Activity Report 2012

Project-Team RAP

Networks, Algorithms and Probabilities

RESEARCH CENTER
Paris - Rocquencourt

THEME
Networks and Telecommunications

Table of contents

Project-Team RAP

Keywords: Markovian Model, Stochastic Algorithms, Distributed Algorithms, Optical Networks

Creation of the Project-Team: February 01, 2004 .

1. Members

Research Scientists
Nicolas Broutin [Research Associate (CR) Inria]
Christine Fricker [Research Associate (CR) Inria]
Fabrice Guillemin [France Telecom R&D, Lannion]
Philippe Robert [Team Leader, Research Director (DR) Inria, HdR]
James Roberts [Research Director (DR) Inria]

Faculty Members
Hanene Mohamed [Université Paris Ouest Nanterre La Défense]
Danielle Tibi [Université Denis Diderot]

PhD Students
Mathieu Feuillet [Détachement du Corps des Mines]
Emanuele Leoncini [INRA-Inria]
Nada Sbihi [Université Pierre et Marie Curie]

Administrative Assistant
Virginie Collette [(AI) Inria]

2. Overall Objectives

2.1. Overall Objectives

The research team RAP (Networks, Algorithms and Communication Networks) was created in 2004 on the basis of a long standing collaboration between engineers at Orange Labs in Lannion and researchers from Inria Paris — Rocquencourt. The initial objective was to formalize and expand this fruitful collaboration.

At France-Telecom R&D in Lannion, the members of the team are experts in the analytical modeling of communication networks as well as on some of the operational aspects of network management concerning traffic measurements on ADSL networks, for example.

At Inria Paris — Rocquencourt, the members of RAP have a recognized expertise in modeling methodologies applied to stochastic models of communication networks.

RAP also has the objective of developing new fundamental tools to investigate *probabilistic* models of complex communication networks. We believe that mathematical models of complex communication networks require a deep understanding of general results on stochastic processes. The two fundamental domains targeted are:

1. Design and analysis of algorithms for communication networks.
2. Analysis of scaling methods for Markov processes: fluid limits and functional limit theorems.

From the very beginning, it has been decided that RAP would focus on a number of particular issues over a period of three or four years. The general goal of the collaboration with Orange Labs is to develop, analyze and optimize algorithms for communication networks. Two domains are currently investigated in the framework of this collaboration:

1. Design of algorithms to allocate bandwidth in optical networks.
2. Content Centric Networks.

3. Scientific Foundations

3.1. Design and Analysis of Algorithms

Data Structures, Stochastic Algorithms

The general goal of the research in this domain is of designing algorithms to analyze and control the traffic of communication networks. The team is currently involved in the design of algorithms to allocate bandwidth in optical networks and also to allocate resources in content-centric networks. See the corresponding sections below.

The team also pursues analysis of algorithms and data structures in the spirit of the former Algorithms team. The team is especially interested in the ubiquitous divide-and-conquer paradigm and its applications to the design of search trees, and stable collision resolution protocols.

3.2. Scaling of Markov Processes

The growing complexity of communication networks makes it more difficult to apply classical mathematical methods. For a one/two-dimensional Markov process describing the evolution of some network, it is sometimes possible to write down the equilibrium equations and to solve them. The key idea to overcome these difficulties is to consider the system in limit regimes. This list of possible renormalization procedures is, of course, not exhaustive. The advantages of these methods lie in their flexibility to various situations and to the interesting theoretical problems they raised.

A fluid limit scaling is a particularly important means to scale a Markov process. It is related to the first order behavior of the process and, roughly speaking, amounts to a functional law of large numbers for the system considered.

A fluid limit keeps the main characteristics of the initial stochastic process while some second order stochastic fluctuations disappear. In "good" cases, a fluid limit is a deterministic function, obtained as the solution of some ordinary differential equation. As can be expected, the general situation is somewhat more complicated. These ideas of rescaling stochastic processes have emerged recently in the analysis of stochastic networks, to study their ergodicity properties in particular.

3.3. Structure of random networks

This line of research aims at understanding the global structure of stochastic networks (connectivity, magnitude of distances, etc) via models of random graphs. It consists of two complementary foundational and applied aspects of connectivity.

RANDOM GRAPHS, STATISTICAL PHYSICS AND COMBINATORIAL OPTIMIZATION. The connectivity of usual models for networks based on random graphs models (Erdős–Rényi and random geometric graphs) may be tuned by adjusting the average degree. There is a *phase transition* as the average degree approaches one, a *giant* connected component containing a positive proportion of the nodes suddenly appears. The phase of practical interest is the *supercritical* one, when there is at least a giant component, while the theoretical interest lies at the *critical phase*, the break-point just before it appears.

At the critical point there is not yet a macroscopic component and the network consists of a large number of connected component at the mesoscopic scale. From a theoretical point of view, this phase is most interesting since the structure of the clusters there is expected (heuristically) to be *universal*. Understanding this phase and its universality is a great challenge that would impact the knowledge of phase transitions in all high-dimensional models of *statistical physics* and *combinatorial optimization*.

RANDOM GEOMETRIC GRAPHS AND WIRELESS NETWORKS. The level of connection of the network is of course crucial, but the *scalability* imposes that the underlying graph also be *sparse*: trade offs must be made, which required a fine evaluation of the costs/benefits. Various direct and indirect measures of connectivity are crucial to these choices: What is the size of the overwhelming connected component? When does complete connectivity occur? What is the order of magnitude of distances? Are paths to a target easy to find using only local information? Are there simple broadcasting algorithms? Can one put an end to viral infections? How much time for a random crawler to see most of the network?

NAVIGATION AND POINT LOCATION IN RANDOM MESHES. Other applications which are less directly related to networks include the design of improved navigation or point location algorithms in geometric meshes such as the Delaunay triangulation build from random point sets. There the graph model is essentially fixed, but the constraints it imposes raise a number of challenging problems. The aim is to prove performance guarantees for these algorithms which are used in most manipulations of the meshes.

4. New Results

4.1. Algorithms: Bandwidth Allocation in Optical Networks

Participants: Christine Fricker, Philippe Robert, James Roberts.

The development of dynamic optical switching is widely recognized as an essential requirement to meet anticipated growth in Internet traffic. Since September 2009, RAP has investigated the traffic management and performance evaluation issues that are particular to this technology. A first analysis of passive optical networks used for high speed Internet access led to the proposal of an original dynamic bandwidth allocation algorithm and to an evaluation of its traffic capacity. Our activity on optical networking is carried out in collaboration with Orange Labs with whom we have a research contract. We have also established contacts with Alcatel-Lucent Bell Labs and had fruitful exchanges with Iraj Saniee and his team on their proposed time-domain wavelength interleaved networking architecture (TWIN).

We have analyzed the traffic capacity of wavelength division multiplexing (WDM), passive optical networks (PONs) where user stations (optical network units) are equipped with tunable transmitters. For these systems users can use any of the multiple wavelengths to transmit their data but only within the limit determined by the number of transmitters they possess. A mean field approximation is used to estimate the capacity of a limited-gated multiserver polling system with a limit on the number of servers a given station can use simultaneously. The approximation provides an expression for the stability limit under very general assumptions about the traffic process and system configuration.

In 2011, we began work on bandwidth allocation in meshed networks. We have evaluated the TWIN architecture in a metropolitan area network with an original medium access control (MAC) algorithm. This algorithm was inspired by our prior work on access networks and ensures an efficient and fair allocation of bandwidth to flows between network nodes.

The TWIN architecture is not extensible to a wide area for reasons of scalability and the excessive signalling delay between geographically distant nodes. We have therefore invented a new notion of a multipoint-to-multipoint lightpath that avoids these problems. A patent relating to this invention has been granted. This patent is owned by Orange following the terms of our contract with them. The paper [16] describes the invention and its evaluation. A major advantage demonstrated in this paper is the energy saving achieved by the use of the proposed optical technology in place of electronic routers. An extended version of the paper has been accepted for publication in Journal of Optical Communication and Networking [24].

Ongoing research seeks to apply this type of networking solution to data centres, on one hand, and to geographically spread tier-1 Internet carrier networks, on the other. Some of this work is performed in collaboration with Orange Labs under the terms of our research contract. An interesting new development is the application of new coherent optical technology that allows tunable receivers as well as tunable transmitters. We are evaluating the performance of a bandwidth allocation algorithm that exploits this technology.

A wider reaching collaboration has been established under the terms of a Celtic Plus project called SASER. This project was approved by the EU in 2012 and funding has been obtained for our participation from the French authorities. The project kickoff meeting was held in November 2012. Our contribution relates to the use of TWIN to create an extended metropolitan optical network. Our partners in the corresponding work package task are Orange, Telecom Bretagne and the engineering school ENSSAT. Overall reponsibility for the work package (where alternative optical network architectures are also evaluated) is with Alcatel-Lucent Bell Labs.

4.2. Algorithms: Content-Centric Networking

Participants: Mathieu Feuillet, Christine Fricker, Philippe Robert, James Roberts, Nada Sbihi.

RAP is participating in an ANR project named CONNECT which contributes to the definition and evaluation of a new paradigm for the future Internet: a content-centric network (CCN) where, rather than interconnecting remote hosts like IP, the network directly manages the information objects that users publish, retrieve and exchange. CCN has been proposed by Van Jacobson and colleagues at the Palo Alto Research Center (PARC). In CCN, content is divided into packet-size chunks identified by a unique name with a particular hierarchical structure. The name and content can be cryptographically encoded and signed, providing a range of security levels. Packets in CCN carry names rather than addresses and this has a fundamental impact on the way the network works. Security concerns are addressed at the content level, relaxing requirements on hosts and the network. Users no longer need a universally known address, greatly facilitating management of mobility and intermittent connectivity. Content is supplied under receiver control, limiting scope for denial of service attacks and similar abuse. Since chunks are self-certifying, they can be freely replicated, facilitating caching and bringing significant bandwidth economies. CCN applies to both stored content and to content that is dynamically generated, as in a telephone conversation, for example. RAP is contributing to the design of CCN in two main areas:

- the design and evaluation of traffic controls, recognizing that TCP is no longer applicable and queue management will require new, name-based criteria to ensure fairness and to realize service differentiation;
- the design and evaluation of replication and caching strategies that realize an optimal trade-off of expensive bandwidth for cheap memory.

The team also contributes to the development of efficient forwarding strategies and the elaboration of economic arguments that make CCN a viable replacement for IP. CONNECT partners are Alcatel-Lucent (lead), Orange, Inria/RAP, Inria/PLANETE, Telecom ParisTech, UPMC/LIP6.

A paper describing a proposed flow-aware approach for CCN traffic management and its performance evaluation has been presented at the conference Infocom 2012 [20]. We have reviewed the literature on cache performance (dating from early work on computer memory management) and identified a practical and versatile tool for evaluating the hit rate (proportion of requests that are satisfied from the cache) as a function of cache size and the assumed object popularity law. This approximate method was first proposed in 2002 by Che, Tung and Wang for their work on web caching. We applied this approximation to evaluate CCN caching performance taking into account the huge population and diverse popularity characteristics that make other approaches ineffective [19]. The excellent accuracy of this method over a wide range of practically relevant traffic models has been explained mathematically [18]. CONNECT ends in December 2012. We are currently defining a new project proposal that should be submitted to the ANR INFRA call in February 2013.

4.3. Scaling Methods: Fluid Limits in Wireless Networks

Participant: Philippe Robert.

This is a collaboration with Amandine Veber (CMAP, École Polytechnique). The goal is to investigate the stability properties of wireless networks when the bandwidth allocated to a node is proportional to a function of its backlog: if a node of this network has x requests to transmit, then it receives a fraction of the capacity proportional to $\log(1 + x)$, the logarithm of its current load. A fluid scaling analysis of such a network is presented. We have shown that the interaction of several time scales plays an important role in the evolution of such a system, in particular its coordinates may live on very different time and space scales. As a consequence, the associated stochastic processes turn out to have unusual scaling behaviors which give an interesting fairness property to this class of algorithms. A heavy traffic limit theorem for the invariant distribution has also been proved. A generalization to the resource sharing algorithm for which the $\log$ function is replaced by an increasing function.

4.4. Algorithms: Distributed Hash Tables

Participants: Mathieu Feuillet, Philippe Robert.

The Distributed Hash Table (DHTs) consists of a large set of nodes connected through the Internet. Each file contained in the DHT is stored in a small subset of these nodes. Each node breaks down periodically and it is necessary to have back-up mechanisms in order to avoid data loss. A trade-off is necessary between the bandwidth and the memory used for this back-up mechanism and the data loss rate. Back-up mechanisms already exist and have been studied thanks to simulation. To our knowledge, no theoretical study exists on this topic. We modeled this problem thanks to standard queues in order to understand the behavior of a single file and the global dynamic of the system. With a very simple centralized model, we have been able to emphasise a trade-off between capacity and life-time with respect to the duplication rate. From a mathematical point of view, we have been able to study different time scales of the system with an averaging phenomenon. A paper has been submitted on this subject for the case where there are at most two copies of each file [25]. An article for the general case is in preparation. A more sophisticated distributed model with mean field techniques is under investigation.

On the side of this project, we notably studied the distribution of hitting times of the classical Ehrenfest and Engset models by using martingale techniques, furthermore their asymptotic behavior has been analyzed when the size of the system increases to infinity [11].

4.5. Stochastic Modeling of Biological Networks

Participants: Emanuele Leoncini, Philippe Robert.

This is a collaboration with Vincent Fromion from INRA Jouy en Josas, which started on October 2010.

The goal is to propose a mathematical model of the production of proteins in prokaryotes. Proteins are biochemical compounds that play a key role in almost all the cell functions and are crucial for cell survival and for life in general. In bacteria the protein production system has to be capable to produce abut 2500 different types of proteins in different proportions (from few dozens for the replication machinery up to 100000 for certain key metabolic enzymes). Bacteria uses more than the 85% of their resources to the protein production, making it the most relevant process in these organisms. Moreover this production system must meet two opposing problems: on one side it must provide a minimal quantity for each protein type in order to ensure the smooth-running of the cell, on the other side an “overproduction policy” for all the proteins is infeasible, since this would impact the global performance of the system and of the bacterium itself.

Gene expression is intrinsically a stochastic process: gene activation/deactivation occurs by means the encounter of polymerase/repressor with the specific gene, moreover many molecules that take part in the protein production act at extremely low concentrations. We have restated mathematically the classical model using Poisson point processes (PPP). This representation, well-known in the field of queueing networks but, as far as we know, new in the gene expression modeling, allowed us to weaken few hypothesis of the existing models, in particular the Poisson hypothesis, which is well-suited in some cases, but that, in some situations, is far from the biological reality as we consider for instance the protein assemblage. See [12].

The theoretical environment of Poisson point processes has lead us to propose a new model of gene expression which captures on one side the main mechanisms of the gene expression and on the other side it tries to consider hypothesis that are more significant from a biological viewpoint. In particular we have modeled: gene activation/deactivation, mRNA production and degradation, ribosome attachment on mRNA, protein elongation and degradation. We have shown how the probability distribution of the protein production and the protein lifetime may have a significant impact on the fluctuations of the number of proteins. We have obtained analytic formulas when the duration of protein assemblage and degradation follows a general probability distribution, i.e. without the Poisson hypothesis. In particular, by using a PPP representation we have been able to include the deterministic continuous phenomenon of protein degradation, which is the main protein degradation mechanism for stable proteins. We have showed moreover that this more realistic description is surprisingly identical in distribution with the classic assumption of protein degradation by means of a degrading protein (*proteosome*). We have used our model also to compare the variances resulting by choosing different hypotheses for the probability elongation, in particular we have hypothesize the protein assembly to be deterministic. This assumption is justified because of the elongation step, which consists of a large number of elementary steps, can be described by the sum of exponential steps and the resulting distribution is well approximated by a Gaussian distribution because of the central limit theorem. Under the hypothesis of small variance of the resulting Gaussian distribution, we can assume the elongation step to be deterministic. The model has showed how, under the previous hypothesis, the variance on the number of proteins is bigger than the classical model with the Poisson hypothesis.

We have developed a C++ stochastic simulator for our general model, which has allowed the computation of variance when it was not possible to derive explicit analytic close formulas and the simulation of some extension of the actual model.

4.6. Stochastic Networks: Large Bike Sharing Systems

Participants: Christine Fricker, Hanene Mohamed, Danielle Tibi.

This is a collaboration with Nicolas Gast (EPFL) starting in December 2010. Bike sharing systems were launched by numerous cities as a part of urban transportation, for example Velib in 2007 (20 000 bikes, 1 500 stations). One of the major issues is the availability of the resources: bikes or free slots. These systems become a hot topic in Operation Research but studies on these stochastic networks are very few. To our knowledge, no theoretical study of such bike sharing systems exist taking into account the limited capacity of the stations.

We modeled this system in a symmetric case. Mean field limit gives the dynamic of a large system and the limiting stationary behavior of a single station as the system gets large. Analytical results are obtained and convergence proved in the standard model via Lyapounov functions. It allows to find the best ratio of bikes par station and to measure the improvement of incentive mechanisms, as choosing among two stations for example. Redistribution by trucks is also investigated. See [26].

Further results have been obtained for some heterogeneous systems. By mean field techniques, analytical results are obtained with Hanene Mohamed for systems with clusters (see [17]).

In a work in progress with *Danielle Tibi* , a more direct method is used when the network has a product form invariant measure by central and local limit theorem. It is a way to prove in this case the equivalence of ensembles, known in physic statistics. It applies to the simplest non homogeneous model. It gives a way to generalize the cluster case.

4.7. Random Graphs

Participant: Nicolas Broutin.

4.7.1. Connectivity in models of wireless networks

This is joint work with S. Boucheron (Paris 7), L. Devroye (McGill), N. Fraiman (McGill), and G. Lugosi (Pompeu Fabra).

The traditional models for wireless networks rely on geometric random graphs. However, if one wants to ensure that the graph be fully connected the radius of influence (hence the power necessary, and number of links) is too large to be fully scalable. Recently some models have been proposed that skim the neighbours and only retain a random subset for each node, hence creating a sparser overlay that would hopefully be more scalable. The first results on the size of the subsets which guarantee connectivity of overlay (the irrigation graph) [3] confirm that the average number of links per node is much smaller, but it remains large. These results motivate further investigations on the size of the largest connected component when one enforces a constant average degree which are in the process of being written.

4.7.2. Random graphs and minimum spanning trees

This is a long term collaboration with L. Addario-Berry (McGill), C. Goldschmidt (Oxford) and G. Miermont (ENS Lyon).

The random graph of Erdős and Rényi is one of the most studied models of random networks. Among the different ranges of density of edges, the "critical window" is the most interesting, both for its applications to the physics of phase transitions and its applications to combinatorial optimization (minimum spanning tree, constraint satisfaction problems). One of the major questions consists in determining the distribution of distances between the nodes. A limit object (a scaling limit) has been identified, that allows to describe precisely the first order asymptotics of pairwise distances between the nodes. This limit object is a random metric space whose definition allows to exhibit a strong connection between random graphs and the continuum random tree of Aldous. A variety of questions like the diameter, the size of cycles, etc, may be answered immediately by reading them on the limit metric space [2].

In a stochastic context, the minimum spanning tree is tightly connected to random graphs via Kruskal's algorithm. Random minimum spanning trees have attracted much research because of their importance in combinatorial optimization and statistical physics; however, until now, only parameters that can be grasped by local arguments had been studied. The scaling limit of the random graphs obtained in [2] permits to describe precisely the metric space scaling limit of a random minimum spanning tree [21], which identifies a novel continuum random tree which is truly different from that of Aldous.

4.7.3. Analysis of recursive partitions

This is joint work with R. Neininger (Frankfurt) and H. Sulzbach (Frankfurt/McGill).

The quadtrees are essential data structures that permit to store and manipulate geometric data by building a recursive partition of the space. In order to evaluate their performance, Flajolet and his co-authors have estimated the average cost of reporting all the data matching certain random queries. When the query does not fully specify all the fields, one talk about a partial match query. Such queries are ubiquitous, but analyzing their behaviour turns out to be intricate, and no performance guarantee was available in the form of a bound on the probability that any query would take much more time that one expects. [14] provides such guarantees by analysing the behaviour of all the queries at the same time, as a process. This yields estimates for the cost of the worst possible query (not a uniformly random one), as well as asymptotics for the variance and higher moments.

This line of research has motivated the analysis of the related combinatorial model of recursive lamination of the disk. The model had been recently introduced, but no full analysis was available. The techniques developed in the context of quadtrees have inspired a proof that the dual tree of the recursive lamination does converge to a limit tree-like metric space which is identified [23].

4.7.4. Navigation and point location in Poisson Delaunay triangulation

Nicolas Broutin has recently initiated a project with O. Devillers (Inria Sophia) and R. Hemsley (Inria Sophia) concerning the performance of local routing algorithms in plane subdivisions. Such algorithms also turn out to be important for the *point location* problem: for instance, finding the face of the subdivision which contains a query point is the first step towards inserting this point as a vertex. The aim is to prove that when the subdivision consists of the faces of a Delaunay triangulation, and when the points are random, any natural strategy which would take you closer to the aim performs well. Preliminary results about a specific routing algorithm, the cone walk, that we designed for its amenability to analysis appear in [22].

4.8. Stochastic Networks: Jackson Networks

Participant: Danielle Tibi.

Lyapounov functions and essential spectral radius of Jackson networks, joint work with I. Ignatiouk-Robert (University of Cergy-Pontoise). A family of explicit multiplicative Lyapounov functions is constructed for any stable Jackson network. Optimizing the multiplicative factor over this family provides an upper bound for the essential spectral radius of the associated Markov process. For some particular classes of Jackson networks, this upper bound coincides with a lower bound derived from large deviations arguments, thus providing the exact value of the essential spectral radius. The main example is given by Jackson networks with routing matrix having a tree structure (in the sense that for any node i, at most one other node can route its customers to i). The result also holds for other types of routing matrices (e.g. completely symmetrical), under some conditions over the different arrival and service rates. See [27].

5. Bilateral Contracts and Grants with Industry

5.1. Contracts

- CRE with Orange Labs “ Dynamical Optical Networking in the Internet”. Contract on bandwidth allocation algorithm in optical networks. Duration 2 years starting from 01/01/12.
- CELTIC-Plus Saser “Safe and Secure European Routing” submitted. RAP participates in the section on optical networks. Participants include Orange labs, Alcaltel-Lucent, Telecom Institute, ENSSAT as well as a number of German laboratories. Duration three years.
- ANR Project “CONNECT: Content-Oriented Networking: a New Experience for Content Transfer”. The proposal submitted to the VERSO programme has been accepted. The planned starting date is January 2011 and the project is scheduled to last 2 years. The lead partner is Alcatel-Lucent Bell Labs France and the other partners are RAP, Inria/PLANETE, Orange LAbs, TelecomParisTech, UPMC.
- The ANR Boole contract (Models for random Boolean functions and applications) has been transferred from the Algorithms project, and the funding will last until August 2013.
- PhD grant CJS (Contrat Jeune Scientifique) Frontières du vivant of INRA for Emanuele Leoncini.

5.2. Bilateral Grants

- A bilateral project PHC Tournesol funded by Campus France (formerly Egide) will cover the costs of exchanges between *Nicolas Broutin* and Stefan Langerman (FNRS, UL Brussels). The topic of the collaboration is coloration of random hypergraphs for channel assignment in networks.

6. Partnerships and Cooperations

6.1. International Research Visitors

RAP team has received the following people:

- Louigi Addario-Berry (McGill)
- Vida Dujmovic (Carleton)
- Matthieu Jonckheere (CONICET, Buenos Aires, Argentina)
- Liudmila Rozanova (CNR — IIT, University of Pisa)
- Iraj Saniée (Alcatel-Lucent Bell Labs)
- Hamed Amini (EPFL)
- Christina Goldschmidt (Oxford)
- Ross Kang (CWI)
- Stefan Langerman (UL Bruxelles)
- Henning Sulzbach (Frankfurt)

6.2. National Research Visitors

RAP team has received the following people:

- Bernard Arzur (Orange Labs)
- Thomas Bonald (Telecom ParisTech, Paris)
- Emilie Coupechoux (Inria, TREC)
- Davide Cuda (Orange Labs)
- Fabrice Guillemin (Orange Labs)
- Raluca Indre (Orange Labs)
- Esther le Rouzic (Orange Labs)
- Patrick Loiseau (Eurecom)

7. Dissemination

7.1. Leadership within scientific community

Nicolas Broutin organized a workshop on Models of Sparse Random Graphs and Network Algorithms that was held at the Banff International Research Station, Canada, in February. He organized a session on "probability and statistics on graphs" at the XII Latin American Congress on Probability and Mathematical Statistics (CLAPEM), Vina del Mar, Chile. He has been co-organizer and co-chair of the program committee for the international meeting on Analysis of Algorithms that took place at the CRM in Montreal in June 2012.

Christine Fricker is member of the jury of agrégation.

Philippe Robert is Associate Editor of the Book Series "Mathématiques et Applications" edited by Springer Verlag and Associate Editor of the journal "Queueing Systems, Theory and Applications". He is member of the scientific council of EURANDOM. He is also associate Professor at the École Polytechnique in the department of applied mathematics where he is in charge of lectures on mathematical modeling of networks. He has been a member of the technical programme committee of the conference ICCCN (2012).

James Roberts is a Fellow (membre émérite) of the SEE. In 2012, he has been a member of the technical programme committee of the following conferences: NOMEN, CoNext, ITC.

7.2. Teaching

Nicolas Broutin has taught at the Master Parisien de Recherche en Informatique (MPRI), in the course 2.15 on Analysis of Algorithms. He also gave a series of tutorials on the continuum random tree at the Adama summer school in Mahdia, Tunisia.

Mathieu Feuillet is teaching assistant for the course "Traffic, Queueing and Networks" given by Thomas Bonald at Telecom ParisTech. He defended his PhD thesis intitled *Bandwidth allocation in large stochastic networs*. He received the Gilles Kahn Award for his thesis.

Emanuele Leoncini is teaching assistant at the University PIerre et Marie Curie.

Philippe Robert gives Master2 lectures in the laboratory of the Probability of the University of Paris VI. He is also giving lectures in the "Programme d'approfondissement de Mathématiques Appliquées et d'Informatique" on Networks and Algorithms at the École Polytechnique. He was a reviewer of the PhD document of S. Malik (UPMC) and P. Keller (Universität Potsdam).

James Roberts was reviewer for the thesis defense of Massimo Gallo (EDITE), Addisu Tadesse Eshete (NTNU, Norway), Pedro Aranda (U. Paderborn, Germany); he was committee member for the HDR of Mai Trang Nguyen (EDITE). He was member of the appointment committee at KTH (Sweden) for the promotion to Assistant Professor of G. Dan.

7.3. Conference and workshop committees, invited conferences

Nicolas Broutin has given lectures at the annual meeting of ANR Boole, the A3 congress at the CIRM, and the invited session on "spatial stochastic models" at the World Congress in Probability and Statistics. He has presented his results at the Probability seminar at McGill, the Séminaire Combinatoire Philippe Flajolet at IHP, and the Algo lunch at UL in Brussels. He has been invited talk at the Oberwolfach Meeting on "scaling limits for models of statistical physics". *Nicolas Broutin* has participated to workshops on "probabilistic combinatorics" at McGill Bellair's intitute, and on "interaction stochastic/computational geometry" organized in Cluny by the ANR Presage. He has visited the computer science department of UL in Brussels. *Nicolas Broutin* has submitted his HDR, the defense will take place in January 2013.

Mathieu Feuillet gave a talk at the conference ALEA 2012 in Marseille (March 2012).

Christine Fricker gave a talk at the conference AofA in Montreal (June 18 2012).

Emanuele Leoncini gave a talk in the RAP team seminar at Inria Rocquencourt (November 2012), an invited talk at the CMAP at Ecole Polytechnique (November 2012). *Mathieu Feuillet* and *Emanuele Leoncini* are in the organizing committee of the "Junior Seminar" at Inria Rocquencourt. *Emanuele Leoncini* participated to the "Journés ALÉA 2012" (March 2012) at CIRM in Marseilles.

James Roberts gave invited talks at Technicolor (April), BCAM Bilbao (June), ATT Labs (Sept), Bell Labs Murray Hill (Sept), KTH Stockholm (Oct), NTNU (Nov). He presented papers at NOMEN 2012 (March) and ITC (Sept).

Philippe Robert gave a set of 5 lectures at BCAM (Bilbao) on fluid limits (January 2012) and a talk at the ICERM, Brown University, Providence (October 2012).

Nada Sbihi presented a paper at Infocom (March).

8. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] M. FEUILLET. *Allocation de bande passante dans les grands réseaux stochastiques*, Ecole Polytechnique X, July 2012, http://hal.inria.fr/pastel-00717671.

Articles in International Peer-Reviewed Journals

[2] L. ADDARIO-BERRY, N. BROUTIN, C. GOLDSCHMIDT. *The continuum limit of critical random graphs*, in "Probability Theory and Related Fields", 2012, vol. 152, p. 367–406, http://dx.doi.org/10.1007/s00440-010-0325-4.

[3] N. BROUTIN, L. DEVROYE, N. FRAIMAN, G. LUGOSI. *Connectivity threshold of Bluetooth graphs*, in "Random Structures and Algorithms", 2012, (21 pages) to appear.

[4] N. BROUTIN, O. FAWZI. *Longest distance in random circuits*, in "Combinatorics, Probability & Computing", 2012, vol. 21, p. 856–881.

[5] N. BROUTIN, P. FLAJOLET. *The distribution of the height and diameter in random non-plane binary trees*, in "Random Structures & Algorithms", 2012, vol. 41, p. 215–252.

[6] N. BROUTIN, C. HOLMGREN. *The total path length of split trees*, in "The Annals of Applied Probability", 2012, vol. 22, 1745—1777.

[7] N. BROUTIN, J.-F. MARCKERT. *Asymptotic of trees with a prescribed degree sequence and applications*, in "Random Structures and Algorithms", 2012, (26 pages) to appear.

[8] N. BROUTIN, R. NEININGER, H. SULZBACH. *A limit process for partial match queries in random quadtrees and 2-d trees*, in "The Annals of Applied Probability", 2012, (30 pages) to appear.

[9] E. COFFMAN, P. ROBERT, F. SIMATOS, S. TARUMI, G. ZUSSMAN. *A performance analysis of channel fragmentation in dynamic spectrum access systems*, in "Queueing Systems, Theory and Applications", 2012, vol. 71, n^{o} 3, p. 293–320, http://www.springerlink.com/content/gv07032073277n06/fulltext.pdf.

[10] M. FEUILLET. *On the flow-level stability of data networks without congestion control: the case of linear networks and upstream trees*, in "Queueing Systems", February 2012, vol. 70, n^{o} 2, p. 105-143 [*DOI :* 10.1007/s11134-011-9265-7], http://hal.inria.fr/hal-00660115.

[11] M. FEUILLET, P. ROBERT. *On the Transient Behavior of Ehrenfest and Engset Processes*, in "Advances in Applied Probability", 2012, vol. 44, n^{o} 2, p. 792–826, http://arxiv.org/abs/1108.6228.

[12] V. FROMION, E. LEONCINI, P. ROBERT. *Stochastic Gene Expression in Cells: A Point Process Approach*, in "SIAM Journal on Applied Mathematics", June 2012, To Appear, http://arxiv.org/abs/1206.0362.

[13] N. LITVAK, P. ROBERT. *A Scaling analysis of a Cat and Mouse Markov chain*, in "Annals of Applied Probability", 2012, vol. 22, n^{o} 2, p. 792–826, http://arxiv.org/abs/0905.2259.

International Conferences with Proceedings

[14] N. BROUTIN, R. NEININGER, H. SULZBACH. *Partial match queries in random quadtrees*, in "Proceedings of the ACM-SIAM Symposium on Discrete Algorithms (SODA)", Y. RABANI (editor), 2012, p. 1056–1065.

[15] Y. CHABCHOUB, C. FRICKER, P. ROBERT. *Improving the detection of On-line Vertical Port Scan in IP Traffic*, in "IEEE 7th International Conference on Risks and Security of Internet and Systems", Cork, Ireland, IEEE Communications Society, October 2012.

[16] D. CUDA, R.-M. INDRE, E. LE ROUZIC, J. ROBERTS. *Dynamic bandwidth allocation for all-optical wide-area networks*, in "AlgoTel 2012 : 14èmes Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications", La Grande Motte, France, April 2012, p. 1-4, http://hal.inria.fr/hal-00690596.

[17] C. FRICKER, N. GAST, H. MOHAMED. *Mean field analysis for inhomogeneous large bike-sharing systems*, in "Proceedings of the DMTCS Conference", 2012, p. 365-376.

[18] C. FRICKER, P. ROBERT, J. ROBERTS. *A versatile and accurate approximation for cache performance*, in "24th International Teletraffic Congress", Kraków, IEEE Communications Society, September 2012, http://arxiv.org/abs/1202.3974.

[19] C. FRICKER, P. ROBERT, J. ROBERTS, N. SBIHI. *Impact of traffic mix on caching performance in a content-centric network*, in "IEEE NOMEN, Workshop on Emerging Design Choices in Name-Oriented Networking", Orlando, USA, March 2012, http://arxiv.org/abs/1202.0108.

[20] S. OUESLATI, J. ROBERTS, N. SBIHI. *Flow-Aware traffic control for a content-centric network*, in "Proc of IEEE Infocom 2012", 2012.

Other Publications

[21] L. ADDARIO-BERRY, N. BROUTIN, C. GOLDSCHMIDT, G. MIERMONT. *The scaling limit of the minimum spanning tree of a complete graph*, 2012, Submitted (55 pages).

[22] N. BROUTIN, O. DEVILLERS, R. HEMSLEY. *A cone can help you find your way in a Poisson Delaunay triangulation*, 2012, Submitted.

[23] N. BROUTIN, H. SULZBACH. *The dual tree of a recursive triangulation of the disk*, 2012, arXiv:1211.1343 [math.PR].

[24] D. CUDA, R.-M. INDRE, E. LE ROUZIC, J. ROBERTS. *Getting routers out of the core: Building an optical wide area network with "multipaths"*, 2012, http://arxiv.org/abs/1110.1245.

[25] M. FEUILLET, P. ROBERT. *A Scaling Analysis of a Transient Stochastic Network*, 2012, Preprint.

[26] C. FRICKER, N. GAST. *Incentives and regulations in bike-sharing systems with stations of finite capacity*, January 05 2012, http://arxiv.org/abs/1201.1178.

[27] I. IGNATIOUK-ROBERT, D. TIBI. *Explicit Lyapunov functions and estimates of the essential spectral radius for Jackson networks*, 2012, Preprint, http://arxiv.org/abs/1206.3066.

[28] P. ROBERT, A. VEBER. *On the Fluid Limits of a Resource Sharing Algorithm with Logarithmic Weights*, November 2012, http://arxiv.org/abs/1211.5968.