For instance, a memory of only 12 kB and only few seconds are sufficient to process a multiset with several million elements and to build an estimate with accuracy of order 2 percent. The algorithms are validated both by mathematical analysis and by experimentation on real Internet traffic.

6.4. Simulation and Optimization Tools

Participants: David Coudert, Olivier Dalle, Luc Hogie, Juan-Carlos Maureira, Christelle Molle, Julian Monteiro, Napoleão Nepomuceno, Brice Onfroy, Fabrice Peix, Judicael Ribault, Hervé Rivano, Michel Syska, Issam Tahiri.

In order to cope with the constant evolution and ever growing complexity and size of networks, new tools and modeling techniques are regularly developed within MASCOTTE. These tools are first developed to answer the internal needs of the team, but we also pay attention to the visibility and the dissemination of these tools in the scientific community.

6.4.1. Discrete-Event Simulation

In the domain of discrete-event simulation, our development efforts on the Open Simulation Architecture (OSA) are going on [119] (See Section 5.1 and http://osa.inria.fr/wiki/.) In particular, we still pay a particular attention to the design and software engineering of our simulation tools[71]. Despite its general purpose, OSA is mainly motivated by our on-going research in the "SPREADS" ANR project, a three years project (with four other french teams) about evaluation and optimization of a peer-to-peer based reliable storage system: for this research, we need to run simulations of very large peer-to-peer systems, which is not possible with the currently existing simulation tools. This simulation challenge motivates in turn a collaboration on within the INRIA ARC “Broccoli” project with Institut TELECOM in Evry and the INRIA ADAM EPI in Lille. This collaboration is about very large scale deployment and instrumentation of OSA distributed simulations on Grid-computing facilities (e.g., on Grid 5000).

Since OSA is still in early ages, we have also been using and contributing to other simulation software. This includes in particular significant contributions to the Omnet++ simulator [76], [77]. These contributions were mainly motivated by our work on the design and prototyping of a new wireless system, called Spiderman, that provides a continuous and high-speed wireless connection on-board fast moving vehicles like trains [76].

We also designed and developed a Dynamic Routing Model Simulator (DRMSim) [113] (see Section 5.1), which addresses the specific problem of large-scale simulations of (inter-domain) routing models on large networks. DRMSim is a discrete-event simulator that comes with a generic routing models and implementations of BGP as well as of State-of-the-Art compact routing protocols. It relies on the Dipergrafs library, which allows efficient operations on large graphs (see Section 5.1). This simulator is designed in particular to address the limitations found in other simulators in terms of the number of nodes they can handle and in the models they propose.

Mobility issues in MANETs have also been studied using simulations. In [117] we have studied the impact of mobility on MANET topology. More precisely, we consider a network composed of a finite number of stations which move into a closed environment. The mobility is defined by the *Random Waypoint* mobility model. Thus, the aim of these works is to determine the impact of the mobility on the network connectivity. The result is an empirical formulation of two bounds on the number of connected components into the network.

In [118] we have proposed a new mobility model concerning MANETs. This article explains a new mobility paradigm based on tasks execution. This is a scheduled mobility model. We consider that each station composing a MANET has to execute mobility tasks into an environment. This environment is defined by a graph in which each edge is a move axis and each node is a location. With this kind of model, we are able to translate any existing mobility model.

6.4.2. Combinatorial Network Optimization

The MASCOPT library has reached maturity and is intensively used inside the team for testing and evaluation of optimization programs (see Section 5.1 and http://www-sop.inria.fr/mascotte/mascopt). During the last year we have pursued its development and the following research has been validated by implementing the algorithm with MASCOPT.

In [15] several algorithms on the optimization of the capacity of wireless mesh networks have been implemented and tested using MASCOPT.

In [79], the study of the effects of the acknowledgment traffic on the capacity of wireless mesh networks has been modeled in a linear programming formulation. The implementation in MASCOPT was solved using the column generation process.

6.5. Graph Theory

Participants: Julio Araujo, Jorgen Bang-Jensen, Jean-Claude Bermond, Nathann Cohen, David Coudert, Frédéric Giroire, Frédéric Havet, Nicolas Nisse, Stéphane Pérennes, Bruce Reed, Leonardo Sampaio, Ignasi Sau-Valls.

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 three important topics: graph colouring, width parameters and random graphs.

- Graph colouring is a hot topic in Graph Theory. It is one of the oldest problem in combinatorics (with the 4-colour problem), has a central position in Discrete Mathematics and a huge number of applications. Lots of new results have been obtained the last ten years with the fast development of new techniques (structural and probabilistic). In MASCOTTE we studied graph colouring problems via these new methods (probabilistic method, discharging method,...).

- The theory of width parameters (tree-width, branch-width, ...) is a deep and algorithmically useful structure theory. Therefore it is now widely studied and used. In particular, it is strongly related to graph searching problems (see 6.6).
- Since the seminal paper of Erdös and Rényi, the theory of random graphs has now grown a very active field with an extensive literature. There are many beautiful results in the theory of random graphs as well as various applications in computer science, biology, ... In Mascotte, we study random graphs for their own sake but as well as tools to solve some graph-theoretic questions which have nothing to do with randomness.

6.5.1. Graph colouring

Colouring and edge-colouring 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 Hadwiger's conjecture, the List Colouring Conjecture and the Acyclic Edge-Colouring Conjecture. We also investigated the relation between the chromatic number and the crossing number of a graph.

We are also interested in colouring problems arising from some practical problems: improper colouring, $L(p,q)$-labelling, directed star arboricity and good edge-labelling. The first two are both motivated by channel assignment and the last two are motivated by problems arising in WDM networks. In [70], some of these problems are summarized.

We also studied some other variants of colouring like circular colouring, non-repetitive colouring and frugal colouring.

Hadwiger's conjecture: The famous Hadwiger's conjecture asserts that every graph with no K_t-minor is $(t-1)$-colourable. The case $t=5$ is known to be equivalent to the Four Colour Theorem by Wagner, and the case $t=6$ is settled by Robertson, Seymour and Thomas. So far the cases $t \geq 7$ are wide open. In [73], we prove the following two theorems: There is an $O(n^2)$ algorithm to decide whether or not a given graph G satisfies Hadwiger's conjecture for the case t. Every minimal counterexample to Hadwiger's conjecture for the case t has at most $f(t)$ vertices for some explicit bound $f(t)$.

In [31], we show an approximate version of Hadwiger's conjecture. A K_t-expansion consists of t vertex-disjoint trees, every two of which are joined by an edge. We call such an expansion *odd* if its vertices can be two-coloured so that the edges of the trees are bichromatic but the edges between trees are monochromatic. We show that, for every t, if a graph contains no odd K_t-expansion then its chromatic number is $O(t\sqrt{\log t})$. In doing so, we obtain a characterization of graphs which contain no odd K_t-expansion which is of independent interest. We also prove that given a graph and a subset S of its vertex set, either there are k vertex-disjoint odd paths with endpoints in S, or there is a set X of at most $2k^2$ vertices such that every odd path with both ends in S contains a vertex in X. Finally, we discuss the algorithmic implications of these results.

Edge-colouring: The most celebrated conjecture on edge-colouring is the List Colouring Conjecture asserting that the chromatic index is always equal to the list chromatic index. Together with Vizing's Theorem it implies the following conjecture : For any graph G with maximum degree Δ, the list chromatic index is at most $\Delta+1$. In [105], we give a short proof of a result of Borodin showing that this later conjecture holds for planar graphs of maximum degree at least 9.

We also investigate the algorithmic issue of edge-colouring. For any $c>1$, we describe [74] a linear time algorithm for fractionally edge colouring simple graphs with maximum degree at least $|V|/c$.

A proper edge-colouring with the property that every cycle contains edges of at least three distinct colours is called an *acyclic edge-colouring*. The *acyclic chromatic index* of a graph G, denoted $\chi'_a(G)$ is the minimum k such that G admits an *acyclic edge-colouring* with k colours. The Acyclic Colouring Conjecture states that $\chi'_a(G) = \Delta(G) + 2$ for every graph G. In [106], [56], 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 and outerplanar graphs. We also show that $\chi'_a(G) \leq \Delta(G) + 25$ for all planar graph G.

Crossing and colouring: The crossing number of a graph G, denoted by $cro(G)$, is the minimum number of crossings in any drawing of G in the plane.

The Four Colour Theorem states that if a graph has crossing number zero then it is 4-colourable. It is then natural to find upper bounds on the chromatic number in terms of its crossing number. Oporowski and Zhao showed that a graph with crossing number at most 3 is 5-colourable unless it contains a K_6. They conjecture that this result could be extended to graphs with crossing number at most 5. In [110], we disprove this conjecture but show that every graph with crossing number at most 4 and containing no K_6 is 5-colourable. We also show some colourability 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-colourable.

Improper colouring: A *k-improper ℓ-colouring* is a mapping c from its vertex set into a set of colours such that every vertex has at most k neighbours with the same colour. A result of Lovász states that for any graph G, such a partition exists if $\ell \geq \left\lceil \frac{\Delta(G)+1}{k+1} \right\rceil$. When $k = 0$, this bound can be reduced by Brooks' Theorem, unless G is complete or an odd cycle. In [28], we study the following question, which can be seen as a generalisation of the celebrated Brooks' Theorem to improper colouring: does there exist a polynomial-time algorithm that decides whether a graph G of maximum degree Δ has k-improper chromatic number at most $\lceil \frac{\Delta+1}{k+1} \rceil - 1$? We show that the answer is no, unless P = NP, when $\Delta = \ell(k+1)$, $k \geq 1$ and $\ell + \sqrt{\ell} \leq 2k + 3$. We also show that, if G is planar, $k = 1$ or $k = 2$, $\Delta = 2k + 2$, and $\ell = 2$, then the answer is still no, unless P = NP. These results answer some questions of Cowen et al. [Journal of Graph Theory 24(3):205-219, 1997].

$L(p,q)$-labelling: An *$L(p,q)$-labelling 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 neighbour. Such a concept is a modeling of a simple channel assignment, in which the separation between channels depends on the distance. More precisely, it has to be at least p if they are very close and q if they are close (but not very close). The goal is to find an $L(p,q)$-labelling f of G with minimum *span* (i.e. $\max\{f(u) - f(v), u, v \in V(G)\}$). It is well known that deciding if a graph has an $L(p,1)$-labelling with minimum span k is NP-complete. We show that it remains NP-complete when restricted to planar graphs [109] or vertex-edge incidence graphs [36] which form a small class of bipartite graphs. We also give [33] some upper bouns for the span of an $L(1,1)$-labelling of a planar graph with large girth.

Directed star arboricity: A *star* is an arborescence in which the root dominates all the other vertices. A *galaxy* is a vertex-disjoint union of stars. The *directed star arboricity* of a digraph D, denoted by $dst(D)$, is the minimum number of galaxies needed to cover $A(D)$. In [69], we show that $dst(D) \leq \Delta(D) + 1$ and that if D is acyclic then $dst(D) \leq \Delta(D)$. These results are proved by considering the existence of spanning galaxies in digraphs. Thus, we study the problem of deciding whether a digraph D has a spanning galaxy or not. We show that it is NP-complete (even when restricted to acyclic digraphs) but that it becomes polynomial-time solvable when restricted to strongly connected digraphs.

Good edge-labelling: Let $\mathcal{P}$ be a family of dipaths of a DAG (Directed Acyclic Graph) G. The *load* of an arc is the number of dipaths containing this arc. Let $\pi(G,\mathcal{P})$ be the maximum of the load of all the arcs and let $w(G,\mathcal{P})$ be the minimum number of wavelengths (colours) needed to colour the dipaths of $\mathcal{P}$ in such a way that two dipaths with the same wavelength are arc-disjoint. There exist DAGs such that the ratio between $w(G,\mathcal{P})$ and $\pi(G,\mathcal{P})$ cannot be bounded. An *internal cycle* is an oriented cycle such that all the vertices have at least one predecessor and one successor in G (said otherwise every cycle contain neither a source nor a sink of G). We prove [97] that, for any family of dipaths $\mathcal{P}$, $w(G,\mathcal{P}) = \pi(G,\mathcal{P})$ if and only if G has no internal cycle. We also consider a new class of DAGs, which is of interest in itself, those for which there is at most one dipath from a vertex to another. We call these digraphs UPP-DAGs. For these UPP-DAGs we show that the load is equal to the maximum size of a clique of the conflict graph. We prove that the ratio between $w(G, \mathcal{P})$ and $\pi(G, \mathcal{P})$ cannot be bounded. For that we introduce *good edge-labellings* of the conflict graph, namely edge-labellings such that for any ordered pair of vertices (x, y) there do not exist two paths from x to y with increasing labels. In [48], [95], we aim at characterizing the class of graphs that admit a good edge-labelling. First, we exhibit infinite families of graphs for which no such 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: C_3-free outerplanar graphs, planar graphs of girth at least 6, subcubic $\{C_3, K_{2,3}\}$-free graphs.

Varied colourings: In [34], we study circular choosability, a notion recently introduced by Mohar and by Zhu. First, we provide a negative answer to a question of Zhu about circular cliques. We next prove that $cch(G) = O\left(ch(G) + \ln|V(G)|\right)$ for every graph G. We investigate a generalisation of circular choosability, the circular f-choosability, where f is a function of the degrees. We also consider the circular choice number of planar graphs. Mohar asked for the value of $\tau := \sup cch(G) : G$ is planar, and we prove that $6 \leq \tau \leq 8$, thereby providing a negative answer to another question of Mohar. We also study the circular choice number of planar and outerplanar graphs with prescribed girth, and graphs with bounded density.

We also study non-repetitive colouring. 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 coloured. A trail is called *non-repetitive* if the sequence of colours of its edges is non-repetitive. If G is a plane graph, a *facial non-repetitive edge-colouring* of G is an edge-colouring 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 colours of a facial non-repetitive edge-colouring of G. In [112], 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.

We also worked on frugal colouring. In [80], we prove that every graph with maximum degree Δ can be properly $(\Delta + 1)$-coloured so that no colour appears more than $O(\log\Delta/\log\log\Delta)$ times in the neighbourhood of any vertex. This is best possible up to the constant factor in the O(–) term. We also provide an efficient algorithm to produce such a colouring.

Finally, in [43], we consider the class of graphs that contain no odd hole, no antihole, and no ”prism” (a graph consisting of two disjoint triangles with three disjoint paths between them). We give an algorithm that can optimally color the vertices of these graphs in time $O(n^2 m)$.

6.5.2. Width parameters

A key notion in the tree-width theory is the duality between the bramble-number of a graph and its tree-width. Adapting the method introduced in Graph Minors x [Robertson and Seymour, Journal of Combinatorial Theory B 52(2): 153-190 (1991)], we propose a new proof of it [23]. Our approach is based on a new definition of submodularity on partition functions which naturally extends the usual one on set functions. The proof does not rely on Menger's theorem, and thus greatly generalises the original one. It thus provides a dual for matroid tree-width. One can also derive all known dual notions of other classical width-parameters from it.

On the algorithmic point of view, lots of polynomial time algorithms based on tree-width use a related duality fact: if a graph has no $r \times r$ grid minor then its tree-width is bounded by 2^{20r^5}. This huge upper bound is far from being tight (a polynomial in r bound is conjectured) and implies the existence of large constant in the actual time-complexity of the algorithms and thus make the algorithms not efficient practically. Hence an issue is to find the tight upper bound or at least lower the actual upper bound. In [26], we show that a graph with no 3×3 grid minor has treewidth at most 7. This is tight and improves the best known upper bound which was 2942.

In [22], we present a result concerning the relation between the path-width of a planar graph and the path-width of its topological dual. More precisely, we prove that for a 3-connected planar graph G, $pw(G) \leq 3pw(G^*) + 2$. For 4-connected planar graphs, and more generally for Hamiltonian planar graphs, we prove a stronger bound $pw(G^*) \leq 2pw(G) + c$. The best previously known bound was obtained by Fomin and Thilikos who proved that $pw(G^*) \leq 6pw(G) + cte$. The proof is based on an algorithm which, given a fixed spanning tree of G, transforms any given decomposition of G into one of G^*. The ratio of the corresponding parameters is bounded by the maximum degree of the spanning tree. In [82], we present a result concerning the relation between the branch-with of a graph embedded in a surface of Euler genus g and the branch-width of its topological dual. We prove that $\mathbf{b}w(G^*) \leq 6 \times \mathbf{b}w(G) + 2g - 4$ for any graph G embedded in a surface of Euler genus g.

6.5.3. Random graphs

We studied various parameters of random graphs and random walks.

In [65], we investigate the giant component problem in random graphs with a given degree sequence. We generalize the critical condition of Molloy and Reed [Molloy, M., and B. Reed, Random Structures Algorithms 6 (1995), 161-179], which determines the existence of a giant component in such a random graph, in order to include degree sequences with heavy tails. We show that the quantity which determines the existence of a giant component is the value of the smallest fixed point inside the interval $[0, 1]$ of the generating function $F(s) = \sum_{i\geq 1} \delta_i s^{i-1}$, where δ_i is the asymptotic proportion of the total degree contained in vertices of degree i. Moreover, we show that this quantity also determines the existence of a core (i.e., the maximal subgraph of minimum degree at least 2) that has linear total degree.

In [19], we consider the complete graph on n vertices whose edges are weighted by independent and identically distributed edge weights and build the associated minimum weight spanning tree. We show that if the random weights are all distinct, then the expected diameter of such a tree is $\Theta(n^{1/3})$. This settles a question of Frieze and McDiarmid [Random Structures Algorithms, 10(1-2):5–42, 1997]. The proofs are based on a precise analysis of the behaviour of random graphs around the critical point.

Given a branching random walk, let M_n be the minimum position of any member of the nth generation. In [20], we calculate $\mathbb{E}(M_n)$ to within $O(1)$ and prove exponential tail bounds for $\mathbb{P}(|M_n - \mathbb{E}(M_n)| > x)$, under quite general conditions on the branching random walk. In particular, together with work by Bramson [Z. Wahrsch. Verw. Gebiete 45 (1978) 89-108], our results fully characterise the possible behaviour of $\mathbb{E}(M_n)$ when the branching random walk has bounded branching and step size.

6.5.4. Miscellaneous

In [40] we prove the following result. Suppose that s and t are vertices of a 3-connected graph G such that $G - \{s, t\}$ is not bipartite and there is no cutset X of size three in G for which some component U of $G - X$ is disjoint from $\{s, t\}$. Then either (1) G contains an induced path P from s to t such that $G - V(P)$ is not bipartite or (2) G can be embedded in the plane so that every odd face contains one of s or t. Furthermore, if (1) holds then we can insist that $G - V(P)$ is connected, while if G is 5-connected then (1) must hold and P can be chosen so that $G - V(P)$ is 2-connected.

A *circuit* in a simple undirected graph $G = (V, E)$ is a sequence of vertices $\{v_1, v_2, ..., v_{k+1}\}$ such that $v_1 = v_{k+1}$ and $\{v_i, v_{i+i}\} \in E$ for $i = 1, ..., k$. A circuit C is said to be *edge-simple* if no edge of G is used twice in C. In [107], [57], 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.

6.6. Algorithms

Participants: Nathann Cohen, Afonso Ferreira, Florian Huc, Gianpiero Monaco, Nicolas Nisse, Stéphane Pérennes, J-P. Perez Seva, Bruce Reed, Hervé Rivano, Ignasi Sau-Valls.

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 either with exact algorithms or approximation ones. We are mainly focused on four important topics:

- The routing problems plays an essential role in communication networks. It involves how to transfer data from some origins to some destinations within a reasonable amount of time. In MASCOTTE, we consider this problem in centralized and distributed environments. We also consider the routing problem in particular graph classes and in general graphs.
- Graph searching gathers an active research community (see, e.g., the first three editions of the "Workshop on Graph Searching, Theory and Applications" took place in Crete (2006), Brazil (2008) and Czech Republic (2009)). In particular, the graph searching problem has been widely studied for its close relationship with graph decompositions (see Section 6.5). Note that this problem has also a practical impact in the area of optical network reconfiguration which is dealt with in Section 6.1.
- The field of algorithmic game theory combines computer science concepts of complexity and algorithm design with game theory and economic theory. Algorithmic game theory is considered as the most powerful tool dealing with non-cooperative systems in which the lack of coordination among the players produces inefficient solutions in the optimization of systems requirements. There are a lot of situations occurring in real life in which we seek the maximization of our own benefit and very often the final outcome of our efforts also depends on the behavior of other people we have no control on. In MASCOTTE, we are interested in considering communication problems arising in networks with non-cooperative users.
- Parameterized complexity is a recent approach to deal with intractable computational problems having some parameters that can be relatively small with respect to the input size. This area has been developed extensively during the last decade. More precisely, a parameter P is any function mapping graphs to non-negative integers. The parameterized problem associated with parameter P asks, for some fixed k, whether $P(G) \geq k$ for a given graph G. For decision problems with input size n and parameter k, the goal is to design an algorithm with running time $f(k).n$, where f depends only on k. Problems having such an algorithm are said to be fixed-parameter tractable (FPT).

6.6.1. Routing

We consider the routing problem through three different approaches: compact routing, the (ℓ, k)-routing problem and the disjoint paths problem. First two studies consider specific classes of graphs while the third one considers general graphs.

<u>Compact routing:</u>

In any distributed communication network it is important to deliver messages between pairs of nodes. Routing schemes consist in the design of a routing table in each node (node's local memory where the routing information is stored) together with a protocol that allow each node to decide toward which port (incident edge) it must transmit a message knowing the message's destination. Compact routing consider the tradeoffs between the length of the computed routes and the size of routing tables (the local knowledge of each node about the network's topology). Antoher issue of interest is the computation of routing table.

In general, it is difficult to establish good tradeoffs between the length of computed routes and the size of the routing tables. Efficient algorithms for computing routing tables should take advantage of the particular properties arising in large scale networks. We consider two properties: low (logarithmic) diameter and high clustering coefficient (implying the existence of few large induced cycles). We propose a routing scheme that computes short routes in the class of k-chordal graphs, i.e., graphs with no chordless cycles of length more than k [81]. This algorithm has been implemented using DRMSim 6.4.

<u>(ℓ, k)-routing problem:</u>

In the (ℓ, k)-routing problem, each node can send at most ℓ packets and receive at most k packets. In this setting, the goal is to minimize the number of time steps required to route all packets to their respective destinations, under the constraint that each link can be crossed simultaneously by no more than one packet. Permutation routing is the particular case $\ell = k = 1$. In the r-central routing problem, all nodes at distance at most r from a fixed node v want to send a packet to v. In [37], we study the permutation routing, the r-central routing and the general (ℓ, k)-routing problems on plane grids, that is square grids, triangular grids and hexagonal grids. We use the *store-and-forward* Δ-port model, and we consider both full and half-duplex networks. The main contributions are the following: (1) tight permutation routing algorithms on full-duplex hexagonal grids, and half duplex triangular and hexagonal grids, (2) tight r-central routing algorithms on triangular and hexagonal grids, (3) tight (k, k)-routing algorithms on square, triangular and hexagonal grids, and (4) good approximation algorithms (in terms of running time) for (ℓ, k)-routing on square, triangular and hexagonal grids, together with new lower bounds on the running time of any algorithm using shortest path routing. All these algorithms are completely distributed, i.e. can be implemented independently at each node. Finally, we also formulate the (ℓ, k)-routing problem as a WEIGHTED EDGE COLORING problem on bipartite graphs. We provide a survey on above problems in [93].

Disjoint paths problems:

Given a number of requests (pair of vertices), the disjoint paths problem asks whether there exist pairwise disjoint paths to be assigned to all requests. We investigate several variants of this widely studied problem.

In [39], we propose a polynomial-time algorithm that, given ℓ requests, finds ℓ disjoint paths in a symmetric directed graph. It is known that the problem of finding $\ell \geq 2$ disjoint paths in a directed graph is NP-hard [S. Fortune, J. Hopcroft, J. Wyllie, Journal of Theoretical Computer Science 10 (2) (1980) 111-121]. However, by studying minimal solutions it turns out that only a finite number of configurations are possible in a symmetric digraph. We use Robertson and Seymour's polynomial-time algorithm [N. Robertson, P. D. Seymour, Graph minors xiii, Journal of Combinatorial Theory B (63) (1995) 65-110] to check the feasibility of each configuration.

A graph G is k-linked if G has at least $2k$ vertices $(x_1, y_1), \cdots, (x_k, y_k)$, such that G contains k pairwise disjoint paths between x_i and y_i ($i = 1$ to k). We say that G is parity-k-linked if G is k-linked and, in addition, the paths can be chosen such that the parities of their length are prescribed. Thomassen was the first to prove the existence of a function $f(k)$ such that every $f(k)$-connected graph is parity-k-linked if the deletion of any $4k - 3$ vertices leaves a nonbipartite graph. In [41], we show that the above statement is still valid for $50k$-connected graphs. This is the first result that connectivity which is a linear function of k guarantees the Erdös-Pósa type result for parity-k-linked graphs. In [72], we consider a similar problem where each vertex is on at most two of these paths. We present an $O(m\alpha(m,n)logn)$ algorithm for fixed k, where n, m are the number of vertices and the number of edges, respectively, and the function $\alpha(m, n)$ is the inverse of the Ackermann function. This is the first polynomial time algorithm for this problem, and generalizes polynomial time algorithms by Kleinberg, and Kawarabayashi and Reed, respectively, for the half integral disjoint paths packing problem, i.e., without the parity requirement. We also have algorithms running in $O(m(1+\epsilon))$ time for any $\epsilon > 0$ for this problem, if k is up to $o(logloglogn)$ for general graphs, up to $o(loglogn)$ for planar graphs, and up to $o(loglogn/g)$ for graphs on the surface, where g is Euler genus. Furthermore, if k is fixed, then we have linear time algorithms for the planar case and for the bounded genus case.

6.6.2. Graph Searching

Graph Searching encompasses a wide variety of combinatorial problems related to the capture of an arbitrary fast 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. We mainly investigate three variants of graph searching: visible graph searching, connected graph searching and distributed graph searching. The first study is motivated by the relationship between graph searching and graph decompositions, while the main motivation for both other studies is the design of distributed protocols allowing searchers to compute a capture strategy.

Roughly, if the fugitive is visible (i.e., the searchers are permanently aware of the position of the fugitive) then graph searching is equivalent to treewidth, while it is equivalent to pathwidth otherwise. In [30], we introduce non-deterministic graph searching where the fugitive is visible a limited number of steps. We prove the NP-hardness of this problem and design an exponential exact algorithm for solving it. This new variant leads to the unified view of graph decompositions in terms of partition functions and partitioning-trees [23].

A strategy is called connected if the clear part (the part where the fugitive cannot stand) always induces a connected subgraph. In particular, when the strategy has to be computed online, this property ensures safe communications between the searchers during the whole strategy. In [44], we investigate the cost of the connectedness of a strategy. We design an algorithm that computes a connected capture strategy using at most $O(tw(G) * k)$ times the search number of G, in any k-chordal graph G with treewidth $tw(G)$.

We then propose a polynomial-time distributed algorithm for clearing any network using the optimal number of searchers assuming that the searchers have some knowledge about the network they are clearing. More precisely, we prove that the amount of information necessary to clear any n-node network in a monotone distributed way is $\Theta(nlogn)$ bits [45]. When the network is unknown a priori, we propose a polynomial-time distributed algorithm for clearing any n-node network using $O(\frac{n}{logn})$ times the optimal number of searchers and we prove this is optimal [38].

6.6.3. Algorithmic Game Theory

In highly distributed systems, it might be too strong or unrealistic to assume that the resources of the system are directly accessible and controllable by a centralized authority. Therefore, we consider communication problems arising in networks with autonomous or non-cooperative users. In such a scenario, users pursue an own often selfish strategy and the system evolves as a consequence of the interactions among them. The interesting arising scenario is thus characterized by the conflicting needs of the users aiming to maximize their personal profit and of the system wishing to compute a socially efficient solution.

The uncoordinated users' behavior, addressing communication primitives in an individualistic and selfish manner, poses several intriguing questions ranging from the definition of reasonable and practical models, to the quantification of the efficiency loss due to the lack of users' cooperation. We survey several results lately achievied in this research area and propose interesting future research directions [91].

We consider the pure Nash equilibrium as the outcome of the game and in turn as the concept capturing the notion of stable solution of the system. We make different progresses on the understanding of a variety of problems in communication networks. We study the performances of Nash equilibria in isolation games, a class of competitive location games recently introduced by Zhao et al. For all the cases in which the existence of Nash equilibria has been shown, we give tight or asymptotically tight bounds on the prices of anarchy and stability under the two classical social functions mostly investigated in the scientific literature, namely, the minimum utility per player and the sum of the players' utilities. Moreover, we prove that the convergence to Nash equilibria is not guaranteed in some of the not yet analyzed cases [53].

6.6.4. Parameterized complexity

We design FPT-algorithms for four NP-complete problems: the Bounded-Degree Connected Sub-graph Problems on Planar Graphs, the Bounded leaves Sub-tree Problem, the Fractional Path Coloring Problem and the Spanning Galaxies Problem.

In [18], [83], we present subexponential parameterized algorithms on planar graphs for a family of problems that consist in, given a graph G, finding a connected subgraph H with bounded maximum degree, while maximizing the number of edges (or vertices) of H. These problems are natural generalisations of the LONGEST PATH problem. Our approach uses bidimensionality theory to obtain combinatorial bounds, combined with dynamic programming techniques over a branch decomposition of the input graph. These techniques need to be able to keep track of the connected components of the partial solutions over the branch decomposition, and can be seen as an *algorithmic tensor* that can be applied to a wide family of problems that deal with finding connected subgraphs under certain constraints.

An out-tree T is an oriented tree with exactly one vertex of in-degree zero and a vertex x of T is called internal if its out-degree is positive. In [55], we design randomized and deterministic algorithms for deciding whether an input digraph contains a subgraph isomorphic to a given out-tree with k vertices. Both algorithms run in $O^*(5.704^k)$ time. We apply the deterministic algorithm to obtain an algorithm of runtime $O^*(c^k)$, where c is a constant, for deciding whether an input digraph contains a spanning out-tree with at least k internal vertices. This answers in the affirmative a question of Gutin, Razgon and Kim (Proc. AAIM'08).

In [27], we study the natural linear programming relaxation of the path coloring problem. We prove constructively that finding an optimal fractional path coloring is FPT with the degree of the tree as parameter: the fractional coloring of paths in a bounded degree trees can be done in a time which is linear in the size of the tree, quadratic in the load of the set of paths, while exponential in the degree of the tree. We give an algorithm based on the generation of an efficient polynomial size linear program. Our algorithm is able to explore in polynomial time the exponential number of different fractional colorings, thanks to the notion of trace of a coloring that we introduce. We further give an upper bound on the cost of such a coloring in binary trees and extend this algorithm to bounded degree graphs with bounded treewidth. Finally, we also show some relationships between the integral and fractional problems, and derive a $(1 + 5/3e)$-approximation algorithm for the path coloring problem in bounded degree trees, improving on existing results. This classic combinatorial problem finds applications in the minimization of the number of wavelengths in wavelength division multiplexing (WDM) optical networks. In [74], we describe a linear time algorithm for fractionally edge colouring simple graphs with maximum degree at least $|V|/c$ $(c > 1)$.

In [69], we prove that the parametrized version of the Spanning Galaxies Problem (see Section 6.5) has a linear kernel.

6.6.5. *Miscellaneous*

In [78] Tolerance graphs model interval relations in such a way that intervals can tolerate a certain degree of overlap without being in conflict. This class of graphs, which generalizes in a natural way both interval and permutation graphs, has attracted many research efforts since their introduction, as it finds many important applications in constraint-based temporal reasoning, resource allocation and scheduling problems, among others. In this article we propose the first non-trivial intersection model for general tolerance graphs, given by three-dimensional parallelepipeds, which extends the widely known intersection model of parallelograms in the plane that characterizes the class of bounded tolerance graphs. Apart from being important on its own, this new representation also enables us to improve the time complexity of three problems on tolerance graphs. Namely, we present optimal $O(n \log n)$ algorithms for computing a minimum coloring and a maximum clique, and an $O(n^2)$ algorithm for computing a maximum weight independent set in a tolerance graph with n vertices, thus improving the best known running times $O(n^2)$ and $O(n^3)$ for these problems, respectively.

In [42], we consider the following problem in a n-node graph $G = (V, E)$. Place $m = n$ points on the vertices of G independently and uniformly at random. Once the points are placed, relocate them using a bijection from the points to the vertices that minimizes the maximum distance between the random place of the points and their target vertices. We look for an upper bound on this maximum relocation distance that holds with high probability (over the initial placements of the points). For general graphs and in the case $m \leq n$, we prove the $\#P$-hardness of the problem and that the maximum relocation distance is $O(\sqrt{n})$ with high probability. We present a Fully Polynomial Randomized Approximation Scheme when the input graph admits a polynomial-size family of witness cuts while for trees we provide a 2-approximation algorithm. Many applications concern the variation in which $m = (1 - q)n$ for some $0 < q < 1$. We provide several bounds for the maximum relocation distance according to different graph topologies.

7. Contracts and Grants with Industry

7.1. Contract with Alcatel-Lucent bell-labs (Antwerpen, Belgium), 12/2008 -12/2010

Participants: David Coudert, Luc Hogie, Nicolas Nisse, Stéphane Pérennes, Issam Tahiri.

On Dynamic Compact Routing Schemes in collaboration with LABRI (Bordeaux)

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

7.2. 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 (the ADR finances a Ph.D. student).

(http://inria.bell-labs.commonlab.homeip.net/index.php/High_Manageability)

7.3. Grant 3-Roam Province PACA, 12/2007 - 11/2010

Participants: David Coudert, Napoleão Nepomuceno.

Grant for a Ph.D. student (N. Nepomuceno) cofinanced by the SME 3-Roam and the *région PACA* on optimization and dynamic routing in wireless backhaul networks.

7.4. Contract APRF (région PACA) RAISOM with 3-Roam and AVISTO, 05/2009 - 04/2012

Participants: Jean-Claude Bermond, David Coudert, Napoleão Nepomuceno, Stéphane Pérennes, Hervé Rivano, Issam Tahiri.

On Wireless IP Service Deployment optimization and monitoring.

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

8. Other Grants and Activities

8.1. National Collaborations

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

Participants: David Coudert, Frédéric Giroire, Dorian Mazauric, Joanna Moulierac, Napoleão Nepomuceno, Brice Onfroy.

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 10/2009-09/2012

Participants: Nathann Cohen, David Coudert, Frédéric Havet, Stéphane Pérennes, Michel Syska.

The project AGAPE (Parametrized and exact graph algorithms) is led by MASCOTTE and implies also LIRMM (Montpellier) and LIFO (Orléans).

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

8.1.3. ANR SPREADS 12/2007- 11/2010

Participants: Olivier Dalle, Frédéric Giroire, Julian Monteiro, Philippe Mussi, Stéphane Pérennes, Judicael Ribault, Michel Syska.

The project SPREADS (Safe P2p-based REliable Architecture for Data Storage) is leaded by the SME UBISTORAGE; other partners are the INRIA teams MASCOTTE and REGAL in Rocquencourt and Eurecom and LACL Paris XII. It concerns the evaluation and optimization of a peer-to-peer based reliable storage system for which simulations of very large peer-to-peer systems will be done using OSA. It has got the approbation and label of the "pôle de compétitivité" SCS.

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

8.1.4. ANR VERSO ECOSCells 11/2009-10/2012

Participants: Jean-Claude Bermond, David Coudert, Hervé Rivano.

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 SME and 6 research institutes: Alcatel-Lucent Bell Labs (leader), Orange Labs, 3ROAM, 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)

8.1.5. ARC BROCCOLI, 01/2008-12/2009

Participants: Olivier Dalle, Luc Hogie, Juan-Carlos Maureira, Julian Monteiro, Fabrice Peix, Judicael Ribault.

ARC BROCCOLI (Building instRumenting and deplOying Component-based arChitecture fOr Large-scale applIcations) involves the INRIA teams MASCOTTE, ADAM in Lille Nord Europe and Télécom SudParis - ACMES team in Evry. The topic is the very large scale deployment and instrumentation of OSA distributed simulations on Grid-computing facilities (e.g. on Grid 5000).

8.1.6. Action ResCom, 2006-...

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

8.1.7. Action Graphes, 2006-...

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

8.2. European Collaborations

8.2.1. European project IST AEOLUS, Integrated Project IST-015964, 09/2005-02/2010

Participants: Jean-Claude Bermond, David Coudert, Frédéric Giroire, Frédéric Havet, Stéphane Pérennes, Hervé Rivano.

On Algorithmic Principles for Building Efficient Overlay Computers (AEOLUS), in collaboration with 21 European universities and coordinated by University of Patras, Greece.

The recent explosive growth of the Internet gives rise to the possibility of a global computer of grand-scale consisting of Internet-connected computing entities (possibly mobile, with varying computational capabilities, connected among them with different communication media), globally available and able to provide to its users a rich menu of high-level integrated services that make use of its aggregated computational power, storage space, and information resources. Achieving this efficiently and transparently is a major challenge that can be overcome by introducing an intermediate layer, the overlay computer.

The goal of AEOLUS is to investigate the principles and develop the algorithmic methods for building such an overlay computer that enables this efficient and transparent access to the resources of an Internet-based global computer.

MASCOTTE is the leader of Sub-Project 2 on resource management.

The work within this subproject focuses on the study of fundamental issues for accessing and managing communication resources in an overlay computer. Our research addresses novel and challenging algorithmic issues for efficient resource discovery and querying like construction of overlay networks, query routing and execution, and for sharing critical resources like bandwidth.

(http://aeolus.ceid.upatras.gr/)

8.2.2. PHC Proteus (with Ljubljana) 01/2009-12/2010

Responsable: Frédéric Havet.

On Graph colouring: theoretical and algorithmic aspects.

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

Responsable: Frédéric Havet.

On Graph colouring: theoretical and algorithmic aspects.

8.3. International Collaborations

8.3.1. Join team "RESEAUXCOM", 01/2003-12/2009

Responsable: Jean-Claude Bermond.

Joint team with the Network Modeling Group (S.F.U., Vancouver, Canada). One of the main objectives is to strengthen our collaboration with S.F.U. Many reciprocal visits have been performed.

(http://www-sop.inria.fr/teams/mascotte/equipeassociee/reseauxcom/)

8.3.2. Join team "EWIN", 01/2009-12/2011

Responsable: Frédéric Havet.

Joint team EWIN (Efficient algorithms in WIreless Networks) with the Departamento de Computação of Universidade Federal do Ceará of Fortaleza (Brazil).

(http://www-sop.inria.fr/teams/mascotte/equipeassociee/ewin/)

8.4. Guests

Jorgen Bang-Jensen: University of Southern Denmark, Odensee, Denmark, October 3-29, 2009 (4 weeks)

Ricardo Correa: Universidade Federal do Ceará, Fortaleza, Brasil, November 23-December 6, 2009 (2 weeks)

Manoel Campelo: Universidade Federal do Ceará, Fortaleza, Brazil, November 28- December 12, 2009 (2 weeks)

Luisa Gargano: Salerno Italy, July 1-August 31, 2009 (2 months)

Rok Erman: University of Ljubljana, Slovenia, June 21-27, 2009 (1 week)

Pavol Hell: Simon Fraser University, Vancouver, Canada, October 15-29, 2009 (2 weeks)

Jan Himmelspach: University Rostock, Rostock, Germany, May 23- June 6, 2009 (2 weeks)

Dan Kilper: Alcatel-Lucent Bell-Labs, Holmdel, USA, December 11, 2009 (1 day)

Bernard Lidicky: Charles University, Pragues, Czech Republic, June 21-27, 2009 (1 week)

Claudia Linhares-Sales: Universidade Federal do Ceará, Fortaleza, Brasil, October 1-10, 2009 (10 days)

Frédéric Majorzick: University of Bordeaux (LaBRi) France, October 5-7, 2009 (3 days)

Giorgos B. Mertzios: RWTH Aachen University, Aachen, Germany. September 20-October 3, 2009 (2 weeks)

Ondrej Pandrac: Charles University, Pragues, Czech Republic, June 21-27, 2009 (1 week)

Anis Ouni: EPI SWING, CITI, INSA Lyon, France, April 20-30, 2009 (10 days)

Dimitri Papadimitriou: Alcatel Lucent Bell-Labs, Antwerpen, Belgium, January 15-16, 2009 (2 days)

David Peleg: Weizmann Institute of Science, Rehovot, Istael, October 13-17, 2009 (4 days)

Dimitrios M. Thilikos: National and Kapodistrian University of Athens, Grece, June 17-23, 2009 (1 week)

Ugo Vaccaro: Salerno Italy, July 1-August 31, 2009 (2 months)

Gabriel Weiner: Carleton University, Ottawa, Canada, June 1-15, 2009 (2 weeks)

Joseph Yu: S.F.U. Vancouver, Canada, February 24- May 22, 2009 (3 months)

8.5. Visits of Mascotte members to other research institutions

J-C. Bermond: Visit to LMD, Marseille, France (February 24, 2009);

N. Cohen: Visit to G-SCOP, Grenoble, France (September 16-18, 2009); Visit to the University of Ljubljana, Slovenia, (October 25 – November 11, 2009);

D. Coudert: LIAFA, Paris, France (January 14, 2009); Alcatel-Lucent Bell labs, Antwerpeen, Belgium, (October 22-23, 2009);

O. Dalle: Visit to VSIM at Carleton University, Ottawa, Canada (July, 21 - July 31, 2009; August 9 - August 20, 2009); Visit to SFU, Vancouver, Canada (August 1-9, 2009); Visit to INRIA/ADAM, Lille (June 9-12, 2009); Visit to DAATLE, Gardanne (Nov 24, 2009).

F. Havet: Visit to LIAFA, Paris, France (February 17-20, 2009); Visit to G-SCOP, Grenoble, France (September 16-18, 2009); Visit to LIA, Federal University of Ceará, Brasil, (November 7–13, 2009);

J-C. Maureira: Visit to VSIM at Carleton Univeristy, Ottawa, Canada (August, 3-20, 2009);

D. Mazauric: Visit to UFC (Universidade Federal do Ceará), Fortaleza, Brazil (July 29 - September 2, 2009);

C. Molle: Visit to the Department of Electrical and Computer Engineering, University of Waterloo, Ontario, Canada (January 7-February 7, 2009);

J. Monteiro: Visit to Carleton University, Ottawa, Canada, (July 20 - Aug 09, 2009);

N. Nepomuceno: Visit to Universidade Federal do Ceará, Fortaleza, Brazil, (July 9 - September 1st 2009);

N. Nisse: Visit to LaBRI, Bordeaux, France (March 9-13, 2009, and November 26- December 5, 2009); Visit to LIFL, EPI POPS, Lille, France (March 5, 2009); Many short visits to LIF, Marseille, France;

S. Pérennes: Visit to Simon Fraser Univ., School of Computer sciences, Vancouver, Canada (November 3-23, 2009)

J. Ribault: Visit to ACMES, Evry, France (January 19-23, 2009); Visit to LACL, Créteil, France (April 20-May 1); Visit to Carleton University, Ottawa, Canada (July 27-August 14); Visit to ACMES, Evry, France (September 14-October 2, 2009);

H. Rivano: Many short visits to CITI lab (INSA Lyon/INRIA) and long stay (September - December);

I. Sau-Valls: Visit to the Algorithms Research Group of University of Bergen. Bergen, Norway (May 14-21, 2009); Visit to the Research Group on Graph Theory and Combinatorics of UPC, Barcelona, Spain (February 1-8, 2009 and August, 2009).

9. Dissemination

9.1. Leadership within the scientific community

9.1.1. Participation in Committees

J-C. Bermond: expert for DRTT, AERES, ANRT and various projects outside France (Canada,...); member of the *comité de sélection* of 61^{e} section of UNS; responsible of the *Pôle ComRed* of I3S; member of the recruiting committee of an ingeneer for the *Pôle ComRed* of I3S; member of the Ph.D. committee of the University of Marseille.

D. Coudert: expert for the National Sciences and Engineering Research Council of Canada (NSERC) and the ANR; Member of committee 525 (Applied mathematics) of the *fonds québécois de la recherche sur la nature et les technologies* (FQNRT), research in team program, 2009; International expert for the Ministry of Education, Youth and Sports of the Czech Republic under the priority axis 2 "Regional R&D centres" of Operational Programme Research and Development for Innovation, a major research programme co-funded from the EU Structural Funds, 2009; Member of the *comité du suivi doctoral* of INRIA Sophia Antipolis (since 01/2009); Member of *comité de sélection* of 61^{e} section for UNS, 2009.

F. Giroire: member of I3S laboratory committee.

F. Havet: elected member of I3S laboratory committee.

J. Moulierac: responsible of a new international master of science at University of Nice Sophia Antipolis (http://ubinet.inria.fr).

H. Rivano: elected member of the CNRS National Committee, nominated member of I3S laboratory committee (- September), nominated member of CITI laboratory committee (October -).

M. Syska: member of the *comité de sélection* of 27^{e} section of the IUT, Univ. of Nice Sophia; director of the Licence LP SIL degree at IUT.

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 and the SIAM book series on Discrete Mathematics, Transactions on Network Optimization and Control (2009), Discrete Mathematics, Algorithms and Applications (2009).

A. Ferreira: Journal of Parallel and Distributed Computing (Academic Press), Parallel Processing Letters (World Scientific), Journal of Interconnection Networks (World Scientific), Wireless Networks (Springer).

O. Dalle: ICST International Conference on Simulation Tools and Techniques (SIMUTools 2009), Rome, February 2009 [94].

B. Reed: Journal of Combinatorial Theory, Series B (Elsevier). Journal of Graph Theory.

9.1.3. Steering Committees

J-C. Bermond: Member of the Advisory Committee of I-SPAN 2009 The 10th International Symposium on Pervasive Systems, Algorithms and Networks December 14-16, 2009 Kaohsiung, Taiwan, R.O.C;

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

O. Dalle: ICST International Conference on Simulation Tools and Techniques (SIMUTools 2009), Rome, February 2009;

F. Havet: Journées Combinatoire et Algorithmes du Littoral Méditerranéen (JCALM);

N. Nisse: 3rd edition of the International workshop on Mobility, Algorithms, Graph Theory In dynamic Networks (IMAGINE 2009) that was held in conjonction with SIROCCO 2009 - Piran, Slovenia - May 28th, 2009;

B. Reed: Member of the Pacific Institute for Mathematical Sciences Scientific Review Committee until June 30 2009.

9.1.4. Workshop organization

2nd Bellairs Workshop on Probabilistic Combinatorics and WVD, one week, March 2009, Bellairs Research Institute, Barbados. B. Reed co-organizer

CRM workshop on Combinatorics, Randomized Algorithms and Probability, one week, May 2009, CRM in Montreal, Canada. B. Reed co-organizer

Invited minisymposium which formed part of the CANADAM conference, May 2009, CRM in Montreal, Canada. B. Reed co-organizer

AGAPE'09, Lozari, France, May 25-29 2009 (70 participants).
F. Havet organizing chair

IMAGINE'09, 3rd International workshop on Mobility, Algorithms, Graph Theory In dynamic NEtworks. Piran, Slovenia, May 28th, 2009. I. Sau-Valls co-chair

Workshop on Probabilistic and Extremal Combinatorics, one week, August 2009, BIRS in Banff, Alberta, Canada. B. Reed co-organizer

2nd Czech-Slovenian-French Workshop on Graph Colouring, Sept. 21-25, 2009, Puyloubier, France.
F. Havet organizing chair.

Valuetools'09, Invited session, Pisa, Italy, Sept 22, 2009.
O. Dalle organizing chair

JCALM'09, Sophia Antipolis, France, October 19-20 2009 (25 participants).
F. Havet organizing chair.

9.1.5. Participation in program committees

J-C. Bermond: ACM Mobility 2009.

F. Giroire: 11th *rencontres francophones sur les aspects algorithmiques des télécommunications* (Algotel 2009), Carry-le-Rouet, France, June 16-19, 2009.

O. Dalle: International Workshop on Network Simulation Tools (NSTOOLS 2009), Pisa, Italy, October 19, 2009; High Performance Computing & Simulation (HPCS 2009) Conference, Leipzig, Germany, June 21-24 2009.

B. Reed: 5th Latin-American Algorithms, Graphs and Optimization Symposium (LAGOS 2009), Gramado, Brazil, November 3-7, 2009.

F. Havet: 11th *Journées Graphes et Algorithmes* (JGA 2009), Montpellier, France November 5-6, 2009.

H. Rivano: ACM Mobility 2009.

9.2. HdR, Theses, Internships

9.2.1. Theses

9.2.1.1. Theses defended in 2009

C. Gomez [14]: *Radio Mesh Networks and the Round Weighting Problem*. Ph.D. thesis, Université de Nice Sophia Antipolis, 2009.

C. Molle [15]: *Structures combinatoires et simulation des réseaux radio maillés*. Ph.D. thesis, Université de Nice Sophia Antipolis, 2009.

J.P. Perez Seva [16]: *Optimisation d'algorithmes de traitement de signal sur les nouvelles architectures modernes de calculateur parallèle embarqué*. Ph.D. thesis, Université de Nice Sophia Antipolis, 2009.

P. Reyes Valenzuela [17]: *Optimisation et simulation pour l'étude des réseaux ambiants*. Ph.D. thesis, Université de Nice Sophia Antipolis, 2009.

I. Sau-Valls [18]: *Optimization in graphs under degree constraints. Application to telecommunication networks*. Ph.D. thesis, Université de Nice Sophia Antipolis, 2009.

9.2.1.2. Theses in preparation

J. Araujo: *Dynamic network routing*, since December 2009.

N. Cohen: *Allocation de fréquences et coloration des L-graphes*, since October 2008.

J-C. Maureira: *Méthodes et outils pour la modélisation et la simulation centrées réseau à base de composants Fractal*, since February 2008.

D. Mazauric: *Conception et analyse d'algorithmes distribués d'ordonnancement dans les réseaux sans-fil*, since October 2008.

J. Monteiro: *Modélisation et analyse de réseaux pair-à-pair utilisés pour le stockage fiable de données*, since October 2007.

N. Nepomuceno: *Optimisation et routage dynamique dans les réseaux sans fil*, since December 2007.

B. Onfroy: *Design and management of networks with low power consumption*, since October 2009.

J. Ribault: *Modélisation et simulation à événements discrets à base de composants Fractal*, since January 2008.

L. Sampaio Rocha: *Algorithmic aspects of graph colourings*, since November 2009.

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

9.2.2. Participation in thesis Committees

J-C. Bermond: Ph.D. committee member of P. Reyes (UNS, Nice, France, August 5 2009), I. Sau-Valls (UNS, Nice, France, October 16, 2009), C. Molle (UNS, October 29, 2009), C. Gomes (UNS, Nice, France, December 1, 2009). HDR committee of R. Klasing: referee and member, Bordeaux, November 16, 2009)

D. Coudert: Ph.D. referee of G. Monaco, (U. L'Aquilla, Italy, December 7 2009); Ph.D. committee of I. Sau-Valls, (UNS, Nice, France, October 16, 2009.

S. Pérennes: Ph.D. committee member of P. Reyes (UNS, Nice, France, August 5, 2009), C. Molle (UNS, October 29, 2009), C. Gomes (UNS, Nice, France, December 1, 2009). HDR committee of R. Klasing: referee and member (Bordeaux, November 16, 2009)

H. Rivano: Ph.D. committee member of P. Reyes (UNS, Nice, France, August 5, 2009) Ph.D. committee member of C. Molle (UNS, Nice, France, October 29, 2009)

M. Syska: reviewer and Ph.D. committee member of G. Quercini (Univ. di Genova / DISI, Italy May 8th, 2009).

9.2.3. Internships

J-C. Bermond and F. Giroire: supervised the internship of Julio Araujo (UFC Foraleza, Brazil) on good edge-labelling of graphs, March 2009 (1 month).

D. Coudert and L. Hogie: supervised the internship of Issam Tahiri (PFE INPT Rabat, Morocco) on the design of a simulation tool for dynamic routing schemes in the Internet, March-September 2009 (6 months).

D. Coudert: supervised the internship of Christian Delettre (PFE EPU 3, UNS, France) on the dynamic management of virtual topologies in multi-layer networks, March-September 2009 (6 months).

D. Coudert and N. Nisse: supervised the internship of Ronan Soares (UFC Foraleza, Brazil) on routing reconfiguration in WDM networks, March-May 2009 (3 months).

D. Coudert and N. Nisse: supervised the internship of Saber Ben Nejma (PFE Sup'Com Tunis, Tunisia) on Routing reconfiguration in WDM networks, September-December 2009 (4 months).

O. Dalle and J-C. Maureira: supervised the internship of Paula Uribe on Extending the INET Framework for Directional and Asymmetric wireless Comunications, April-October 2009 (7 months).

F. Giroire and S. Pérennes: supervised the internship of Stéphane Caron (ENS Ulm) on the study of placement policies in P2P storage systems, June-August 2009 (3 months).

F. Giroire and S. Pérennes: supervised the internship of Sandeep Kumar Gupta (IIT Delhi) on the algorithmics of P2P storage systems, May-July 2009 (10 weeks).

F. Giroire and M. Syska: supervised the internship of Nikhil Arora (IIT Delhi / India) on Implementation and evaluation of a peer-to-peer storage system over the AEOLUS (Algorithmic Principles for Building Efficient Overlay Computers / European project) testbed, May-July 2009 (3 months).

9.3. Teaching

MASCOTTE has widely contributed to the launching and success of UBINET: a new international master of science at University of Nice Sophia Antipolis (http://ubinet.inria.fr), just launched in october 2009. J. Moulierac is in charge of this master. O. Dalle is in charge of the seminars and J-C. Bermond is a member of the managing committee. Several members of MASCOTTE are involved in teaching in this Master of Science in Ubiquitous Networking and Computing.

At the graduate level, members of MASCOTTE are also involved in teaching in other Masters like the master MDFI of University of Marseille or in the 3rd year of engineering schools.

The members of MASCOTTE are heavily involved in teaching activities at undergraduate levels (Licence, IUT, Master 1, ENS program, Engineering Schools like Polytech'Nice). Some members are also involved in administrative duties related to teaching. For example, M. Syska is director of the Licence LP SIL degree at IUT. The teaching is carried out by members of the University as part of their teaching duties, and for INRIA CNRS or Ph.D.'s as extra work.

Altogether that represents more than 1000 hours per year.

The members of MASCOTTE also supervise several student projects and internships at all levels (Master 1 and 2, Engineering Schools).

9.4. Participation in conferences and workshops

9.4.1. Invited talks

J-C. Bermond at DIMACS/DyDAn Workshop on Approximation Algorithms in Wireless Ad Hoc and Sensor Networks, DIMACS, Rutgers University, NJ USA April 22 - 24, 2009. Journées Graphes et Optimisation en l'honneur de Charles Delorme, Orsay, June 26, 2009

9.4.2. Participation in scientific meetings

Alcatel-Lucent/INRIA joint lab workshop, Paris, France, January 15-16, 2009.
Attended by J-C. Bermond and D. Coudert.

Dynamic Compact Routing project meeting, Sophia Antipolis, France, January 16, 2009.
Attended by D. Coudert, L. Hogie, F. Giroire, J. Moulierac, N. Nisse and S. Pérennes.

WiMax Day, CITI, Lyon (with Alcatel-Lucent Bell-Labs), February 11, 2009.
Attended by N. Nepomuceno and H. Rivano.

MASCOTTE'09, *Mascotte Team meeting*, March 11-13 2009, Le Boréon, France.
Attended by almost all members of Mascotte.

8th Journées du Pôle ResCom du GDR ASR, Paris, France, March 26-27, 2009.
Attended by D. Coudert and C. Molle (speaker).

JSPOC, *Pretty Structure, Existential Polytime and Polyhedral Combinatorics*, April 7-9, 2009, Paris, France.
Attended by N. Cohen.

JCALM'09, 6th *Journées Combinatoire et Algorithmes du Littoral Méditerranéen*. Programmation linéaire pour l'algorithmique et la combinatoire, May 7th, 2009, LIF, Marseille France.
Attended by N. Cohen, C. Gomes, F. Giroire, F. Havet, D. Mazauric, C. Molle, N. Nepomuceno, N. Nisse, H. Rivano and I. Sau-Valls.

DGA, *Rencontre DGA-Recherche et Innovation Scientifique*, May 14, 2009, Paris, France.
Attended by C. Molle (poster).

INRIA/Bell labs Workshop on Fundamentals of Communications and Networking, Bell-Labs, Murray Hill, NJ, USA, June 1-3, 2009.
Attended by D. Coudert (speaker) and H. Rivano (speaker).

ALADDIN'09, 3rd *Meeting of the ALADDIN Project*, June 11-12, 2009, La Rochelle, France.
Attended by P. Reyes (speaker).

ANR SPREAD/USS SIMGRID, Journées simulation de grands systèmes distribués/P2P, August 30-September 1, 2009, INRIA Sophia Antipolis, France.
Attended by O. Dalle, F. Giroire, L. Hogie, J. Monteiro, J. Ribault.

OP RDI Evaluation workshop (Operational Programme Research and Development for Innovation), Prague, Czech Republic, August 31 - September 4, 2009.
Attended by D. Coudert.

Alcatel-Lucent Bell labs workshop, Paris, France, September 18, 2009.
Attended by D. Coudert and N. Nisse.

IST FET AEOLUS Workshop, Athens, Greece, September 21-22, 2009.
Attended by J-C. Bermond and D. Coudert.

2nd Czech-Slovenian-French Workshop on Graph Colouring, September 21-25, 2009, Puyloubier, France.
Attended by N. Cohen and F. Havet.

AdR Hima, Alcatel-Lucent / INRIA Joint lab, Paris, France, October 1-2, 2009.
Attended by J-C. Bermond, F. Giroire and D. Coudert.

GRASTA'09, 3rd *Workshop on Graph Searching*, October 5-9, 2009, Valtice, Czech Republic.
Attended by N. Nisse and I. Sau-Valls.

Journée Mobilité Alcatel Villa Arson, October 7, 2009.
Attended by H. Rivano.

JCALM'09, 7th *Journées Combinatoire et Algorithmes du Littoral Méditerranéen*, October 19-20 2009, Sophia Antipolis, France.
Attended by N. Cohen (speaker), F. Giroire, F. Havet (speaker), D. Mazauric, J. Moulierac, N. Nepomuceno, N. Nisse (speaker), B. Onfroy, B. Reed (speaker) L. Sampaio and I. Sau-Valls.

Alcatel-Lucent Bell-Labs/INRIA joint lab workshop, Paris Rocquencourt, France, October 20-21, 2009.
Attended by D. Coudert (speaker), N. Nisse and H. Rivano.

JGA'09, 11th *Journées Graphes et Algorithmes* 2009, November 5-6, 2009, Montpellier, France.
Attended by D. Coudert, D. Mazauric (speaker), C. Molle (speaker), N. Nisse and L. Sampaio.

ANR ECOSCells project kickoff meeting, Avignon, France, November 9, 2009.
Attended by D. Coudert, N. Nepomuceno, N. Nisse and H. Rivano.

ANR ALADDIN, Bordeaux, France, November 26-27, 2009.
Attended by N. Nisse (speaker).

Dynamic Compact Routing project meeting, Bordeaux, France, December 3-4, 2009.
Attended by D. Coudert, L. Hogie and N. Nisse.

9.4.3. Participation in conferences

JDIR'09, 10th *journées doctorales en informatique et réseaux*, Belfort, France, February 2-4, 2009.
Attended by D. Mazauric (speaker).

ONDM'09 *13th Conference on Optical Design and Modeling*, Braunschweig, Germany, February 18-20, 2009.
Attended by D. Coudert (speaker).

SIMUTools'09, 2nd *International Conference on Simulation Tools and Techniques*, Rome, Italy, March 2-6 2009.
Attended by O. Dalle, J-C. Maureira (speaker), J. Monteiro (speaker), J. Ribault (speaker).

OMNeT++'09, *2th International Workshop on OMNeT++*, March 6th, 2009, Rome, Italy.
Attended by J-C. Maureira (speaker).

AGT'09, *DIMAP Workshop on Algorithmic Graph Theory*, March 23-25, 2009, Warwick, UK.
Attended by D. Coudert, N. Nisse (speaker) and I. Sau-Valls (speaker)

OW2 Annual Conference, Paris, France, April 1-2, 2009.
Attended by J. Ribault (speaker).

VTC09-Spring, 69th *IEEE Vehicular Technology Conference*, Barcelona, Spain, April 26-29, 2009.
Attended by C. Molle (speaker).

SIROCCO'09, 16th International Colloquium on Structural Information and Communication Complexity, Piran, Slovenia, May 25-27, 2009.
Attended by I. Sau-Valls (speaker).

CTW'09, 8th Cologne Twente Workshop on Graphs and Combinatorial Optimization, Paris, France, June 2-4, 2009.
Attended by I. Sau-Valls (speaker).

HotMESH'09, 1st *IEEE WoWMoM Workshop on Hot Topics in Mesh Networking*, June 15-19, 2009, Kos, Greece.
Attended by N. Nepomuceno (speaker).

AlgoTel'09, 11th *rencontres francophones sur les aspects algorithmiques des télécommunications*, Carry-le-Rouet, France, June 16-19, 2009.
Attended by D. Coudert, F. Giroire, D. Mazauric (speaker), J. Monteiro (speaker), J. Moulierac, N. Nisse, S. Pérennes, P. Reyes (speaker), H. Rivano (speaker), and I. Tahiri.

WG'09, 35th International Workshop on Graph-Theoretic Concepts in Computer Science, Montpellier, France, June 24-26, 2009.
Attended by I. Sau-Valls (speaker).

IWOCA'09, 20th *International Workshop on Combinatorial Algorithms*, Hradec nad Moravicí, Czech Republic, June 28-July 2, 2009.
Attended F. Giroire (speaker).

Eurocomb'09, *European Conference on Combinatorics, Graph Theory and Applications*, September 7-11, 2009, Bordeaux, France.
Attended by F. Havet (speaker).

P2P'09, 9th *IEEE International Conference on Peer-to-Peer Computing* , Seattle, US, September 9-11, 2009.
Attended by F. Giroire and J. Monteiro (speaker).

AdHocNow'09, 8th *International Conference on AD-HOC Networks* & *Wireless*, Murcia, Spain, September 23-25, 2009.
Attended by C. Gomes (speaker) and P. Reyes (speaker).

RAID'09, 12th *International Symposium on Recent Advances in Intrusion Detection*, Saint Malo, France, Septemper 23-25, 2009.
Attended by F. Giroire.

CFIP'09, *Colloque francophone sur l'ingénierie des protocoles* 2009, October 12-15, 2009, Strasbourg, France.
Attended by C. Molle.

GROW'09, *Fourth workshop on Graph Classes, Optimization, and Width Parameters*, October 15-17, 2009, Bergen, Norway.
Attended by F. Havet (speaker).

LCN'09, 34th *IEEE Conference on Local Computer Networks*, Zurich, Switzerland, October 20-23, 2009.
Attended by J. Monteiro (speaker).

ITST'09, *9th International Conference on ITS Telecomunication*, October 21-23, 2009, Lille, France.
Attended by J-C. Maureira (speaker) and P. Uribe.

LAGOS'09, *V Latin-American Algorithms, Graphs and Optimization Symposium*, November 3-7, 2009, Gramado, Brasil.
Attended by F. Havet (speaker).

WSC'09, *Winter Simulation Conference*, Austin, Texas, USA, December 13-16, 2009.
Attended by O. Dalle and J. Ribault (speaker).

9.4.4. Participation in schools

ARRIVAL/AEOLUS, Joint ARRIVAL/AEOLUS Workshop & School (EC FP6 IST/FET projects ARRIVAL and AEOLUS)-Large-Scale Optimization: Robustness, Online and Offline Issues, May 13-15, 2009, Patras, Greece.
Attended by C. Gomes and N. Nepomuceno.

AGAPE, Spring School on Fixed Parameter and Exact Algorithms May 25-29 2009, Lozari, Corsica (France).
Attended by J-C. Bermond, N. Cohen and F. Havet.

HTDC'09, *école d'hiver 'Hot Topics in Distributed Computing'*, La Plagne, France, March 15-20, 2009.
Attended by F. Giroire, J. Monteiro (speaker), S. Pérennes, J. Ribault.

9.4.5. Scientific Popularization

Several members of MASCOTTE were involved in the "Fête de la Science": in particular, a video describing the research activities of MASCOTTE has been made (http://www.youtube.com/user/Scienceparticipative#p/u/4/mzR-diIWxNA).

J-C. Bermond has given lectures about Sudoku in classes of "seconde" (June 18, 2009).

10. Bibliography

Major publications by the team in recent years

[1] L. ADDARIO-BERRY, F. HAVET, S. THOMASSÉ. *Paths with two blocks in n-chromatic digraphs*, in "Journal of Combinatorial Theory Ser. B", vol. 97, 2007, p. 620–626, http://dx.doi.org/10.1016/j.jctb.2006.10.001CA.

[2] 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", IEEE, April 2009, p. 1431 - 1439, http://dx.doi.org/10.1109/INFCOM.2009.5062059.

[3] J.-C. Bermond, J. Galtier, R. Klasing, N. Morales, S. Pérennes. *Hardness and approximation of Gathering in static radio networks*, in "Parallel Processing Letters", vol. 16, n^{o} 2, 2006, p. 165–183, http://dx.doi.org/10.1142/S0129626406002551CL.

[4] I. Caragiannis, A. Ferreira, C. Kaklamanis, S. Pérennes, H. Rivano. *Fractional Path Coloring in Bounded Degree Trees with Applications*, in "Algorithmica", 2009, http://dx.doi.org/10.1007/s00453-009-9278-3, Published online: 14 February 2009GR.

[5] D. Coudert, P. Datta, S. Pérennes, H. Rivano, M.-E. Voge. *Shared Risk Resource Group: Complexity and Approximability issues*, in "Parallel Processing Letters", vol. 17, n^{o} 2, June 2007, p. 169-184, http://dx.doi.org/10.1142/S0129626407002958US.

[6] D. Coudert, F. Huc, D. Mazauric, N. Nisse, J.-S. Sereni. *Reconfiguration of the Routing in WDM Networks with Two Classes of Services*, in "13th Conference on Optical Network Design and Modeling (ONDM), Braunschweig, Germany", IEEE, February 2009, http://hal.inria.fr/inria-00331807.

[7] O. Dalle, C. Mrabet. *An Instrumentation Framework for component-based simulations based on the Separation of Concerns paradigm*, in "Proc. of 6th EUROSIM Congress (EUROSIM'2007), Ljubljana, Slovenia", September 2007, http://www.eurosim2007.org/.

[8] F. V. Fomin, P. Fraigniaud, N. Nisse. *Nondeterministic Graph Searching: From Pathwidth to Treewidth*, in "Algorithmica", vol. 53, n^{o} 3, 2009, p. 358-373, http://www.springerlink.com/content/42g5tp1588w89186/ NO .

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

[10] F. Havet, J.-S. Sereni, R. Skrekovski. *3-facial colouring of plane graphs*, in "SIAM Journal on Discrete Mathematics", vol. 22, n^{o} 1, 2008, p. 231–247, http://dx.doi.org/10.1137/060664124SI.

[11] J.-F. Lalande, M. Syska, Y. Verhoeven. *Mascopt - A Network Optimization Library: Graph Manipulation*, n^{o} RT-0293, INRIA Sophia Antipolis, 2004 route des lucioles - BP 93 - FR-06902 Sophia Antipolis, April 2004, http://hal.inria.fr/inria-00069887/fr/, Technical report.

[12] Z. Li, I. Sau. *Graph Partitioning and Traffic Grooming with Bounded Degree Request Graph*, in "35th International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2009)", Lecture Notes in Computer Science, June 2009, http://www.lirmm.fr/wg2009/, Best student paper award CA ES .

[13] C. Molle, F. Peix, H. Rivano. *Génération de colonnes pour le routage et l'ordonnancement dans les réseaux radio maillés*, in "Colloque francophone sur l'ingénierie des protocoles (CFIP 2008)", March 2008, http://cfip2008.imag.fr/wp/, Best student paper award.

Year Publications

Doctoral Dissertations and Habilitation Theses

[14] C. Gomes. *Radio Mesh Networks and the Round Weighting Problem*, Université de Nice-Sophia Antipolis (UNS), December 1st 2009, http://tel.archives-ouvertes.fr/, Ph. D. Thesis FR .

[15] C. MOLLE. *Optimisation de la capacité des réseaux radio maillés*, Université de Nice-Sophia Antipolis (UNS), October 29th 2009, http://tel.archives-ouvertes.fr/tel-00428940/fr/, Ph. D. Thesis.

[16] J.-P. PEREZ SEVA. *Les optimisations d'algorithmes de traitement du signal sur les architectures modernes parallèles et embarquées*, Université de Nice-Sophia Antipolis (UNS), August 24th 2009, Ph. D. Thesis.

[17] P. REYES. *Data Gathering in Radio Networks*, Université de Nice-Sophia Antipolis (UNS), August 5th 2009, http://tel.archives-ouvertes.fr/tel-00418297/en/, Ph. D. Thesis CL .

[18] I. SAU. *Optimization in Graphs under Degree Constraints. Application to Telecommunication Networks*, Université de Nice-Sophia Antipolis (UNS) and Universitat Politècnica de Catalunya (UPC), October 16th 2009, http://www.cs.technion.ac.il/~ignasi/PhD_Ignasi.pdf, Ph. D. Thesis ES .

Articles in International Peer-Reviewed Journal

[19] L. ADDARIO-BERRY, N. BROUTIN, B. A. REED. *Critical random graphs and the structure of a minimum spanning tree*, in "Random Structures and Algorithms", vol. 35, 2009, p. 323–347, http://portal.acm.org/citation.cfm?id=1598965 CA .

[20] L. ADDARIO-BERRY, B. A. REED. *Minima in branching random walks*, in "Annals of Probability", vol. 37, 2009, p. 1044–1079, http://arxiv.org/abs/0712.2582 CA .

[21] O. AMINI, F. GIROIRE, F. HUC, S. PÉRENNES. *Minimal selectors and fault tolerant networks*, in "Networks", 2009, http://doi.wiley.com/10.1002/net.20326, To appear. Published online 31 July 2009, DOI 10.1002/net.20326.

[22] O. AMINI, F. HUC, S. PÉRENNES. *On the pathwidth of planar graphs*, in "SIAM Journal of Discrete Mathematics", vol. 23, n^{o} 3, August 2009, p. 1311-1316, http://dx.doi.org/10.1137/060670146.

[23] O. AMINI, F. MAZOIT, N. NISSE, S. THOMASSÉ. *Submodular partition functions*, in "Discrete Mathematics", vol. 309, n^{o} 20, 2009, p. 6000-6008, http://www-sop.inria.fr/members/Nicolas.Nisse/publications/.

[24] O. AMINI, S. PÉRENNES, I. SAU. *Hardness and Approximation of Traffic Grooming*, in "Theoretical Computer Science", vol. 410, n^{o} 38-40, 2009, p. 3751-3760, http://dx.doi.org/10.1016/j.tcs.2009.04.028ES.

[25] J.-C. BERMOND, R. CORREA, M.-L. YU. *Optimal Gathering Protocols on Paths under Interference Constraints*, in "Discrete Mathematics", vol. 309, n^{o} 18, September 2009, p. 5574-5587, http://dx.doi.org/10.1016/j.disc.2008.04.037, A preliminary version has been presented at CIAC06BRCA.

[26] E. BIRMELÉ, J. A. BONDY, B. A. REED. *Tree-width of graphs without a 3 by 3 grid minor*, in "Discrete Applied Mathematics", vol. 157, 2009, p. 2577–2598, http://portal.acm.org/citation.cfm?id=1553060.

[27] I. CARAGIANNIS, A. FERREIRA, C. KAKLAMANIS, S. PÉRENNES, H. RIVANO. *Fractional Path Coloring in Bounded Degree Trees with Applications*, in "Algorithmica", 2009, http://dx.doi.org/10.1007/s00453-009-9278-3, Published online: 14 February 2009GR.

[28] R. CORREA, F. HAVET, J.-S. SERENI. *About a Brooks-type theorem for improper colouring*, in "Australasian Journal of Combinatorics", vol. 43, 2009, p. 219–230, hal.inria.fr/inria-00223009/en/ BR .

[29] A. FERREIRA, A. GOLDMAN, J. MONTEIRO. *Performance Evaluation of Routing Protocols for MANETs with Known Connectivity Patterns Using Evolving Graphs*, in "Wireless Networks", 2009, http://www.springerlink.com/content/c82014477847t646, In press BR .

[30] F. V. FOMIN, P. FRAIGNIAUD, N. NISSE. *Nondeterministic Graph Searching: From Pathwidth to Treewidth*, in "Algorithmica", vol. 53, n^o 3, 2009, p. 358-373, http://www.springerlink.com/content/42g5tp1588w89186 NO .

[31] J. GEELEN, B. GERARDS, B. A. REED, P. SEYMOUR, A. VETTA. *On the odd-minor variant of Hadwiger's conjecture*, in "J. Combin. Theory Ser. B", vol. 99, 2009, p. 20–29, http://portal.acm.org/citation.cfm?id=1465824 CA NL US .

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

[33] F. HAVET. *Choosability of the square of planar subcubic graphs with large girth*, in "Discrete Mathematics", vol. 309, 2009, p. 3553–3563, http://cat.inist.fr/?aModele=afficheN&cpsidt=21712750.

[34] F. HAVET, R. KANG, T. MÜLLER, J.-S. SERENI. *Circular choosability*, in "Journal of Graph Theory", vol. 61, n^o 4, 2009, p. 241–334 CA CZ .

[35] F. HAVET, R. KANG, J.-S. SERENI. *Improper Colouring of Unit Disk Graphs*, in "Networks", vol. 54, n^o 3, 2009, p. 150–164, http://hal.inria.fr/inria-00150464UK.

[36] F. HAVET, S. THOMASSÉ. *Complexity of $(p, 1)$-total labelling*, in "Discrete Applied Mathematics", vol. 157, 2009, p. 2859–2870, http://dx.doi.org/10.1016/j.dam.2009.03.021.

[37] F. HUC, I. SAU, J. ZEROVNIK. *(ℓ, k)-Routing on Plane Grids*, in "Journal of Interconnection Networks", vol. 10, n^o 1-2, 2009, p. 27-57, http://arxiv.org/abs/0803.2759 ES SI .

[38] D. ILCINKAS, N. NISSE, D. SOGUET. *The Cost of Monotonicity in Distributed Graph Searching*, in "Distributed Computing", vol. 22, n^o 2, 2009, p. 117-127, http://www.springerlink.com/content/l83712581771v2j0/.

[39] A. JARRY, S. PÉRENNES. *Disjoint Path in symmetric Graphs*, in "Discrete Applied Mathematics", vol. 157, n^o 1, 2009, p. 90-97, http://dx.doi.org/10.1016/j.dam.2008.04.024CH.

[40] K. KAWARABAYASHI, O. LEE, B. A. REED. *Removable cycles in non-bipartite graphs*, in "J. Combin. Theory Ser. B", vol. 99, 2009, p. 30–38, http://portal.acm.org/citation.cfm?id=1465820 JP BR .

[41] K. KAWARABAYASHI, B. A. REED. *Highly parity linked graphs*, in "Combinatorica", vol. 29, 2009, p. 215–225, http://portal.acm.org/citation.cfm?id=1569773 JP .

[42] R. KLASING, Z. LOTKER, A. NAVARRA, S. PÉRENNES. *From Balls and Bins to Points and Vertices*, in "Algorithmic Operations Research (AlgOR)", vol. 4, n^o 2, 2009, p. 133-143, http://journals.hil.unb.ca/index.php/AOR/article/view/4668 IT IL .

[43] B. LÉVÊQUE, F. MAFFRAY, B. A. REED, N. TROTIGNON. *Coloring Artemis graphs*, in "Theoretical Computer Science", vol. 410, 2009, p. 2234–2240, http://portal.acm.org/citation.cfm?id=1530984.

[44] N. NISSE. *Connected graph searching in chordal graphs*, in "Discrete Applied Mathematics", vol. 157, n^{o} 12, 2009, p. 2603-2610, http://portal.acm.org/citation.cfm?id=1553062.

[45] N. NISSE, D. SOGUET. *Graph Searching with Advice*, in "Theoretical Computer Science", vol. 410, n^{o} 14, 2009, p. 1307-1318, http://www.springerlink.com/content/10t11145m1182477/.

[46] H. RIVANO, F. THEOLEYRE, F. VALOIS. *A Framework for the Capacity Evaluation of Multihop Wireless Networks*, in "Ad Hoc and Sensor Wireless networks (AHSWN)", 2009, ftp://ftp-sop.inria.fr/mascotte/personnel/Herve.Rivano/Biblio/rtv09.pdf, Accepted for publication: March 19th 2009. To appear.

International Peer-Reviewed Conference/Proceedings

[47] 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", IEEE, April 2009, p. 1431 - 1439, http://dx.doi.org/10.1109/INFCOM.2009.5062059.

[48] J. ARAUJO, N. COHEN, F. GIROIRE, F. HAVET. *Good Edge-Labelling of Graphs*, in "proceedings of the Latin-American Algorithms, Graphs and Optimization Symposium (LAGOS'09), Gramado, Brazil", Electronic Notes in Discrete Mathematics, Elsevier, November 2009, http://hal.inria.fr/inria-00383343/en/, to appearBR.

[49] D. BARMAN, J. CHANDRASHEKAR, N. TAFT, M. FALOUTSOS, L. HUANG, F. GIROIRE. *Debating IT Monoculture for End Host Intrusion Detection*, in "ACM SIGCOMM Workshop on Research on Enterprise Networking – WREN, Barcelona, Spain", ACM, August 2009, p. 27–36, http://doi.acm.org/10.1145/1592681.1592686US.

[50] J.-C. BERMOND, D. COUDERT, J. MOULIERAC, S. PÉRENNES, H. RIVANO, I. SAU, F. SOLANO DONADO. *MPLS label stacking on the line network*, in "IFIP Networking, Aachen, Germany", L. FRATTA, H. SCHULZRINNE, Y. TAKAHASHI, O. SPANIOL (editors), Lecture Notes in Computer Science, vol. 5550, Springer, May 2009, p. 809-820, http://hal.inria.fr/inria-00354267/PLES.

[51] J.-C. BERMOND, D. COUDERT, J. MOULIERAC, S. PÉRENNES, I. SAU, F. SOLANO DONADO. *Designing Hypergraph Layouts to GMPLS Routing Strategies*, in "16th International Colloquium on Structural Information and Communication Complexity (SIROCCO), Piran, Slovenia", Lecture Notes in Computer Science, vol. 5869, Springer, May 2009, http://hal.inria.fr/inria-00428685/fr/ESPL.

[52] J.-C. BERMOND, N. NISSE, P. REYES, H. RIVANO. *Fast Data Gathering in Radio Grid Networks*, in "Proceedings of the 8th international conference on Ad Hoc Networks and Wireless (AdHoc-Now)", Lecture Notes in Computer Science, vol. 5793, Springer, 2009, p. 69-82, http://hal.inria.fr/inria-00363908/fr/CL.

[53] V. BILÒ, M. FLAMMINI, G. MONACO, L. MOSCARDELLI. *On the performances of Nash Equilibria in Isolation Games*, in "Proceedings of the 15th International Computing and Combinatorics Conference (COCOON 2009), Niagara Falls, New York, U.S.A.", Lecture Notes in Computer Science, vol. 5609, Springer, July 2009, p. 17-26, http://www.springerlink.com/content/t02154u9h640t1xx/ IT .

[54] A. CASTEIGTS, S. CHAUMETTE, A. FERREIRA. *Characterizing Topological Assumptions of Distributed Algorithms in Dynamic Networks*, in "Proc. of 16th Intl. Conference on Structural Information and Communication Complexity (SIROCCO'09), Piran, Slovenia", Lecture Notes in Computer Science, vol. 5869, Springer-Verlag, May 2009, http://www.imfm.si/sirocco09/.

[55] N. COHEN, F. V. FOMIN, G. GUTIN, E. J. KIM, S. SAURABH, A. YEO. *Algorithm for Finding k-Vertex Out-trees and Its Application to k-Internal Out-branching Problem*, in "COCOON", 2009, p. 37-46, http://dx.doi.org/10.1007/978-3-642-02882-3_5NOUK.

[56] N. COHEN, F. HAVET, T. MÜLLER. *Acyclic edge-colouring of planar graphs*, in "European Conference on Combinatorics, Graph Theory and Applications (Eurocomb 2009), Bordeaux, France", vol. 34, September 2009, p. 417-421, http://eurocomb09.labri.fr/pmwiki/pmwiki.php IL .

[57] D. COUDERT, F. GIROIRE, I. SAU. *Edge-Simple Circuits Through 10 Ordered Vertices in Square Grids*, in "20th International Workshop on Combinatorial Algorithms – IWOCA, Hradec nad Moravicí, Czech Republic", J. KRATOCHVÍL, M. MILLER (editors), Lecture Notes in Computer Science, vol. 5874, Springer, June 2009, p. 134-145, http://hal.inria.fr/inria-00429146ES.

[58] D. COUDERT, F. HUC, D. MAZAURIC, N. NISSE, J.-S. SERENI. *Reconfiguration of the Routing in WDM Networks with Two Classes of Services*, in "13th Conference on Optical Network Design and Modeling (ONDM), Braunschweig, Germany", IEEE, February 2009, http://hal.inria.fr/inria-00331807.

[59] D. COUDERT, D. MAZAURIC, N. NISSE. *On Rerouting Connection Requests in Networks with Shared Bandwidth*, in "DIMAP workshop on Algorithmic Graph Theory (AGT09), Warwick, UK", Electronic Notes in Discrete Mathematics, vol. 32, Elsevier, March 2009, p. 109-116, http://dx.doi.org/10.1016/j.endm.2009.02.015.

[60] D. COUDERT, N. NEPOMUCENO, H. RIVANO. *Minimizing Energy Consumption by Power-Efficient Radio Configuration in Fixed Broadband Wireless Networks*, in "First IEEE WoWMoM Workshop on Hot Topics in Mesh Networking (HotMESH), Kos, Greece", IEEE, June 2009, http://hal.inria.fr/inria-00344344/BR.

[61] O. DALLE, F. GIROIRE, J. MONTEIRO, S. PÉRENNES. *Analysis of Failure Correlation Impact on Peer-to-Peer Storage Systems*, in "Proceedings of the 9th IEEE International Conference on Peer-to-Peer Computing (P2P)", September 2009, p. 184–193, http://dx.doi.org/10.1109/P2P.2009.5284518.

[62] A. FERREIRA. *Road-mapping the Digital Revolution: Visions from COST Foresight 2030 (An exercise in multi-disciplinarity)*, in "Proceedings of IEEE Wireless VITAE'09, Aalborg, Denmark", IEEE Press, May 2009, ftp://ftp-sop.inria.fr/mascotte/Publications/Fer09.pdf.

[63] M. FLAMMINI, A. MARCHETTI-SPACCAMELA, G. MONACO, L. MOSCARDELLI, S. ZAKS. *On the complexity of the regenerator placement problem in optical networks*, in "Proceedings of the 21st ACM Symposium on Parallelism in Algorithms and Architectures (SPAA 2009), Calgary, Canada", ACM, August 2009, p. 154-162, http://portal.acm.org/citation.cfm?doid=1583991.1584035IT.

[64] M. FLAMMINI, G. MONACO, L. MOSCARDELLI, H. SHACHNAI, M. SHALOM, T. TAMIR, S. ZAKS. *Minimizing total busy time in parallel scheduling with application to optical networks*, in "Proceedings of the 23rd IEEE International Parallel and Distributed Processing Symposium (IPDPS 2009), Rome, Italy", IEEE, May 2009, p. 1-12, http://www.cs.technion.ac.il/~hadas/PUB/busy_times.pdf IT .

[65] N. FOUNTOULAKIS, B. A. REED. *A general critical condition for the emergence of a giant component in random graphs with given degrees*, in "European Conference on Combinatorics, Graph Theory and Applications (Eurocomb 2009), Bordeaux, France", vol. 34, September 2009, p. 639–645, http://eurocomb09.labri.fr/pmwiki/pmwiki.php DE .

[66] F. GIROIRE, J. CHANDRASHEKAR, N. TAFT, E. SCHOOLER, K. PAPAGIANNAKI. *Exploiting Temporal Persistence to Detect Covert Botnet Channels*, in "12th International Symposium on Recent Advances in Intrusion Detection (RAID'09), Saint Malo, France", SPRINGER (editor), Lecture Notes in Computer Science, vol. 5758, September 2009, http://dx.doi.org/10.1007/978-3-642-04342-0_17US.

[67] F. GIROIRE, J. MONTEIRO, S. PÉRENNES. *P2P Storage Systems: How Much Locality Can They Tolerate?*, in "Proceedings of the 34th IEEE Conference on Local Computer Networks (LCN)", Oct 2009, p. 320–323, hal.archives-ouvertes.fr/inria-00408078/fr/.

[68] C. GOMES, J. GALTIER. *Optimal and Fair Transmission Rate Allocation Problem in Multi-hop Cellular Networks*, in "8th International Conference on AD-HOC Networks & Wireless (ADHOC NOW), Murcia, Spain", Lecture Notes in Computer Science, vol. 5793, Springer, September 2009, p. 327-340, http://dx.doi.org/10.1007/978-3-642-04383-3_24.

[69] 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", vol. 34, September 2009, p. 139–143, hal-lirmm.ccsd.cnrs.fr/lirmm-00433050/fr.

[70] F. HAVET, C. LINHARES-SALES. *Combinatória e Problemas em Redes de Telecomunicações*, in "Colloque d'Informatique: Brésil / INRIA, Coopérations, Avancées et Défis, Bento Gonçalves, Brazil", July 2009, ftp://ftp-sop.inria.fr/mascotte/Publications/HaLi09.pdf BR .

[71] J. HIMMELSPACH, O. DALLE, J. RIBAULT. *Design considerations for M&S software*, in "Proceedings of the Winter Simulation Conference (WSC'09), Austin, TX", D. ROSSETTI, R. R. HILL, B. JOHANSSON, A. DUNKIN, R. G. INGALLS (editors), December 2009, http://wwwmosi.informatik.uni-rostock.de/mosi/veroeffentlichungen/inproceedingsreference.2009-06-01.2218174380, Invited Paper DE .

[72] K. KAWARABAYASHI, B. A. REED. *A nearly linear time algorithm for the half integral parity disjoint paths packing problem*, in "Proceedings of the ACM-SIAM Symposium on Discrete Algorithms (SODA 2009)", January 2009, p. 1183–1192, http://portal.acm.org/citation.cfm?id=1496770.1496898 JP .

[73] K. KAWARABAYASHI, B. A. REED. *Hadwiger's Conjecture is decidable*, in "Proceedings of STOC 2009", 2009, p. 445–454, http://portal.acm.org/citation.cfm?id=1536414.1536476 JP .

[74] S. KENNEDY, C. MEAGHER, B. A. REED. *Fractionally Edge Colouring Graphs with Large Maximum Degree in Linear Time*, in "European Conference on Combinatorics, Graph Theory and Applications (Eurocomb 2009), Bordeaux, France", vol. 34, September 2009, p. 47–51, http://eurocomb09.labri.fr/pmwiki/pmwiki.php CA .

[75] Z. LI, I. SAU. *Graph Partitioning and Traffic Grooming with Bounded Degree Request Graph*, in "35th International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2009)", Lecture Notes in Computer Science, June 2009, http://www.lirmm.fr/wg2009/, Best student paper award CA ES .

[76] J.-C. MAUREIRA BRAVO, D. DUJOVNE, O. DALLE. *Generation of Realistic 802.11 Interferences in the Omnet++ INET Framework Based on Real Traffic Measurements*, in "Second International Workshop on Omnet++, Rome, Italy", March 2009, http://doi.acm.org/10.1145/1537614.1537708.

[77] J.-C. MAUREIRA BRAVO, P. URIBE, O. DALLE, T. ASAHI, J. AMAYA. *Component based approach using OMNeT++ for Train Communication Modeling*, in "Proceedings of 9th International Conference on ITS Telecommunication, Lille, France", October 2009, ftp://ftp-sop.inria.fr/mascotte/Publications/AADMU09.pdf CL .

[78] G. MERTZIOS, I. SAU, S. ZAKS. *A New Intersection Model and Improved Algorithms for Tolerance Graphs*, in "35th International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2009)", Lecture Notes in Computer Science, June 2009, http://www.lirmm.fr/wg2009/ IL ES DE .

[79] C. MOLLE, M.-E. VOGE. *Effects of the Acknowledgment Traffic on the Capacity of Wireless Mesh Networks*, in "69th IEEE Vehicular Technology Conference (VTC2009-Spring), Barcelona, Spain", April 2009, http://hal.archives-ouvertes.fr/hal-00434057/fr/.

[80] M. MOLLOY, B. A. REED. *Asymptotically optimal frugal colouring*, in "Proceedings of Twentieth Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)", 2009, p. 106-114, http://portal.acm.org/citation.cfm?id=1496782 CA .

[81] N. NISSE, I. RAPAPORT, K. SUCHAN. *Distributed computing of efficient routing schemes in generalized chordal graphs*, in "Proceedings of the 16th International Colloquium on Structural Information and Communication Complexity (SIROCCO), Piran, Slovenia", Lecture Notes in Computer Science, Springer-Verlag, 2009, http://hal.inria.fr/inria-00423454CL.

[82] I. SAU, D. M. THILIKOS. *On Self-Duality of Branchwidth in Graphs of Bounded Genus*, in "8th Cologne Twente Workshop on Graphs and Combinatorial Optimization (CTW), Paris, France", June 2009, http://www.lix.polytechnique.fr/ctw09/ctw09-proceedings.pdf ES GR .

[83] I. SAU, D. M. THILIKOS. *Subexponential Parameterized Algorithms for Bounded-Degree Connected Subgraph Problems on Planar Graphs*, in "DIMAP workshop on Algorithmic Graph Theory (AGT09), Warwick, UK", Electronic Notes in Discrete Mathematics, vol. 32, Elsevier, March 2009, p. 59-66, http://dx.doi.org/10.1016/j.endm.2009.02.009ESGR.

[84] A. SILVA, P. REYES, M. DEBBAH. *Congestion in Randomly Deployed Wireless Ad-Hoc and Sensor Networks*, in "International Conference on Ultra Modern Telecommunications, St. Petersburg, Russia", October 2009, http://hal.inria.fr/inria-00417774/enCL.

[85] F. SOLANO DONADO, J. MOULIERAC. *Routing in All-Optical Label Switched-based Networks with Small Label Spaces*, in "13th Conference on Optical Network Design and Modeling (ONDM), Braunschweig, Germany", IFIP/IEEE, February 2009, ftp://ftp-sop.inria.fr/mascotte/personnel/Joanna.Moulierac/pdf/solano09routing.pdf PL ES .

National Peer-Reviewed Conference/Proceedings

[86] J.-C. BERMOND, D. MAZAURIC, P. NAIN. *Algorithmes distribués d'ordonnancement dans les réseaux sans-fil*, in "10es Journées Doctorales en Informatique et Réseaux (JDIR), Belfort, France", February 2009, http://jdir.utbm.fr/index.php.

[87] J.-C. BERMOND, N. NISSE, P. REYES, H. RIVANO. *Fast Data Gathering in Radio Grid Networks*, in "11es Rencontres Francophones sur les Aspects Algorithmiques de Télécommunications (AlgoTel'09), Carry le Rouet", A. CHAINTREAU, C. MAGNIEN (editors), June 2009, http://www.lif.univ-mrs.fr/algotel09 CL .

[88] D. COUDERT, F. HUC, D. MAZAURIC, N. NISSE, J.-S. SERENI. *Reconfiguration dans les réseaux optiques*, in "11es Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel'09), Carry le Rouet", A. CHAINTREAU, C. MAGNIEN (editors), June 2009, p. 25-28, http://hal.inria.fr/inria-00331807.

[89] D. COUDERT, N. NEPOMUCENO, H. RIVANO. *Joint Optimization of Routing and Radio Configuration in Fixed Wireless Networks*, in "11es Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel'09), Carry le Rouet", A. CHAINTREAU, C. MAGNIEN (editors), June 2009, p. 49-52, http://hal.inria.fr/inria-00384968/fr/BR.

[90] O. DALLE, F. GIROIRE, J. MONTEIRO, S. PÉRENNES. *Analyse des Corrélations entre Pannes dans les Systèmes de Stockage Pair-à-Pair*, in "11es rencontres francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel'2009), Carry-Le-Rouet France", A. CHAINTREAU, C. MAGNIEN (editors), 2009, http://hal.inria.fr/inria-00384822/en/, Best Student Paper Award.

Scientific Books (or Scientific Book chapters)

[91] V. BILÒ, I. CARAGIANNIS, A. FANELLI, M. FLAMMINI, C. KAKLAMANIS, G. MONACO, L. MOSCARDELLI. *Game-Theoretic Approaches to Optimization Problems in Communication Networks*, in "Graphs and Algorithms in Communication Networks: Studies in Broadband, Optical, Wireless, and Ad Hoc Networks", EATCS Texts in Theoretical Computer Science, vol. XXVII, Springer, November 2009, p. 241-264, http://www.springer.com/computer/foundations/book/978-3-642-02249-4 IT GR .

[92] T. CINKLER, D. COUDERT, M. FLAMMINI, G. MONACO, L. MOSCARDELLI, X. MUÑOZ, I. SAU, M. SHALOM, S. ZAKS. *Traffic Grooming: Combinatorial Results and Practical Resolutions*, in "Graphs and Algorithms in Communication Networks: Studies in Broadband, Optical, Wireless, and Ad Hoc Networks", EATCS Texts in Theoretical Computer Science, vol. XXVII, Springer, November 2009, p. 63-94, http://www.springer.com/computer/foundations/book/978-3-642-02249-4 HU IT ES IS .

[93] I. SAU, J. ZEROVNIK. *Permutation Routing and (ℓ,k)-Routing on Plane Grids*, in "Graphs and Algorithms in Communication Networks: Studies in Broadband, Optical, Wireless, and Ad Hoc Networks", EATCS Texts in Theoretical Computer Science, vol. XXVII, Springer, November 2009, p. 265-279, http://www.springer.com/computer/foundations/book/978-3-642-02249-4 SI .

Books or Proceedings Editing

[94] O. DALLE, L.-F. PERRONE, G. STEA, G. A. WAINER (editors). *2nd International Conference on Simulation Tools and Techniques (SIMUTools 2009)*, ICST, Rome, Italy, March 2-6 2009 US IT CA .

Research Reports

[95] J. ARAUJO, N. COHEN, F. GIROIRE, F. HAVET. *Good edge-labelling of graphs*, n° 6934, INRIA, May 2009, http://hal.inria.fr/inria-00383343/en/, Research ReportBR.

[96] J.-C. BERMOND, C. COLBOURN, L. GIONFRIDDO, G. QUATTROCCHI, I. SAU. *Drop cost and wavelength optimal two-period grooming with ratio 4*, n^{o} RR-7101, INRIA, November 2009, http://hal.archives-ouvertes.fr/inria-00432801/en/, Technical reportUSITES.

[97] J.-C. BERMOND, M. COSNARD, S. PÉRENNES. *Directed acyclic graphs with unique path property*, n^{o} 6932, INRIA, May 2009, hal.archives-ouvertes.fr/docs/00/38/70/85/PDF/upp0509.pdf, Technical report.

[98] J.-C. BERMOND, D. COUDERT, J. MOULIERAC, S. PÉRENNES, H. RIVANO, I. SAU, F. SOLANO DONADO. *MPLS label stacking on the line network*, n^{o} RR-6803, INRIA, January 2009, http://hal.inria.fr/inria-00354267/, Technical reportPLES.

[99] J.-C. BERMOND, D. COUDERT, J. MOULIERAC, S. PÉRENNES, I. SAU, F. SOLANO DONADO. *GMPLS Label Space Minimization through Hypergraph Layouts*, n^{o} RR-7071, INRIA, October 2009, http://hal.archives-ouvertes.fr/inria-00426681/en/, Research ReportPLES.

[100] J.-C. BERMOND, D. COUDERT, J. MOULIERAC, S. PÉRENNES, I. SAU, F. SOLANO DONADO. *GMPLS Routing Strategies based on the Design of Hypergraph Layouts*, n^{o} RR-6842, INRIA, February 2009, http://hal.inria.fr/inria-00360576/, Technical reportPLES.

[101] J.-C. BERMOND, D. COUDERT, J. PETERS. *Online Distributed Traffic Grooming on Path Networks*, n^{o} RR-6833, INRIA, February 2009, http://hal.inria.fr/inria-00359810/, Technical reportCA.

[102] J.-C. BERMOND, X. MUÑOZ, I. SAU. *Traffic Grooming in Bidirectional WDM Ring Networks*, n^{o} RR-7080, INRIA, October 2009, http://hal.inria.fr/inria-00429155/, Technical reportES.

[103] J.-C. BERMOND, N. NISSE, P. REYES, H. RIVANO. *Fast Data Gathering in Radio Grid Networks*, n^{o} RR-6851, INRIA, March 2009, http://hal.inria.fr/inria-00363908, Research ReportCL.

[104] N. COHEN, D. COUDERT, D. MAZAURIC, N. NEPOMUCENO, N. NISSE. *Tradeoffs when optimizing Lightpaths Reconfiguration in WDM networks.*, n^{o} RR-7047, INRIA, September 2009, http://hal.archives-ouvertes.fr/inria-00421140/fr/, Technical report.

[105] N. COHEN, F. HAVET. *Planar graphs with maximum degree $\Delta \geq 9$ are $(\Delta + 1)$-edge-choosable – short proof*, n^{o} RR-7098, INRIA, nov 2009, http://hal.archives-ouvertes.fr/inria-00432389/en/, Technical report.

[106] N. COHEN, F. HAVET, T. MÜLLER. *Acyclic edge-colouring of planar graphs*, n^{o} 6876, INRIA, mar 2009, http://hal.inria.fr/inria-00367394/fr/, Research ReportIL.

[107] D. COUDERT, F. GIROIRE, I. SAU. *Circuit visiting 10 ordered vertices in infinite grids*, n^{o} RR-6910, INRIA, April 2009, http://hal.inria.fr/inria-00378586, Technical reportES.

[108] D. COUDERT, D. MAZAURIC, N. NISSE. *Routing Reconfiguration/Process Number: Networks with Shared Bandwidth.*, n^{o} RR-6790, INRIA, January 2009, http://hal.inria.fr/inria-00350025/, Technical report.

[109] N. EGGEMANN, F. HAVET, S. NOBLE. *k-$L(2,1)$-Labelling for Planar Graphs is NP-Complete for $k \geq 4$*, n^{o} 6840, INRIA, February 2009, http://hal.inria.fr/inria-00360505/fr/, Research ReportUK.

[110] R. ERMAN, F. HAVET, B. LIDICKY, O. PANGRÁC. *5-colouring graphs with 4 crossings*, n° 7110, INRIA, November 2009, Research Report CZ SI .

[111] F. GIROIRE, J. MONTEIRO, S. PÉRENNES. *P2P Storage Systems: How Much Locality Can They Tolerate?*, n° RR-7006, INRIA, July 2009, http://hal.inria.fr/inria-00408078/en/, Research Report.

[112] F. HAVET, S. JENDROL', R. SOTÁK, E. SKRABUL'AKOVÁ. *Facial non-repetitive edge-colouring of plane graphs*, n° 6873, INRIA, March 2009, http://hal.inria.fr/inria-00366589/en/, Research ReportSK.

[113] L. HOGIE, D. PAPADIMITRIOU, I. TAHIRI, F. MAJORCZYK. *Simulating routing schemes on large-scale topologies*, n° RT-0371, INRIA, November 2009, Technical report BE .

[114] F. HUC, C. MOLLE, N. NISSE, S. PÉRENNES, H. RIVANO. *Stability of a local greedy distributed routing algorithm*, n° RR-6871, INRIA, March 2009, http://hal.inria.fr/inria-00366441/, Technical report.

[115] J.-C. MAUREIRA BRAVO, D. DUJOVNE, O. DALLE. *Network Provisioning for High Speed Vehicles Moving along Predictable Routes - Part 1: Spiderman Handover*, n° RR-6850, INRIA, April 2009, http://hal.inria.fr/inria-00369419/en/, Research Report.

[116] A. SILVA, P. REYES, M. DEBBAH. *Congestion in Randomly Deployed Wireless Ad-Hoc and Sensor Networks*, n° RR-6854, INRIA, March 2009, http://hal.inria.fr/inria-00364370, Research ReportCL.

Other Publications

[117] F. GUINAND, B. ONFROY. *MANET : étude de l'impact de la mobilité sur la connexité du réseau*, June 2009, http://www-sop.inria.fr/members/Brice.Onfroy/, 11es rencontres francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel'2009), Poster.

[118] F. GUINAND, B. ONFROY. *MANET : modèle de mobilité planifié*, July 2009, http://www-sop.inria.fr/members/Brice.Onfroy/, Ubimob'09, Demonstration.

[119] J. RIBAULT, F. PEIX, J. MONTEIRO, O. DALLE. *OSA: an Integration Platform for Component-Based Simulation*, March 3-5 2009, http://doi.acm.org/10.1145/1537614.1537668, Second Intl. Conf. on Simulation Tools and Techniques (SIMUTools09), Poster absract..

References in notes

[120] J.-C. BERMOND, D. MAZAURIC, V. MISRA, P. NAIN. *Distributed Call Scheduling in Wireless Networks*, n° RR-6763, INRIA, December 2008, http://hal.inria.fr/inria-00345669, Technical report.

[121] O. DALLE. *OSA: an Open Component-based Architecture for Discrete-Event Simulation*, n° RR-5762, version 2, INRIA, February 2006, http://hal.inria.fr/inria-00070258/fr/, Technical report.

[122] J.-F. LALANDE, M. SYSKA, Y. VERHOEVEN. *Mascopt - A Network Optimization Library: Graph Manipulation*, n° RT-0293, INRIA Sophia Antipolis, 2004 route des lucioles - BP 93 - FR-06902 Sophia Antipolis, April 2004, http://hal.inria.fr/inria-00069887/fr/, Technical report.