INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team MASCOTTE

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

Sophia Antipolis

THEME COM

Activity Report

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1. Team

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

(http://www-sop.inria.fr/mascotte/?lang=en)

Head

Jean-Claude Bermond [DR CNRS]

Vice-head

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Administrative assistants

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Patricia Lachaume [ITA CNRS (part time)]

Staff member INRIA

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Staff members CNRS

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Frédéric Havet [CR]
Ralf Klasing [CR (till 31/10/05)]
Stéphane Pérennes [CR]
Hervé Rivano [CR]
Stéphane Thomassé [University of Lyon I, September 2005 - August 2006 (délégation CNRS)]

Staff members University of Nice-Sophia Antipolis

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Jérôme Galtier [Engineer France Telecom R&D]
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Expert Engineers

Cyrine Mrabet [IA INRIA since 17/10/05]
Fabrice Peix [ACI Sécurité PRESTO]

Post-doctoral fellows

Stéphane Bessy [Post-Doc MENRT, 01/10/04 - 31/08/05]
Raphael Chand [Post-Doc INRIA, since 01/12/05]
Pallab Datta [Post-Doc CRESCCO,Iowa State U., 28/02/05- 25/05/05]
Pierre-Francois Dutot [Post-Doc CRESCCO,Grenoble, 01/05/05-31/07/05]
Jean-François Lalande [ATER UNSA till 31/08/05]

PhD Students

Omid Amini [Allocataire X since 13/10/05, 1st year]
Florian Huc [BDI CNRS/Région, since 01/10/05, 1st year]
Gurvan Huiban [PhD student (co-supervision with Brazil), 3rd year, halftime Mascotte]
Aubin Jarry [Allocataire Moniteur Couplé, 3rd year, until 31/08/05]
Nelson Morales [Grant CONYCIT Chile, 3rd year]
Séverine Petat [Contract CRE France Telecom R&D, 4th year]
Jean-Sébastien Sereni [Allocataire moniteur MENRT, 3rd year]
Marie-Emilie Voge [BDI CNRS/Région, 3rd year]

Invited Researchers

Louigi Addario-Berry [McGill University, Montreal, Canada, 2 months]
Yannick Brehon [ENST Paris, 1 week]
Colin Cooper [King's College London, 1 week]
Ricardo Correa [Universidade Federal do Ceará, Brazil, 1 month]
Ross Kang [Oxford,England 1 week]
Zvi Lotker [CWI Amsterdam, Netherlands, 2 weeks]
Tobias Muller [Oxford,England 1 week]
Alfredo Navarra [University of L'Aquila, Italy, 2 weeks]
Joseph Peters [Simon Fraser University, Vancouver, Canada, 5 months]
Tomasz Radzik [King's College London, 1 month]
Fabiano Sarracco [Pre-doc CRESCCO, La Sapienza, Rome, 5 months]
Fabrice Theoleyre [CITI/ARES INSA Lyon/INRIA Rhone-Alpes, Lyon, France. 2 weeks]
Stéphane Thomassé [University of Lyon I, 1 week]
Marcelo Luis Vinagreiro [Universidade Federal do Ceará, Brazil, 3 weeks]
Joseph Yu [Simon Fraser University, Vancouver, Canada, 5 months]

Internships

Yves Baumes [ESSI, Sophia Antipolis, 3 months]
Foued Ben Hfaiedh [INSAT, Tunis, 4 months]
Marie-Laure Gnemmi [ENSEA, Cergy-Pontoise, 2 months]
Cristiana Gomes [Pre-doc UFMG Brazil, 3 months]
Florian Huc [Ecole Centrale, Paris, 1 month]
Duc Phong Le [Master 2, IFI, Vietnam, 6 months]
Faouzi Kaabi [INSAT, Tunis, 4 months]
Clement Lepelletier [DEA MDFI, Marseille, 4 months]
Benjamin Nosenzo [ESSI, Sophia Antipolis, 3 months]
Amar Patel [Master, Sveden, 4 months]
Ignasi Sau Valls [Pre-doc, UPC, Barcelone, 4 months]
Christelle Savio [ENTPE, Vaulx-en-Velin, 9 months]
Vincent Siles [Magistère, ENS Lyon, 1.5 months]

2. Overall Objectives

2.1. Overall Objectives

MASCOTTE is a joint team between INRIA Sophia-Antipolis and the laboratory I3S (Informatique Signaux et Systèmes Sophia-Antipolis) which itself belongs to CNRS (Centre National de la Recherche Scientifique) and UNSA (University of Nice-Sophia Antipolis). Furthermore MASCOTTE is strongly associated with the center of research and development of France Telecom at Sophia-Antipolis via the CRC CORSO.

Its research fields are Simulation, Algorithmic, Discrete Mathematics and Combinatorial Optimization with applications to telecommunication or transportation networks.

In particular, MASCOTTE has developed in the last four years both theoretical and applied tools for the design of heterogeneous networks of various types (like WDM, SDH, ATM, wireless, satellites, ...).

On the one hand, the project aims to construct or design networks or communication algorithms. On the other hand, it also wants to build software simulators or to implement algorithms, but not to conceive protocols. The theoretical results can be applied to various situations and technologies.

3. Scientific Foundations

3.1. Scientific Foundations

Keywords: *ATM networks, Algorithmic, Discrete Mathematics, SDP programming, Simulation, WDM or optical networks, approximation algorithms, combinatorial optimization, connectivity, discrete event systems, evolving or dynamic networks, fault tolerance, frequency allocation, graph theory, integer programming, network design, network flows, parallel and distributed computing, protection, road traffic simulator, satellite constellations, traffic grooming, virtual path layout, wireless networks.*

The project uses tools and theory in the following domains: Discrete Mathematics, Algorithmic, Combinatorial Optimization and Simulation. Typically, a telecommunication network (or an interconnection network) is modeled by a graph. A vertex may represent either a processor, a router, a switch or a person, and an edge (or arc) a connection between the elements represented by the vertices. We can add more information both on the vertices (for example what kind of switch is used, optical or not, number of ports, equipment cost) and on the edges (weights which might correspond to length, costs, bandwidth, capacities) or colors on paths etc. According to the application, various models can be defined and they have to be specified. This modeling part is an important task. To solve the problems, in some cases we can 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 and it can be determined 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 to construct or minimize the cost of a network which can realize certain traffic requests. On many problems, the project works with a deterministic hypothesis (for example if a connection fails it is considered as definitely and not intermittently). The project aims to construct or design networks or communication algorithms or to build software simulators or to implement algorithms but not to conceive protocols. The theoretical results can be applied to various situations and technologies.

4. Application Domains

4.1. Application Domains

For the last five years the project has chosen as main domain of application Telecommunication leaving the domain of parallel computing. The project has also applications in the domain of ”transportation”. However, note that there is some overlap between the two domains; in particular theoretical tools and also communication problems are not really different if one considers transportation or telecommunication networks. Inside the telecommunication domain the applications we consider are strongly dependent on the interest of the industrial partners with whom we collaborate. With France Telecom (and other partners) we have worked on the design of telecommunication backbone networks (either SDH/SONET, WDM, or ATM networks) and on various fault-tolerance (protection) problems (in particular in case of link failures) or grooming (grouping) of small traffic containers into bigger ones. We have also used the PROSIT simulation framework developed in the project both for applications to a road traffic simulator (in the OSSA E.U. project) or in the ASIMUT simulation environment for satellite telecommunication in particular with the CNES.

5. Software

5.1. Advanced Software

- **PROSIT**[1]

[1] http://www-sop.inria.fr/mascotte/prosit/?lang=en

Participants: Olivier Dalle, Philippe Mussi.
PROSIT is a sequential and distributed application framework for discrete event simulation. PROSIT uses object oriented techniques to allow for efficient development of complex discrete event simulation packages. It has been used as the simulation engine for the European projects HIPERTRANS and OSSA, devoted to high performance simulation of road traffic. It has also been at the heart of the ASIMUT simulation environment developed by CNES (the French National Space Centre) for satellite telecommunication systems evaluation.
Licenses of PROSIT have been sold to CNES and to Dassault Data Systems.

5.2. Prototype Software

- **MASCOPT**[2]
  Participants: Ricardo Correa, Marie-Laure Gnemmi, Jean-François Lalande, Fabrice Peix, Michel Syska, Marcelo Luis Vinagreiro.
  the main objective of the MASCOPT (Mascotte Optimization) project is to provide a set of tools for network optimization problems. Examples of problems are routing, grooming, survivability, and virtual network design. MASCOPT will help implementing a solution to such problems by providing a data model of the network and the demands, libraries to handle data and ready to use implementation of existing algorithms or linear programs (e.g. integral multi-commodity flow).
  MASCOPT is Open Source (LGPL) and intends to use the most standard technologies such as Java and XML format providing portability facilities. We finished to implement graph data structure, several basic algorithms working on graph and input/output classes. MASCOPT also provides some graphical tools to display graph results and step by step algorithm demos. We are currently writing network packages and performing experiments on WDM networks [55]. A first application has been released which computes on-board networks with fault tolerance which is described in section 6.3.
  A new release of Mascopt has been developed this year in order to provide easy interfacing mechanism with other libraries such as Parego (by Ricardo Correa, Universidade Federal do Ceará, Brazil).
  Mascopt has been presented at Club InTech'Sophia.
- **OSA**: an Open Component-based Architecture for Discrete-Event Simulations.
  Participants: Olivier Dalle, Cyrine Mrabet, Philippe Mussi.
  Component-based modeling has many well-known good properties. Out of these properties is the ability to dispatch the modeling effort amongst several experts each having their 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.
  This technical report [46] serves two objectives: first it is a position paper in which we argue that ensuring a strong separation of the end-user roles is required to ensure a successful cooperation of all the experts involved in the process of simulating complex systems; second it introduces the Open Simulation Architecture (OSA) and describes how this architecture enforces such a strong separation of the roles and expertise areas.
  Moreover, the OSA architecture is intended to meet the expectations of a large part of the discrete-event simulation community. This report also describes the way OSA provides an open platform intended to support simulationists in a wide set of their simulation activities, and how it allows the reuse and sharing of system models in the simulation community by means of a flexible component model (Fractal).

[2]http://www-sop.inria.fr/mascotte/mascopt/

6. New Results

6.1. Discrete event systems and simulation

6.1.1. Road traffic Simulator

Participants: Olivier Dalle, Philippe Mussi, Christelle Savio.

Preliminary work had been done on methodologies to estimate road traffic by using instrumented vehicles, in complement of or instead of road sensors. In the framework of the MobiVIP project, in [59], [58] we have further investigated the estimation of origin-destination matrices. She has described some methods that can be used for a urban network, in real-time conditions and in the context of high-precision instrumented vehicles use. The comparisons made on a large references ground enable to propose one approach based on state-space modeling. Two solutions for this model are then described and compared: Kalman filtering and the generalized least squares method.

6.2. Network design

Designing a backbone network consists in computing paths for each traffic unit and then in assigning resources along these paths. The set of paths is chosen according to the technology, the protocol or the quality of service 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 multiplexing several wavelength channels onto the same fiber. In WDM networks, the huge bandwidth available on an optical fiber is divided into multiple channels. Each channel carries bandwidth up to several gigabits per second. A minimum unit of 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 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.

In MASCOTTE we have studied the wavelength routing and coloring problem, the traffic grooming problem and the virtual network embedding problem (with application to ATM networks) and other design problems for backbone telecommunication networks with SDH (Synchronous Digital Hierarchy) technology.

6.2.1. Traffic Grooming

Participants: Jean-Claude Bermond, Michel Cosnard, David Coudert, Stéphane Pérennes, Séverine Petat, Ignasi Sau Valls, Michel Syska, Marie-Emilie Voge.

In a WDM network, routing a request consists in assigning it a route in the physical network and a wavelength. If each request uses at most $1/C$ of the bandwidth of the wavelength, we will say that the grooming factor is C. That means that on a given edge of the network we can groom (group) 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 (shortly ADM) used in the network (related to the cost of the nodes).

We have 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 sonet add-drop multiplexers (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 ratio) and where the total number of vertices has to be minimized. In prior work, using tools of graph and design theory, we optimally solved the problem for rings for practical values and infinite congruence classes of values for a given C. In [15] we solved the problem for rings and $C = 6$.

We have also considered the case where the network is a path on N nodes, P_N. Thus the routing is unique. For a given grooming factor C, minimizing the number of wavelengths is an easy problem, well-known and related to the load problem. But minimizing the number of ADM's is NP-complete for a general set of requests and no results are known. Here, we show how to model the problem as a graph partition problem, and using tools of design theory we completely solve the case where $C = 2$, and where we have a static uniform all-to-all traffic (one request for each pair of vertices) [20], [42].

In [43] we give an optimal solution to the Maximum All Request Path Grooming (MARPG) problem motivated by a traffic grooming application. The MARPG problem consists in finding the maximum number of connections which can be established in a path of size N, where each arc has a capacity or bandwidth C (grooming factor). We present a greedy algorithm to solve the problem and an explicit formula for the maximum number of requests that can be groomed. In particular, if $C = s(s+1)/2$ and $N > s(s-1)$, an optimal solution is obtained by taking all the requests of smallest length, that is of length 1 to s. However, this is not true in general since anomalies can exist. We give a complete analysis and the exact number of such anomalies.

In [39] we study another grooming problem which consists in the installation of a minimum number of directed pipes of a given capacity C joining two nodes of the path in order to satisfy a given set of unit requests. Although the assumption are restrictive, this network design problem remains NP-hard. We present several methods : heuristic, mixed integer linear programming and graph decomposition, to handle this grooming problem on a directed path.

6.2.2. Reconfiguration of WDM networks

Participants: Foued Ben Hfaiedh, David Coudert, Pallab Datta, Cristiana Gomes, Florian Huc, Gurvan Huiban, Stéphane Pérennes, Jean-Sébastien Sereni.

In a WDM network we assign to a new request the best possible route (if it exists) without computing a new routing for all requests. Thus, after several modifications of the set of requests, that is after a sequence of arrivals and terminations of requests, the routing may become inefficient. Furthermore, the probability of rejecting new requests may increase, even if there exists a routing for this set of request. So it is interesting to change the routing from time to time to improve the use of the resources in the network.

Given a set of requests and 2 different routings R_1 and R_2 for it, we want to find a set of modifications of the routing to go from R_1 to R_2, according to the following rules: (i) a request can use its new route if it is available, (ii) we can move the route of a request to a temporary position at any time, (iii) when a request uses a temporary route, it uses it until it can reach its final route. Our objective is thus to minimize the number of requests that are simultaneously in a temporary position.

In [24], we establish some similarities and differences with two other known problems: the pathwidth and the pursuit problem. We then present a distributed linear-time algorithm to solve the problem on trees. Last, we give the solutions for some classes of graphs, in particular complete d-ary trees and grids.

In [48] we consider the reconfiguration problem in multi-fiber WDM optical networks. In a real-time network, as the traffic evolves with time, the virtual topology may not remain optimal for the evolving traffic, leading to a degradation of network performance. However, adapting the virtual topology to the changing traffic may lead to service disruption. This optimization problem hence captures the trade-off between network performance and number of reconfigurations applied to the virtual topology. The above problem is solved through a Mixed Integer Linear Programming formulation with a multivariate objective function, that captures both these parameters. However, the problem is NP-hard and such an approach is unable to solve large problem instances in a reasonable time. In this work, we also propose a simulated annealing based heuristic algorithm for solving problems of higher complexity. We compare the performance and the computation time of the MILP model and the heuristic algorithm considering different tests instances. Our results indicate that simulated annealing obtains results within 5% of the optimal solution, thus making it a viable approach in large scale networks.

In [31] we tried to make a concise model in relations with the number of variables and restrictions, to reduce the memory occupation during the optimization process. We also add some cuts to the model.

In [49] we propose an in-depth study of the reconfiguration problem in multi-fiber WDM networks. It consists in defining how to adapt the optical layer to changing traffic patterns. Our objective is to treat the problem globally. We consider arbitrary mesh topologies, all-to-all traffic and multi-hop routing. However, we restrict ourselves to prevision: the traffic evolutions are foreseen. We propose a compact Mixed Integer Linear Programming model, enabling us to solve medium instances. We define several metrics to evaluate the performance of a solution. We also propose some mathematical cuts and a lower bound for the problem. We make extensive experiments based on this model, in order to investigate the influence of different parameters, such as the metric chosen or the cut formulation. To do so, many instances are solved with different networks.

6.2.3. Multi-objective approach for virtual topology design and routing problem

Participants: Gurvan Huiban, Aubin Jarry, Stéphane Pérennes.

In [30] we deal with the classical virtual topology design and routing problems in optical WDM (Wavelength Division Multiplexing) networks. We propose a multi-objective based algorithm to compute the Pareto set of solutions of the problem. Although the computational cost may be high, such approach permits the decision maker to have a better perception of the gain and the loss of choosing any given solution. We describe briefly the treated problem, and the MILP (Mixed Integer Linear Programming) model used. We present the method applied to obtain the Pareto set. We report some computational results and they fully justify the interest of carrying out a multi-objective study.

A different problem motivated by the design of Asynchronous Transfer Mode (ATM) networks was considered in [17] . Given a physical network and an All-to-All traffic, the problem consists in designing a virtual network with a given diameter, which can be embedded in the physical one with a minimum congestion (the congestion is the maximum load of a physical link). Here the problem is solved when the physical network is a ring; an almost optimal solution is given for diameter 2 and bounds for large diameters.

6.2.4. Optimal positioning of active and passive monitoring devices

Participants: Hervé Rivano, Marie-Emilie Voge.

Network measurement is essential for assessing performance issues, identifying and locating problems. Two common strategies are the passive approach that attaches specific devices to links in order to monitor the traffic that passes through the network and the active approach that generates explicit control packets in the network for measurements. One of the key issues in this domain is to minimize the overhead in terms of hardware, software, maintenance cost and additional traffic.

We have studied the problem of assigning tap devices for passive monitoring and beacons for active monitoring. Minimizing the number of devices and finding optimal strategic locations is a key issue, mandatory for deploying scalable monitoring platforms. We present a combinatorial view of the problem from which we derive complexity and approximability results, as well as efficient and versatile Mixed Integer Programming (MIP) formulations [23], [22].

6.3. Fault tolerance

6.3.1. Shared Risk Resources group

Participants: David Coudert, Pallab Datta, Hervé Rivano, Marie-Emilie Voge.

Failure resilience is a desired feature of the Internet. Most traditional restoration architectures assume single-failure assumption, which is not adequate in present day multi-layer networks.

Multiple link failure models, in the form of Shared Risk Link Groups (SRLG's) and Shared Risk Node Groups (SRNG's),are becoming critical in survivable optical network design. We classify both of these forms of failures under a common scenario of shared risk resource groups (SRRG) failures. We develop techniques for the minimum color path problem to tolerate multiple failures arising from a shared resource group failure. We study the minimum color st-cut problem that we prove NP-complete and hard to approximate. We also provide efficient MILP formulation and heuristic algorithms for it [45].

6.3.2. Algorithms to evaluate the reliability of a network

Participants: Jérôme Galtier, Alexandre Laugier.

In [27] we consider problems of network reliability: the two-terminal network reliability consists, given an undirected graph $G = (V, E)$, and a series of independent edge failure events, in computing the probability that two nodes remain connected. The all-terminal network reliability is the probability that the whole network remains connected. We present in the following two different approaches to compute two-terminal and all-terminal reliability, with various characteristics on the precision level of the result. We give an exact algorithm to compute the reliability in $O(|V|f(w)^2 + |E|f(w))$ with $f(x) = \left(\frac{x}{\ln x}\right)^x e^{-(1+o(1))x}$ and w is the tree-width of G. We also present polynomial methods to give bounds on the reliability. We discuss methods to optimize the *mean time to repair* of the components.

6.3.3. *On the minimum number of edges of 2-connected graphs with given diameter*

Participants: Aubin Jarry, Alexandre Laugier.

The problem of interest is to determine the minimum number of edges of a 2-connected graph having a diameter equal to p. This problem deals with telecommunication survivable networks design with constraint of grade of service. In [32] we prove the bounds of the number of edges for 2-connected graphs or for 2-edges-connected graphs with a diameter p. The bound for 2-connected graphs was a conjecture by L. Cacetta.

6.3.4. *Black Hole search*

Participants: Ralf Klasing, Tomasz Radzik, Fabiano Sarracco.

A black hole is a highly harmful stationary process residing in a node of a network and destroying all mobile agents visiting the node without leaving any trace. The Black Hole Search is the task of locating all black holes in a network, through the exploration of its nodes by a set of mobile agents. In [36], [35], [52] we consider the problem of designing the fastest Black Hole Search, given the map of the network, the starting node and, possibly, a subset of nodes of the network initially known to be safe. We study the version of this problem that assumes that there is at most one black hole in the network and there are two agents, which move in synchronized steps. We prove that this problem is not polynomial-time approximable within $\frac{389}{388}$ (unless P=NP). We give a 6-approximation algorithm, thus improving on the previous 9.3-approximation algorithm. We also prove APX-hardness for a restricted version of the problem, in which only the starting node is initially known to be safe.

6.3.5. *Survivable optical network*

Participants: Jean-Claude Bermond, Stéphane Bessy, Jean-François Lalande, Clement Lepelletier, Michel Syska.

In [37], we present a routing algorithm in a survivable optical network. The goal of this algorithm is to route a set of requests on main paths and provide a backup lightpath in case of cable failure, assuming there is only one failure in the network. Our objective is to minimize the resources used in the network and to provide a MN protection scheme which guarantees a full recovery of any failure of a cable. Our approach improves the linear program model of Baroni, Bayvel, and Gibbens, and proposes a new mode of sharing network resources which increases the re-usability of cables. We also show how to apply rounding techniques on a relaxed linear program. We obtain with asymptotically high probability an integer solution such that the objective function is at least $(1-\varepsilon^2)$ times the optimal one. We experimented our approach on real mesh optical network showing the improvements compared to previous works.

Another measure of fault tolerance consists in asking each request to be routed via $f + 1$ vertex disjoint paths. So, the network can tolerate f faults. One can generalize the classical notions of load and optical index and define the f-load and the f-optical index; for example the f-optical index is the minimum number of wavelengths to be assigned to the paths associated to the requests in order that no two paths that share an arc receive the same wavelength. In [57], these parameters are determined for the complete graphs and partly for other topologies like tori and bipartite complete graphs when the set of requests is All to All. The proofs need construction of specific idempotent orthogonal latin squares.

6.3.6. *Satellite boarded fault tolerant networks.*

Participants: Jean-Claude Bermond, Frédéric Havet, Florian Huc, Stéphane Pérennes.

Inside a telecommunication satellite, audio and video signals are routed through a switching network to amplifiers. Since it is impossible to repair a satellite, we choose to multiply the components that may be faulty, that is amplifiers and switches.

The first problem is to build a valid network which allows to route n input signals, to n amplifiers (outputs), arbitrarily chosen among $n + k$, and thus supporting k broken amplifiers. Each switch has 4 links and the routes followed by the signals must be disjoint. Thus for economical constraints, the objective is to build valid networks having the minimum number of switches.

In [47], we studied a variation of this problem where p of the input signals called priorities must be routed to the p amplifiers providing the best quality of service.

6.4. Resource sharing in wireless and sensor networks

6.4.1. Radio networks : Internet in villages.

Participants: Jean-Claude Bermond, Ricardo Correa, Ralf Klasing, Nelson Morales, Stéphane Pérennes, Joseph Peters, Joseph Yu.

Within the CRC CORSO with France Telecom, we have studied the problem of designing efficient strategies to provide Internet access using wireless devices. Typically, in one village several houses wish to access a gateway (a satellite antenna) and to use multi-hop wireless relay routing to do so.

On the one hand,we have modeled the problem as follows: each node (representing a house) is able to communicate to nodes not too far away (at distance at most d_T). On the other hand, there is interference between nodes (at distance at most d_I). The distances can be measured either in terms of Euclidean distances or number of hops. In our first study we have considered the special case where each node has one information (message) that it wants to transmit to (or analogously receive from) the gateway (gathering problem). We have in particular obtained the results for specific topologies like paths or grids for which optimal algorithms have been obtained in [21]. In [56], we have considered the case where there is permanent demand (systolic algorithms). This leads to the definition of a *call scheduling problem*. In such networks the physical space is a common resource that nodes have to share, since concurrent transmissions cannot interfer. We study how one can satisfy steady bandwidth demands according to this constraint. We show that it can be relaxed into a simpler problem: the *call weighting* problem, which is almost a usual multi-commodity flow problem, but the capacity constraints are replaced by the much more complex notion of non interference. Not surprisingly, this notion involves independent sets, and we prove that the complexity of the call weighting problem is strongly related to the one of the independent set problem and its variants (max-weight, coloring, fractional coloring). The hardness of approximation follows when the interferences are described by an arbitrary graph. We refine our study by considering some particular cases for which efficient polynomial algorithms can be provided: the *Gathering* in which all the demand are directed toward the same sink, and specific interference relations: namely those induced by the dimension 1 and 2 Euclidean space, those cases are likely to be the practical ones.

6.4.2. An algorithm for satellite bandwidth allocation

Participants: Jérôme Galtier, Jean-François Lalande.

In [19], [13] we present an algorithm for resource allocation in satellite networks. It deals with planning a time/frequency plan for a set of terminals with a known geometric configuration under interference constraints. Our objective is to minimize the size of the frequency plan while ensuring that the different types of demands are satisfied, each type using a different bandwidth. The proposed algorithm relies on two main techniques. The first generates admissible configurations for the interference constraints, whereas the second uses mixed linear/integer programming with column generation. The obtained solution estimates a possible allocation plan with optimality guarantees, and highlights the frequency interferences which degrade the construction of good solutions.

6.4.3. Energy efficiency

Participants: Ralf Klasing, Alfredo Navarra, Stéphane Pérennes, Fabiano Sarracco.

In [54] we present new results on the performance of the Minimum Spanning Tree heuristic for the *Minimum Energy Broadcast Routing* (MEBR) problem. We first prove that, for any number of dimensions $d \geq 2$, the approximation ratio of the heuristic does not increase when the power attenuation coefficient α, that is the exponent to which the coverage distance must be raised to give the emission power, grows. Moreover, we show that, for any fixed instance, as a limit for α going to infinity, the ratio tends to the lower bound given by the d-dimensional kissing number, thus closing the existing gap between the upper and the lower bound. We establish a 7.45-approximation ratio for the 2-dimensional case, thus significantly decreasing the previously known 12 upper bound (actually corrected to 12.15). Finally, we extend our analysis to any number of dimensions $d \geq 2$ and any $\alpha \geq d$, obtaining a general approximation ratio of $3^d - 1$, again independent of α. The improvements of the approximation ratios are specifically significant in comparison with the lower bounds given by the kissing numbers, as these grow at least exponentially with respect to d. (see [26]).

6.4.4. Influence of self-organization on the capacity of ad-hoc networks

Participants: Hervé Rivano, Vincent Siles, Fabrice Theoleyre.

Mobile ad hoc network (MANet) are spontaneous topologies of mobile nodes where each of them collaborate. Self-organization propose to structure the MANet in order to provide efficient broadcast, routing protocols, localization, etc. Nevertheless, if self-organization appears to be an interesting approach because of the stability or autonomous properties, some weaknesses remain because self-organization selects privileged nodes and links forming a sub-MANet where non-privileged nodes and links are less active. Intuitively, bottleneck can appear in such networks. In this work, we address the issue of capacity of self-organization and the comparison between classical flat MANet and self-organized one. We propose a model of radio resource sharing taking into account local nodes interactions to provide lower and upper bounds. Evaluation functions are given in order to characterize the proposed bounds [40].

6.5. Dynamic networks

6.5.1. Algorithms for the Web Graph.

Participants: Colin Cooper, Ralf Klasing, Alexandre Laugier, Alfredo Navarra, Stéphane Pérennes.

In [38] we identify a web community to an expander sub-graph of the graph web. So, we will cover the graph web by expanders. Starting from a clique which is trivially an expander, we add vertices which are adjacent to the current expander vertices until we obtain a sub-graph which is not an expander. In order to verify is the current sub-graph is an expander, we check a well known property of this kind of graph: any random walk converges quickly to the uniform distribution.

In [44] we study the size of dominating sets, and their generalizations, in two graph processes which are widely used to model aspects of the world-wide web. In these processes each new vertex connects to the existing graph by a constant number, m, of edges. The terminal vertices of these edges are chosen uniformly at random or by preferential attachment depending on the process. We show that almost all such graph processes have minimal dominating sets linear in the size of the graph, and give bounds for this size as a function of m. We obtain the upper bounds from simple on-line algorithms for dominating sets. The lower bounds are obtained by proving that the lexicographically first set of a given size is the most likely to dominate.

Motivated by the Web graph a study of small world graphs is done in [25].

6.5.2. Modeling of Peer-to-Peer networks.

Participants: Colin Cooper, Michel Cosnard, Ralf Klasing, Amar Patel, Tomasz Radzik.

In [53], we consider a randomized algorithm for assigning neighbors to vertices joining a dynamic distributed network. The algorithm acts to maintain connectivity, low diameter and constant vertex degree. This is carried out as follows: on joining each vertex gives a fixed number of tokens to the network. The tokens contain the address of the donor vertex. Tokens make independent random walks in the network. A token can be used by any vertex it is visiting to establish a connection to the donor vertex. This allows joining vertices to be allocated a random set of neighbors, although the overall membership of the network is unknown. The network we obtain in this way is robust under adversarial deletion of vertices and edges and actively reconnects itself.

6.5.3. Connectivity in evolving graphs.

Participants: Afonso Ferreira, Aubin Jarry.

New technologies and the deployment of mobile and nomadic services naturally generqte new route-discovery problems under changing conditions over dynamic networks. Unfortunately, the temporal variations in the topology of dynamic networks are hard to be effectively captured in a classical graph model. We used evolving graphs to capture the dynamic characteristics of such networks; we showed that computing different types of strongly connected components in dynamic networks is NP-complete. We also investigated the concepts of journeys in Evolving Graphs which capture both space and time constraints in routing problems [12].

We further investigated the connected components problem in dynamic networks with special topologies. In a dynamic setting, the topology of a network derives from the set of all the possible links, past and future. We proved that the strongly connected components problem is still NP-complete when the topology is composed of unit disc graphs and the nodes are placed on a grid. On the other hand, we also gave a polynomial-time algorithm, by dynamic programming, in order to compute a maximum strongly connected components when the topology is a tree [12].

One of the new challenges facing research in wireless networks is the design of algorithms and protocols that are energy aware. The *minimum-energy broadcast routing* problem, which attracted a great deal of attention these past years, is NP-hard, even for a planar static network. The best approximation ratio for it is a solution proved to be within a factor 12 of the optimal. One popular way of achieving this ratio is based on finding a Minimum Spanning Tree of the static planar network. We used the evolving graph combinatorial model to prove that computing a Minimum Spanning Tree of a planar network in the presence of *mobility* is NP-Complete. We also gave a polynomial-time algorithm to build a rooted spanning tree of a mobile network, that minimizes the maximum energy used by any one node, thus maximizing the life-time of a wireless communication network [12].

6.6. Graph theory and communication

6.6.1. Graph coloring problems

Participants: Louigi Addario-Berry, Stéphane Bessy, Frédéric Havet, Jean-Sébastien Sereni, Stéphane Thomassé.

We studied different aspect of improper colourings of graphs, related to a channel assignment problem proposed by Alcatel. In [29], we model Alcatel's problem using improper choosability of graphs. The relation between improper colourings and maximum average degree is underlined, which contributes to generalize and to improve previous known results about improper choosability of planar graphs, and graphs of higher genus.

In [28], we focus about complexity issues concerning improper colouring of unit disk graphs, and weighted improper colouring of subgraphs of the triangular lattice.

In [33], [50], we investigate the ratio of the k-improper· chromatic number to the clique number for unit disk graphs and random unit disk graphs to generalize results of McDiarmid and Reed, and results of McDiarmid and Müller, where only proper colouring was considered.

In [41] are studied paths with two blocks in n-chromatic digraphs.

In [16] we provide an example of a 5-chromatic oriented graph D such that the categorical product of D and TT_5 is 3-chromatic.

6.6.2. New progress in enumeration of mixed models

Participant: Jean-Sébastien Sereni.

In [14], we are interested in enumerating (constrained or unconstrained) mixed models, a question raised by Hess and Iyer. They solved the problem for mixed models of size at most 5. Using previous results about posets, we present a new algorithm and obtain results for mixed models with at most 10 elements for constrained mixed models and 9 for unconstrained ones. Enumeration of constrained mixed models is used to compute confidence intervals in the calculations of the Satterwaite method.

6.6.3. Information dissemination

Participants: Ralf Klasing, Stéphane Pérennes.

With the rapid developments in hardware technologies, distributed computing and the interconnected world has become realities, and the term "communication" has become central in computer science. Solving communication tasks under different circumstances is the topic of this textbook [11]. It provides an introduction to the theory of design and the analysis of algorithms for the dissemination of information in interconnection networks, with a special emphasis on broadcast and gossip. The book starts with the classic telegraph and telephone communication modes, and follows the technology up to optical switches. All ideas, concepts, algorithms, analyses and arguments are first explained in an informal way in order to develop the right intuition, and then they are carefully specified in detail. This makes the content accessible for beginners as well as specialists.

In [18] are given lower bounds on systolic gossiping.

6.6.4. From balls and bins to points and vertices

Participants: Ralf Klasing, Zvi Lotker, Alfredo Navarra, Stéphane Pérennes.

Given a graph $G = (V, E)$ with $|V| = n$, we consider the following problem: place 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, we prove in [34] the #P-hardness of the problem and that the maximum relocation distance is $O(\sqrt{n})$ with high probability. We also 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.

6.6.5. Constructing incremental sequences in graphs

Participants: Ralf Klasing, Joseph Peters.

Given a weighted graph $G = (V, E, w)$, we investigate in [51] the problem of constructing a sequence of $n = |V|$ subsets of vertices $M_1, \cdots, M_n$ (called *groups*) with small diameters, where the diameter of a group is calculated using distances in G. The constraint on these n groups is that they must be *incremental*: $M_1 \subset M_2 \subset \cdots \subset M_n = V$. The cost of a sequence is the maximum ratio between the diameter of each group M_i and the diameter of a group N_i^* with i vertices and minimum diameter: $\max_{2 \le i \le n} \left\{ \frac{D(M_i)}{D(N_i^*)} \right\}$. This quantity captures the impact of the incremental constraint on the diameters of the groups in a sequence. We give general bounds on the value of this ratio and we prove that the problem of constructing an optimal incremental sequence cannot be solved approximately in polynomial time with an approximation ratio less than 2 unless $P = NP$. Finally, we provide a 4-approximation algorithm, and we show that the analysis of our algorithm is tight.

7. Contracts and Grants with Industry

7.1. Contract CRE France Telecom R&D

Keywords: *Design of telecommunication networks, Matching, Protection, Routing.*

Contrat de recherche externalisé, CRE with France Telecom R&D, 2003-2005, on matching constraints for the design of telecommunication networks. This contract covers mainly the PhD grant of S. Petat.

7.2. Contract CRC France Telecom R&D

Keywords: *Design of telecommunication networks*, *Fault Tolerance*, *Radio Networks*.

Contrat de recherche collaborative (CRC) with France Telecom R&D, 2003-2005.

As mentioned earlier, we have a strong collaboration with France Telecom R&D inside the CRC CORSO. This means that some researchers of MASCOTTE on one side and engineers of France Telecom R&D on the other side work together on specified subjects approved by a "Comité de pilotage". Among these subjects we can mention the design of telecommunication networks, the study of fault tolerance and the use of radio networks for bringing Internet in places where there is no ADSL.

8. Other Grants and Activities

8.1. National Collaborations

8.1.1. Action MobiVip

MobiVIP is a PREDIT project funded by Ministries of Research, Transportation, Industry and Environment, together with ANVAR and ADEME. In this program, 5 research laboratories and 7 SMEs work in collaboration to experiment, demonstrate and evaluate a new transportation system for cities, based on intelligent small urban vehicles. Mascotte will develop methods for traffic estimation based on instrumentation of those vehicles.

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

8.1.2. ANR Jeunes Chercheurs OSERA

ANR jeunes chercheurs: "OSERA", 2005-2008, on optimization and simulation of ambient networks.

8.1.3. ACI sécurité informatique PRESTO

ACI sécurité "PRESTO", 2003- 2006, on survivability of communication networks, in collaboration with the ENST (Paris) and the LIMOS (Clermont-Ferrand).
(http://www-sop.inria.fr/mascotte/David.Coudert/PRESTO/)

8.2. European Collaborations

8.2.1. European project IST CRESCCO

European project IST : "CRESCCO", 2002-2005, on critical resource sharing for cooperation in complex systems, in collaboration with the universities of Salerno and Roma (Italy), Patras (Greece, coordinator), Geneva (Switzerland) and Kiel (Germany). Mascotte works essentially on the efficient use of bandwidth in WDM networks (Workpackage 4).

(http://www.ceid.upatras.gr/faculty/kakl/crescco).

8.2.2. European project IST AEOLUS

European project IST : "AEOLUS", 2005-2009, on algorithmic principles for building efficient overlay computers, in collaboration with 21 European universities and coordinated by University of Patras, Greece.

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

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

8.2.3. European COST 293 Graal

European COST Action: "COST 293, Graal", 2004-2008. The main objective of this COST action is to elaborate global and solid advances in the design of communication networks by letting experts and researchers with strong mathematical background meet peers specialized in communication networks, and share their mutual experience by forming a multidisciplinary scientific cooperation community. This action has more than 25 academic and 4 industrial partners from 18 European countries. Mascotte works essentially on the design and efficient use of optical backbone network.

D. Coudert for INRIA and J. Galtier for France Telecom R&D are in the management committee of this action.

(http://www.cost293.org).

8.2.4. European COST 355

P. Mussi has joined COST Action 355 **"Changing behavior towards a more sustainable transport system"**. The main objective of this COST Action is to develop a more rigorous understanding of the conditions under which the process of growing unsustainable transport demand could be reversed, by changing travelers , shippers and carriers behavior.

(http://www.cost.esf.org/index.php?id=240&action_number=355)

8.2.5. Bilateral Cooperation CNRS–Oxford

Cooperation CNRS–Oxford, 2003-2005, on frequency allocation problems in wireless networks, in collaboration with the Mathematical Institute of Oxford University.

Funded by the PACA province.

8.2.6. Royal Society Grant with King's College London

Bilateral Cooperation, 04/2004-03/2006, on "Web Graphs and Web Algorithms", in collaboration with the Department of Computer Science, King's College London.

Funded by the Royal Society, U.K.

8.3. International Collaborations

8.3.1. Cooperation INRIA–Brazil Regal and Mobidyn

Cooperation INRIA–Brazil: "REGAL", 2003-20 06, on algorithmic problems for telecommunication networks, in collaboration with the Federal University of Ceara (Fortaleza, Brazil); also funded by the PACA province (06/04-06/06).

Cooperation with the university of Sao Paolo (resp A. Goldman) projet commun Mobidyn INRIA-FAPESP on combinatorial models for dynamic networks.

8.3.2. Join team with the Network Modeling Group (SFU, Vancouver, Canada) : "RESEAUXCOM"

One of the main objectives is to strengthen our collaboration with SFU. Many reciprocal visits have been performed.

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

8.4. Visitors

- *Louigi Addario-Berry*, McGill University, Montreal, Canada, February-March 2005.
- *Yannick Brehon*, ENST, Paris, France, July 2005.
- *Colin Cooper*, King's College London, England, December 2005.
- *Ricardo Correa*, Universidade Federal do Ceará, Brazil, April 2005.
- *Ross Kang*, Oxford,England, June 2005.
- *ZviLotker*, CWI Amsterdam, Netherlands, October 2005.
- *Tobias Muller*, Oxford, England, June 2005.
- *Alfredo Navarra*, University of L'Aquila, Italy, October 2005.

- *Joseph Peters*, Simon Fraser University, Vancouver, Canada. January-may 2005 .
- *Tomasz Radzik*, King’s College London, England, March June and December 2005.
- *Fabiano Sarracco*, La Sapienza, Rome, Italy, January-March 2005 and May-June 2005.
- *Fabrice Theoleyre*, CITI/ARES INSA Lyon/INRIA Rhone-Alpes, Lyon, France. November-december 2005.
- *Stéphane Thomassé*,University de Lyon, France, February 2005.
- *Marcelo Luis Vinagreiro*, University of Sao Paulo, Brazil, July 2005.
- *Joseph Yu*, Simon Fraser University, Vancouver, Canada. January-April 2005.

8.5. Visits of Mascotte members to other research institutions

- *J.-C. Bermond*: Greece (2-30/06/05) and Brazil (University of Fortaleza) 29/10/05 - 21/11/05.
- *D. Coudert*: Montreal University, Montreal Canada, April 09-16 2005.
- *A. Ferreira*: University of Fortaleza Brésil (28/04/05- 07/05/05) and Sao Paulo, Brazil, October 29 - November 7 2005.
- *F. Havet*: McGill University, Montreal Canada, October 06-20, 2005.
- *L. Addario-Berry, F. Havet and J-S. Sereni*: Oxford, England, 14/03/05-25/03/05
- *G. Huiban and M-E. Voge*: LIMOS, Clermont Ferrand, France, 08/03/05-09/03/05.
- *A. Jarry*: IME, University of Sao Paulo, Brazil, February 12 - march 12 2005.
- *R. Klasing*: LaBRI, Bordeaux, 30/01/05 - 06/02/05, King’s College London, 15/03/2005 - 19/03/2005, ETH Zurich, 16/05/05 - 21/05/05, King’s College London, 10/10/2005 - 14/10/2005, Simon Fraser University, Burnaby, Canada, 13/11/2005 - 30/11/2005
- *F. Huc*: Cambridge University, Cambridge UK, October 7-12 2005.
- *G. Huiban*: Federal University of Minas Gerais, June 01-December 31 2005.
- *S. Pérennes*: S.F.U. Vancouver, Canada, 06/11/05 - 30/11/05.
- *H. Rivano*: Montreal University, Montreal Canada, April 09-16 2005, CITI, INRIA/INSA de Lyon, several weeks, year 2005.
- *J.-S. Sereni*: Charles University, Praha Czech Republic, 09/26-10/01 2005

9. Dissemination

9.1. Leadership within the scientific community

9.1.1. Participation in Committees

- *J-C. Bermond*: expert for RNRT; expert for DRTT ; member of the scientific committee of LIRMM (Montpellier); member of the "Commission de Spécialistes de la 27e section" of UNSA; substitute member of the "Commissions de Spécialistes de la 27e section" of UTC (université de Technologie de Compiègne) and Université de la Méditerranée (Aix-Marseille II); member of the I3S Project Committee; nominated member of the RTP (réseaux thématiques) Committee of STIC department " Réseaux " and " Mathématiques de l'Informatique "; member of the PhD committee of Marseille and of the "Conseil Scientifique" of the Ecole Doctorale STIC of Nice-Sophia Antipolis.
- *M. Cosnard*: members of a lot of committees mainly in relation with its direction of UR INRIA of Sophia Antipolis
- *D. Coudert*: member of the COST Action 293 Management Committee.
- *O. Dalle* : member of working group "Vers une théorie de la Simulation" (http://www.lsis.org/versim/), member of the "Commission de Spécialistes de la 27e section" of University of Nice-Sophia Antipolis, member of the “Commission du Développement Logiciel” de l'INRIA Sophia Antipolis, member of the “Commission Informatique” of I3S.
- *A. Ferreira*: nominated member of the I3S laboratory Committee; member of the "Commission d'évaluation" of the INRIA; member of the RNRT commission 3; member of the CNRT Telius board.
- *J. Galtier*: member of the COST Action 293 Management Committee.
- *F. Havet*: member of the I3S laboratory Committee, of the "Commission de Spécialistes de la 25e et 26e section" of the University of Lyon 1, and of the "Commission de Spécialistes de la 27e section" of the University of Montpellier II.
- *R. Klasing*: substitute member of the I3S laboratory Committee.
- *A. Laugier*: referee for ACI "Nouvelles interfaces des mathématiques".
- *P. Mussi*: head of the ReV department (public relations, international and industrial partnerships) of INRIA Sophia Antipolis, member of working group "Modélisation Multiple et Simulation" (GdR MACS, http://mad3.univ-bpclermont.fr/), and working group "Vers une théorie de la Simulation" (http://www.lsis.org/versim/).
- *M. Syska*: nominated member of the I3S laboratory Committee as president of "Commission informatique".

9.1.2. Editorial Boards

- *J-C. Bermond*: Combinatorics Probability and Computing, Discrete Mathematics, Discrete Applied Mathematics, Journal of Graph Theory, Journal of Interconnection Networks (Advisory Board), Mathématiques et Sciences Humaines, Networks, Parallel Processing Letters, Computer SCience Reviews and the SIAM book series on Discrete Mathematics.
- *M. Cosnard*: Editor-in-Chief of Parallel Processing Letters. Member of the Editorial Board of Parallel Computing, of Theory of Computational Systems (TOCS) and of IEEE TPDS.
- *A. Ferreira*: Journal of Parallel and Distributed Computing (Academic Press), Parallel Processing Letters (World Scientific), Parallel Algorithms and Applications (Elsevier), Journal of Interconnection Networks (World Scientific).

9.1.3. Steering Committees

- *M. Cosnard*: is member of the IPDPS (International Parallel and Distributed Processing Symposium) and of the PACT (Parallel Architecture and Compilation Techniques) Steering Committees.
- *A. Ferreira*: AlgoTel, Ecotel.

9.1.4. Workshop organization

- *M. Cosnard, D. Coudert, F. Havet, A. Laugier, P. Mussi, S. Pérennes and M. Syska* organized the Symposium in Honour of Jean-Claude Bermond, Sophia Antipolis, France, December 8-9, 2005.
- *D. Coudert* organized the 3rd Workshop of European Action COST 293 Graal, ENST Paris, May 27-28, 2005.
- *A. Ferreira* organized COST Strategic Workshop on Algorithmic Challenges in FP7, Brussels, Belgium, August 31 - September 1 2005
- *F. Havet* was chairman of the organizing committee of ICGT'05.
- *H. Rivano* organized AlgoTel, Presqu'ile de Giens, France, may 11-13 2005.
- *H. Rivano* organized the ReCap and ResCom workshop, Nice, France, November 8-10 2005.

9.1.5. Participation in program committees

- *J-C. Bermond*: ICGT'05.
- *D. Coudert*: AlgoTel 05.
- *D. Coudert, F. Havet, A. Laugier, S. Perennes and M. Syska*: JCB 60.
- *A. Ferreira*: LATIN 2006, MobiWac 2005, CLADE 2005, ICW'05, ParCo2005, WiMob05, WWAN 2005.
- *J. Galtier*: Networking 05.
- *P. Mussi*: The 2nd Conference on Conceptual Modeling and Simulation (CMS 2005), part of the 2005 International Mediterranean Modeling Multiconference, Marseilles, France, October 20-22 2005; ESM2005, Riga, Latvia, 1-4 June 2005; MESM2006 will be held in Alexandria, Egypt in September 2006; 2005 High Performance Computing & Simulation (HPC&S 05) Conference, June 1 - 4, 2005, Riga, Latvia; MAJECSTIC 2005 Troisième congrès francophone de doctorants en STIC Rennes, France. nov 16-18 2005; MOSIM 06: Conférence Francophone de Modélisation et Simulation Rabat, Morocco, april 3-5 2006

9.2. Teaching

9.2.1. Theses

- The following theses have been defended in 2005:
  - *A. Jarry*: Connexité dans les réseaux de télécommunications. PhD thesis, École doctorale STIC, Université de Nice-Sophia Antipolis, March 2005.
- The following theses are in preparation:
  - *O. Amini*: Problèmes de théorie des graphes.
  - *F. Huc*: Conception de réseaux dynamiques tolérants aux pannes;
  - *G. Huiban*: La reconfiguration dans les réseaux optiques multifibres;
  - *N. Morales*: Méthodes d'approximation pour les problèmes de réseaux de télécommunications avec de contraintes économiques et de traffic incertain;
  - *S. Petat*: Contraintes de couplages pour la conception de réseaux de télécommunications;
  - *J-S. Sereni*: Coloration par listes appliquée à l'allocation de fréquences;
  - *M-E. Voge*: Protection et groupage dans les réseaux de télécommunications.

9.2.2. Member of thesis Committees

- *J-C. Bermond*: Member of PhD thesis committees of R. Groonevelt (07/04/05), and Paul Ghobril (ENST 28/04/05), and Member of HDR thesis committee of Y. Vaxes (Marseille,29/11/05); referee for the PhD thesis of M. Montassier Bordeaux O2/11/05).
- *M. Cosnard*: Member of so many Ph.D. and HDR thesis Committees that he does not remember them.
- *F. Havet*: Member of PhD thesis committee of M. Montassier, University of Bordeaux, November 2, 2005.
- *A. Laugier*: Member of HDR thesis committee of Mourad Bayou, University de Clermont-Ferrand, December 2005.

9.2.3. Internships

- *J-C. Bermond and S. Bessy* supervised the internship of Clement Lepelletier (DEA MDFI Marseille)
- *J-C. Bermond and D. Coudert* supervised the internship of Florian Huc (Centrale Paris)
- *M. Cosnard* supervised the internship of Amar Patel (Master Sveden)
- *D. Coudert* supervised the internship of Foued Ben-Hfaiedh (INSAT Tunis)
- *D. Coudert* supervised the internship of Ignasi Sau-Valls (UPC Barcelone)
- *D. Coudert* supervised the internship of Marie-Laure Gnemmi (ENSEA Cergy-Pontoise)
- *P. Mussi* supervised the internship of Christelle Savio (ENTPE)
- *H. Rivano* supervised the internship of Faouzi Kaabi (INSAT Tunis)
- *H. Rivano* supervised the internship of Cristiana Gomes (UFMG, Brazil)
- *H. Rivano* supervised the internship of Vincent Siles (ENS Lyon)
- *M. Syska* supervised the internship of Yves Baumes (Project ESSI)
- *M. Syska* supervised the internship of Benjamin Nosenzo (Project ESSI)

9.2.4. Teaching

The members of MASCOTTE are heavily involved in teaching activities at undergraduate level (DEUG, IUT, Master 1 and 2, Engineering Schools like ESSI). The teaching is carried out by members of the University as part of their teaching duties, and for INRIA CNRS or PhD's as extra work. It represents more than 1000 hours per year.

For graduate studies, MASCOTTE was strongly involved in the creation of the DEA RSD (Réseaux and Systèmes Distribués) and now members of MASCOTTE teach both in the mandatory lectures and in 3 options of the Master STIC RSD. Members of MASCOTTE are also involved in teaching in other Master's like the master MDFI of Marseille or in Master pro like the Master Telecoms or in the 3rd year of engineering schools. Altogether that represents around 200 hours per year.

The members of MASCOTTE supervise on the average severals internships each year at all levels (Master 1 and 2, Engineering Schools). The students come from various places in France as well as from abroad (e.g. Europe, Chile, United States, India,...). Some of the internship reports are listed in the bibliography under the heading miscellaneous.

9.3. Participation in conferences and workshops

9.3.1. Invited talks

- *D. Coudert*: 2nd Workshop on Optimization of Optical Networks (OON 05), Montreal Canada, April 14-15.
- *F. Havet and A. Ferreira*: Workshop on Fundamental Aspects in Networks Problems, Fortaleza, Brazil, May 1-7 2005.
- *F. Havet and S. Thomassé*: Graph Theory Conference Nyborg, Denmark, December 1-4 2005
- *F. Havet*: Symposium in Honour of Jean-Claude Bermond, Sophia Antipolis, France, December 8-9, 2005.
- *A. Jarry*: "Modèles combinatoires pour les réseaux dynamiques." CNRT Télius, Mobilité dans les Télécoms et Internet : Usages et Technologie. June 15, 2005. CICA, Sophia Antipolis, France.
- *R. Klasing*: "Bringing Internet into Villages using Wireless Communication". COST293 2nd Discussion Workshop, Barcelona (31/09/2005-01/10/2005).
- *R. Klasing*: "Bringing Internet into Villages using Wireless Communication". Seminar Network Modeling Group, Simon Fraser University, Burnaby, Canada. (21/11/2005)
- *P. Mussi*: Forum simulation et transport, Paris, France, January 19-20
- *H. Rivano*: 2nd Workshop on Optimization of Optical Networks (OON 05), Montreal Canada, April 14-15.
- *H. Rivano*: Séminaire du LAMI, Evry, France, December 12 2005.
- *J.-S. Sereni*: Noon Seminars, Institute for Theoretical Computer Science (ITI) and Department of Applied Mathematics (KAM), Charles University, Prague, Sept. 29 2005
- *M. Syska*: has presented the Mascopt library at the club Intech'Sophia seminar (dec 14th).

9.3.2. Participation in scientific meetings

- *J-C. Bermond, D. Coudert and H. Rivano* attended the meeting of ACI-SI PRESTO, Paris, July 5.
- *J-C. Bermond, D. Coudert, O. Dalle, N. Morales, P. Musssi, S. Perennes, H. Rivano, J-S. Sereni and M-E. Voge* attended AlgoTel'05, Presqu'ile de Giens, May 11-13.
- *D. Coudert and M. Syska* attended the final review meeting of European project IST FET CRESCCO, Edinbourg, April 4-6.
- *D. Coudert, G. Huiban, J-F. Lalande, H. Rivano and M-E. Voge* attended the TAROT meeting, Paris, March 18-19.
- *D. Coudert and J. Galtier* attended the 3rd Management Committee meeting, European Action COST 293 Graal, Paris, May 27-28.
- *D. Coudert, J. Galtier and R. Klasing* attended the 4rd Management Committee meeting, European Action COST 293 Graal, UPC Barcelone, September 29 to October 1st.
- *D. Coudert, N. Morales, H. Rivano and M-E. Voge* attended the ResCom meeting, Nice, November 9-10.
- *D. Coudert and H. Rivano* attended PaRISTIC, Labri, Bordeaux, November 21-23.
- *D. Coudert, H. Rivano and M. Syska* attended the kickoff meeting of European project IST FET AEOLUS, Athens, Greece, November 28-29.
- *O. Dalle and P. Mussi* attended the VERSIM workshop held at ONERA, Toulouse, May 10, 2005.
- *O. Dalle, P. Mussi and C. Mrabet* attended the FRACTAL workshop held in Grenoble, Nov 28, 2005.
- *A. Jarry* attended the 3rd Workshop COST 295 Dynamo, Paris, France, May 20-21.
- *P. Mussi* attended MobiVIP project review meeting, Nancy, France, Jun. 17, 2005.
- *P. Mussi* attended action meeting, European Action COST 355, Berlin, Germany, Nov 23-25, 2005.
- *H. Rivano* attended the ReCap meeting, Nice, November 8.
- *H. Rivano* attended the FET Infoday, Brussels, February 13th 2005.
- *H. Rivano* attended the COST 295 Dynamo Kick-off meeting, Brussels, February 27th 2005.

9.3.3. Participation in conferences

- *Members of Mascotte* attended JCB'60, Sophia Antipolis, December 8-9.
- *J.-C. Bermond, D. Coudert, F. Havet, S. Pérennes, J.-S. Sereni and S. Thomassé* attended the 7th International Colloquium in Graph Theory (ICGT'05), Hyères, France, September 11-16.
- *J-C. Bermond, D. Coudert, O. Dalle, N. Morales, P. Mussi, H. Rivano, J-S. Sereni and M-E. Voge* attended AlgoTel'05, Presqu'ile de Giens, May 11-13.
- *S. Bessy* attended Graph Theory, workshop in Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, 16-22 January 2005.
- *M. Cosnard* attended IPDPS 2005, Denver, USA
- *M. Cosnard* attended PACT 2005, Saint Louis, USA.
- *D. Coudert* attended ONDM'05, Milano, Italy, February 07-09.
- *D. Coudert and H. Rivano* attended OON'05, Montreal, Canada, April 14-15.
- *D. Coudert, R. Klasing and F. Sarracco* attended SIROCCO 2005, Mont Saint-Michel, France, May 24-26.
- *J. Galtier* attended Performance 2005, Juan-les-Pins, October 3-7 2005.
- *J. Galtier and A. Laugier* attended DRCN 2005, Island of Ishia (Naples), October 16-19 2005.
- *J. Galtier and A. Laugier* attended the 50th anniversary of the Hungarian method, Budapest, October 31st 2005.
- *F. Havet* attended GRACCO 2005, Angra dos Reis, Brazil, April 27-29 2005.
- *F. Havet* attended the Workshop on Fundamental Aspects in Networks Problems, Fortaleza, Brazil, May 1-7 2005.
- *F. Havet, R. Klasing, N. Morales, J.-S. Sereni and S. Thomassé* attended the Journées Graphes et Algorithmes (JGA05), Bordeaux, France, Nov. 3 - 4 2005.
- *F. Havet*: Graph Theory Conference Nyborg, Denmark, December 1-4 2005
- *G. Huiban* attended ICT 2005, Cape Town, South Africa, May 03-06, 2005
- *J.-F. Lalande, A. Laugier, S. Petat and M.E.Voge* attended ROADEF 2005, Tours, France, February 14-15-16 2005.
- *J.-F. Lalande* attended IEEE INFOCOM 2005, March 13-17, Miami, US.
- *P. Mussi* attended ObjectWeb workshop, Grenoble, France, Nov. 28-29, 2005.
- *J.-S. Sereni* attended WG 2005, Metz, France, June 23-25 2005.
- *J.-S. Sereni* attended EuroComb 2005, Berlin, Germany, Sept. 5-9 2005.

9.3.4. Participation in schools

- *D. Coudert, P. Mussi and H. Rivano* attended the 9th summer school Internet Nouvelle Génération, ING 05, Cote d'Opale, June 13-17, 2005.

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