Activity Report 2015

Project-Team RAP

Networks, Algorithms and Probabilities

RESEARCH CENTER
Paris - Rocquencourt

THEME
Networks and Telecommunications

Table of contents

Project-Team RAP

Creation of the Project-Team: 2004 February 01

Keywords:

Computer Science and Digital Science:

1.3. - Distributed Systems
6.1.2. - Stochastic Modeling (SPDE, SDE)
6.1.4. - Multiscale modeling
7.10. - Network science

Other Research Topics and Application Domains:

1.1. - Biology
1.1.10. - Mathematical biology
1.1.2. - Molecular biology
6. - IT and telecom
6.5. - Information systems

1. Members

Research Scientists

Philippe Robert [Team leader, Inria, Senior Researcher, HdR]
Nicolas Broutin [Inria, Researcher, HdR]
Christine Fricker [Inria, Researcher]

PhD Students

Renaud Dessalles [INRA]
Sarah Eugene [Inria, granted by FP7 BANGMD-ERCSKIPPERAD project]
Wen Sun [Inria]
Guilherme Thompson [Inria,granted by Brazilian Grant]

Administrative Assistant

Nelly Maloisel [Inria]

Others

Plinio Santini Dester [Inria, Intern, from Apr 2015 until Jul 2015]
Yousra Chabchoub [ISEP, Associate Professor]
Hanene Mohamed [Univ. Paris X, Associate Professor]

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 Labsin Lannion and researchers from Inria Paris — Rocquencourt. The initial objective was to formalize and expand this fruitful collaboration.

At Orange Labsin 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. The design of algorithms to allocate resources in large distributed systems is currently investigated in the framework of this collaboration:

3. Research Program

3.1. 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.

3.2. 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 large distributed 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.

3.3. 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. Random Graphs

Participant: Nicolas Broutin.

And/Or trees for random Boolean functions

For some time, a number of teams have tried to devise natural probability distributions on Boolean functions. Indeed, the most natural one, the uniform one, is not quite satisfactory: almost all Boolean functions have maximal complexity, while it is extremely difficult to construct some with high complexity. One approach consists in generating functions by seeing them as "expressions" encoded as a tree of computation. We generalize and unify the previous approaches that are restricted to very specific cases by looking at the distributions induced on the Boolean function by large computation trees that are arbitrary, except for the fact they the neighborhoods of the root (where the computation concentrates) stabilizes in distribution as the sizes of the tree increases [12].

4.2. Resource Allocation in Large Data Centres

Participants: Christine Fricker, Philippe Robert, Guilherme Thompson.

With the exponential increase in internet data transmission volume over the past years, efficient bandwidth allocation in large data centres has become crucial. Illustrating examples are the rapid spread of cloud computing technology, as well as the growth of the demand for video streaming, both of which were quasi non-existent 10 years ago.

Currently, most systems operate under decentralised policies due to the complexity of managing data exchange on large scales. In such systems, customer demands are served respecting their initial service requirements (a certain video quality, amount of memory or processing power etc.) until the system reaches saturation, which then leads to the blockage of subsequent customer demands. Strategies that rely on the scheduling of tasks are often not suitable to address this load balancing problem as the users expect instantaneous service usage in real time applications, such as video transmission and elastic computation. Our research goal is to understand and redesign its algorithms in order to develop decentralised policies that can improve global performance using local instantaneous information. This research is made in collaboration with Fabrice Guillemin, from Orange Labs.

In a first approach to this problem, we examined offloading schemes in fog computing context, where one data centres are installed at the edge of the network. We analyse the case with one data centre close to user which is backed up by a central (bigger) data centre. When a request arrives at an overloaded data centre, it is forwarded to the other data centre with a given probability, in order to help coping with saturation and reducing the rejection of requests. In [16], we have been able to show that the performance of such a system can be expressed in terms of the invariant distribution of a random walk in the quarter plane. As a consequence we have been able to assess the behaviour and performance of these systems, proving the effectiveness of such an offloading arrangement.

In a second step, we investigated allocation schemes which consist in reducing the bandwidth of arriving requests to a minimal value when the system is close to saturation. We analysed the effectiveness of such a downgrading policy, which, if the system is correctly designed, will reduce the fraction of rejected transmissions. We developed a mathematical model which allows us to predict system behaviour under such a policy and calculate the ideal threshold (in the same scale as the resource) after which downgrading should be initiated, given system parameters. We proved the existence of a unique equilibrium point, around which we have been able to determine the probability of the system being above or under the threshold. We found that system blockage can be almost surely eliminated. This policy finds a natural application in the context of video streaming services and other real time applications, such as MPEG-DASH. A document is being written to further publication.

Finally, with those results, we now try to extend our research towards more complex systems, investigating the behaviour of multiple resource systems (such as a Cloud environment, where computational power is provided using unities of CPU and GB of RAM) and other offloading schemes, such as the compulsory forwarding of a request when it's blocked at the edge server, but keeping a trunk reservation to protect the service originally assigned to the big data centre.

4.3. Resource allocation in vehicle sharing systems

Participants: Christine Fricker, Plinio Santini Dester, Hanene Mohamed, Yousra Chabchoub.

This is a collaboration with Danielle Tibi, Université Denis Diderot.

Vehicle sharing systems are becoming an urban mode of transportation, and launched in many cities, as Velib' and Autolib' in Paris. One of the major issues is the avail ability of the resources: vehicles or free slots to return them. These systems became a hot topic in Operation Research and now the importance of stochasticity on the system behavior is commonly admitted. The problem is to understand the system behavior and how to manage these systems in order to provide both resources to users. Our stochastic model is the first one taking into account the finite number of spots at the stations.

With Danielle Tibi, we use limit local theorems to obtain the asymptotic stationary joint distributions of several station states when the system is large (both numbers of stations and bikes), in the case of finite capacities of the stations. This gives an asymptotic independence property for node states. This widely extends the existing results on heterogeneous bike-sharing systems.

Recently we investigate some network load balancing algorithms to improve the bike sharing system behavior. We focus on the choice of the least loaded station among two t o return the bike. A problem is the influence of the delay between the choice time (the beginning of the trip) and the time the station is joined (the end of the trip). However the main challenge is to deal with the choice between two neighboring stations. For that, a system of infinite queues is studied in light traffic. For a bike-shar ing homogeneous model, we restrict our study to a deterministic cooperation of two by two stations. It relies on new results for the classical system of two queues under the join-the-shortest-queue policy.

JC Decaux provides us data describing Velib' user trips. These data are useful to measure the system parameters, validate our models and test our algorithms. Indeed, we use these data to investigate load balancing algorithms such as two-choice policies.

4.4. Scaling Methods

Participants: Philippe Robert, Wen Sun.

4.4.1. Fluid Limits in Wireless Networks

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. This year we completed the analysis of a star network topology with multiple nodes. Several scalings were used to describe the fluid limit behaviour.

4.4.2. The Time Scales of a Transient Network

A large distributed system where users' files are duplicated on unreliable data servers is investigated. Due to a server breakdown, a copy of a file can be lost, it can be retrieved if another copy of the same file is stored on other servers. In the case where no other copy of a given file is present in the network, it is definitely lost. In order to have multiple copies of a given file, it is assumed that each server can devote a fraction of its processing capacity to duplicate files on other servers to enhance the durability of the system.

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. 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 are currently studying different time scales of the system with an averaging phenomenon.

We have used scaling methods with different time scales to derive some asymptotic results on the decay of a simplified network: it is assumed that any copy of a given file is lost at some fixed rate and the total processing capacity of the system is devoted to duplicate the file with least number of copies. We start from the optimal initial state: each file has the maximum number of copies. Due to random losses, the state of the network is transient and all files will be eventually lost. There is a stability assumption for the system having a critical time scale of decay. When the stability condition is not satisfied, i.e. when it is initially overloaded, we have shown that the state of the network converges to an interesting local equilibrium. We are currently studying a more general case which the duplication depends on the structure of the system. See [7].

4.5. Stochastic Models of Biological Networks

Participants: Renaud Dessalles, Sarah Eugene, Philippe Robert.

4.5.1. Stochastic Modelling of self-regulation in the protein production system of bacteria

This is a collaboration with Vincent Fromion from INRA Jouy-en-Josas, which started on December 2014.

In prokaryotic cells (e.g. E. Coli. or B. Subtilis) the protein production system has to produce in a cell cycle (i.e. less than one hour) more than 10^6 molecules of more than 2500 kinds, each having different level of expression. The bacteria uses more than 85% of its resources to the protein production. Gene expression is a highly stochastic process: bacteria sharing the same genome, in a same environment will not produce exactly the same amount of a given protein. Some of this stochasticity can be due to the system of production itself: molecules, that take part in the production process, move freely into the cytoplasm and therefore reach any target in the cell after some random time; some of them are present in so much limited amount that none of them can be available for a certain time; the gene can be deactivated by repressors for a certain time, etc. We study the integration of several mechanisms of regulation and their performances in terms of variance and distribution. As all molecules tends to move freely into the cytoplasm, it is assumed that the encounter time between a given entity and its target is exponentially distributed.

4.5.1.1. Feedback model

We have also investigated the production of a single protein, with the transcription and the translation steps, but we also introduced a direct feedback on it: the protein tends to bind on the promoter of its own gene, blocking therefore the transcription. The protein remains on it during an exponential time until its detachment caused by thermal agitation.

The mathematical analysis aims at understanding the nature of the internal noise of the system and to quantify it. We tend to test the hypothesis usually made that such feedback permits a noise reduction of protein distribution compared to the “open loop” model. We have made the mathematical analysis of the model (using a scaling to be able to have explicit results), it appeared that reduction of variance compared to an “open loop” model is limited: the variance cannot be reduced for more than 50%.

We proposed another possible effect of the feedback loop: the return to equilibrium is faster in the case of a feedback model compared to the open loop model. Such behaviour can be beneficial for the bacteria to change of command for a new level of production of a particular protein (due, for example, to a radical change in the environment) by reducing the respond time to reach this new average. This study has been mainly performed by simulation and it has been shown that the feedback model can go 50% faster than the open loop results. See [13]..

4.5.1.2. Transcription-translation model for all proteins

The other model that has been studied integrates the production of all the proteins. Each gene has to be transcribed in mRNA (using RNA-Polymerase molecules) and each mRNA has to be translated in protein (using ribosome molecules). Experiments (as the one from Taniguchi et al. (2010)) have shown that protein production is subject to high variability especially for highly expressed proteins. Our goal is to determine what in the protein production mechanism is responsible for the noise.

We already made simulations that takes into amount of RNA-Polymerases and Ribosomes and that genes and mRNAs sequester these molecules during the whole the time of elongation. This global sharing of Ribosomes/RNA-Polymerases reproduce only a part of the unknown noise experimentally seen. We are developing Python simulations that extends this model and take into account other feature that might be responsible for the noise in protein production. This new simulation will include new features such as:

- The volume of the cell. We consider it as proportional to the total number of proteins, and will increase as the cell grows. Transcription and translation initiation are then depending on the concentration of respectively free RNA-polymerase and free ribosomes.
- The division of the cell. At division, all components have an equal chance to go in either one of the two daughter cell.
- DNA replication. At some point in the cell cycle, the genome duplicates, doubling therefore the copy number of each gene

The simulation parameters will be fit with the data of Taniguchi et al. (2010) and the goal is to compare our result to see if which aspects of the protein production are responsible for the noise of the proteins.

4.5.2. Stochastic Modelling of Protein Polymerization

This is a collaboration with Marie Doumic, Inria MAMBA team.

The first part of our work focuses on the study of the polymerization of protein. This phenomenon is involved in many neurodegenerative diseases such as Alzheimer's and Prion diseases, e.g. mad cow. In this context, it consists in the abnormal aggregation of proteins. Curves obtained by measuring the quantity of polymers formed in in vitro experiments are sigmoids: a long lag phase with almost no polymers followed by a fast consumption of all monomers. Furthermore, repeating the experiment under the same initial conditions leads to somewhat identical curves up to translation. After having proposed a simple model to explain this fluctuations, we studied a more sophisticated model, closer to the reality. We added a conformation step: before being able to polymere, proteins have to misfold. This step is very quick and remains at equilibrium during the whole process. Nevertheless, this equilibrium depends on the polymerization which is happening on a slower time scale. The analysis of these models involves stochastic averaging principles.

The second part concerns the study of telomeres. This work is made in collaboration with Zhou Xu, Teresa Teixeira, from IBCP in Paris.
In eukaryotic cells, at each mitosis, chromosomes are shortened, because the DNA polymerase is not able to duplicate one ending of the chromosome. To prevent loss of genetic information- which could be catastrophic for the cell-chromosomes are equipped with telomeres at their endings. These telomeres do not contain any genetic information; they are a repetition of the sequence T-T-A-G-G-G thousands times. At each mitosis, there is therefore a loss of telomere. As it has a finite length, when the telomeres are too short, the cell cannot divide anymore: they enter in replicative senescence. Our model tries to captures the two phases of the shortening of telomeres: first, the initial state of the cells, when the telomerase is still active to repair the telomeres. Second, when the telomerase is inhibited, we try to estimate the senescence threshold, when the replication of the cells stops.

5. Bilateral Contracts and Grants with Industry

5.1. Bilateral Contracts with Industry

- Contrat de recherche externalisé avec ORANGE SA "Scheduling Global OS”. Duration three years 2014-2016.
- *Christine Fricker* is the leader of PGMO project “Systèmes de véhicules en libre-service: Modélisation, Analyse et Optimisation” with G-Scop (CNRS lab, Grenoble) and Ifsttar. From 1 to 3 years. From 1/10/2013 to 30/9/2016.
- PhD grant CJS (Contrat Jeune Scientifique) Frontières du vivant of INRA for Renaud Dessalles.
- PhD grant from Fondation Sciences Mathématiques de Paris for Wen Sun.
- PhD grant from Brazilian Government for Guilherme Thompson.

6. Partnerships and Cooperations

6.1. International Initiatives

6.1.1. Inria Associate Teams not involved in an Inria International Labs

6.1.1.1. RNA

An Associate Team between RAP and McGill university provides funding for a project on the theoretical and applied aspects of connectivity in random networks. The co-funding at McGill financed by the via the CARP FQRNT team grant of L. Addario-Berry, L. Devroye and B. Reed (2013-2015)

The bilateral project PHD Procope funded by Campus France (formerly Egide) obtained in 2014 jointly between the LIX at Ecole Polytechnique (PI Marie Albenque) and the Mathematics institute of Frankfurt's university is still running for 2015. The team RAP is associated to the LIX for this contract.

Title: Connectivity and distances in models of random networks and applications

International Partner (Institution - Laboratory - Researcher):

Start year: 2013

See also: http://algo.inria.fr/broutin/aap-rna.html

The projet will shed some new light on two complementary aspects of connectivity and the structure of distances in models of random networks. - We will first explore the nature and universality of phase transition and critical phenomena in random graphs, and more generally for high-dimensional percolation systems. Phase transitions are crucial in statistical physics, but also in the theory of computing where one observes that constraints satisfaction problem exhibit such a sudden change whose understanding is believed to yield important information about hardness of computation. - We will also investigate the connectivity of geometric models of random graphs which are at the core of modelling of wireless networks. In particular we will focus on some global aspects such as the quantification of connectivity, sparsity, and the behavior of diffusion algorithms. We will also design of distributed algorithms to initiate the network which guarantee efficiency and scalability.

6.2. International Research Visitors

6.2.1. Visits of International Scientists

- Louigi Addario-Berry (McGill)
- Cecile Mailler (Bath)
- Jean-Francois Marckert (LaBRI, Bordeaux)
- Leonardo Rolla (Buenos Aires)

6.2.1.1. Internships

- Plinio Santini Dester, M1 student at Polytechnique (Avril-July 2015).

6.2.2. Visits to International Teams

- *Nicolas Broutin* has visited the mathematics department of the University of Bath, the School of Computer Science at McGill University, the computer science laboratory in Bordeaux (LaBRI) and the NYU-ECNU institute for mathematical sciences at NYU Shanghai.

7. Dissemination

7.1. Promoting Scientific Activities

7.1.1. Scientific events selection

7.1.1.1. Member of the conference program committees

- *Philippe Robert*, Caching in Wireless Networks Conference (2015)

7.1.2. Journal

7.1.2.1. Member of the editorial boards

- *Nicolas Broutin* is member of the steering committee of the international meeting on analysis of algorithms (AofA).
- *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”.

7.1.3. Invited talks

- Cédric Bourdais, *Sarah Eugene* , *Philippe Robert* and *Wen Sun*] have been invited to the Young European Queueing Theorists (YEQT'9) workshop in Eindhoven in November 2015.

7.1.4. Conferences

- *Nicolas Broutin* has given lectures at annual meeting of the ALEA working group of the GDR-IM, the workshop GRAAL that took place at IHES, at the workshop organized in honor of Svante Janson's 60's birthday in Sweden, and the workshop on geometric networks at the Symposium on Computational Geometry that was held in Einhoven. He gave a plenary lecture at the conference on analysis of algorithms that was held in Strobl in June. He has also exposed his results at the probability seminar in Grenoble, the seminar of algorithmic and combinatorial geometry at IHP, and at the probability seminar of the NYU-ECNU Math institute in Shanghai.
- *Christine Fricker* and *Guilherme Thompson* participated to ITC 27 (International Teletraffic Congress) in Ghent in September 2015.
- *Renaud Dessalles*, *Philippe Robert* and *Wen Sun* gave talks at INFORMS Applied Probability Conference in July 2015 in Istanbul.
- *Philippe Robert* gave a talk at the department of mathematics at the University of Novosibirsk, in October 2015.

7.1.5. Scientific expertise

- *Christine Fricker* is member of the jury of agrégation.
- *Philippe Robert* is member of the scientific council of EURANDOM.

7.2. Teaching - Supervision - Juries

7.2.1. Teaching

Master : *Nicolas Broutin* Master Parisien de Recherche en Informatique (MPRI), in the course 2.15 on Analysis of Algorithms.

Master: *Nicolas Broutin*, Analysis of Algorithms, NYU Shanghai.

Master: *Philippe Robert*, Master, Probabilités et Applications, UPMC.

Master: *Philippe Robert*, Communication Networks, University of Novosibirsk, 12h.

7.2.2. Juries

- *Nicolas Broutin* has been a member of the committee for the PhD thesis of Daphné Dieuleveut (U Orsay).
- *Philippe Robert* has been reviewer of HDR document by Nidhi Hegde.

8. Bibliography

Publications of the year

Articles in International Peer-Reviewed Journals

[1] N. BROUTIN, L. DEVROYE, G. LUGOSI. *Connectivity of sparse Bluetooth networks*, in "Electronic Communications in Probability", 2015, vol. 20, n^o 48, pp. 1-10, https://hal.archives-ouvertes.fr/hal-01056128

[2] N. BROUTIN, J.-F. MARCKERT. *A new encoding of coalescent processes. Applications to the additive and multiplicative cases*, in "Probability Theory and Related Fields,", 2015, To appear, https://hal.inria.fr/hal-01092562

[3] N. BROUTIN, H. SULZBACH. *The dual tree of a recursive triangulation of the disk*, in "Annals of Probability", 2015, vol. 43, pp. 738–781 [*DOI :* 10.1214/13-AOP894], https://hal.inria.fr/hal-00773362

[4] C. FRICKER, N. SERVEL. *Two-choice regulation in heterogeneous closed networks*, in "Queueing Systems", 2015 [*DOI :* 10.1007/s11134-015-9465-7], https://hal.archives-ouvertes.fr/hal-01235854

[5] V. FROMION, E. LEONCINI, P. ROBERT. *A Stochastic model of the production of multiple proteins in cells*, in "SIAM Journal on Applied Mathematics", December 2015, vol. 75, n^{o} 6, 18 p. , https://hal.archives-ouvertes.fr/hal-01082032

[6] P. ROBERT, A. VEBER. *On the Fluid Limits of a Resource Sharing Algorithm with Logarithmic Weights*, in "The Annals of Applied Probability", July 2015, vol. 25, n^{o} 5, 45 p. , 35 pages, 2 figures, https://hal.inria.fr/hal-00757684

[7] W. SUN, M. FEUILLET, P. ROBERT. *Analysis of Large Unreliable Stochastic Networks*, in "Annals of Applied Probability", December 2015, https://hal.inria.fr/hal-01203096

International Conferences with Proceedings

[8] S. EDDINE ELAYOUBI, C. FRICKER, F. GUILLEMIN, P. ROBERT, B. SERICOLA. *Impatience in mobile networks and its application to data pricing*, in "IEEE ICC 2015 – Communications QoS, Reliability and Modeling Symposium", London, United Kingdom, IEEE, June 2015, 6 p. , https://hal.archives-ouvertes.fr/hal-01082038

[9] S.-E. ELAYOUBI, C. FRICKER, F. GUILLEMIN, P. ROBERT, B. SERICOLA. *Controlling impatience in cellular networks using QoE-aware radio resource allocation*, in "27th ITC International Teletraffic Congress (ITC 27)", Ghent, Belgium, September 2015, https://hal.inria.fr/hal-01179377

[10] V. SIMON, S. MONNET, M. FEUILLET, P. ROBERT, P. SENS. *Scattering and placing data replicas to enhance long-term durability*, in "The 14th IEEE International Symposium on Network Computing and Applications (IEEE NCA15)", Cambridge, United States, September 2015, 6 p. [*DOI :* 10.1109/NCA.2015.15], https://hal.inria.fr/hal-01206960

Scientific Books (or Scientific Book chapters)

[11] P. NICODEME (editor). *Nablus2014 CIMPA Summer School*, Proceedings of the Nablus2014 CIMPA Summer School, Pierre Nicodeme and Naji Qatanani, Nablus, Palestinian Territories, December 2015, 138 p. , https://hal.archives-ouvertes.fr/hal-01214113

Other Publications

[12] N. BROUTIN, C. MAILLER. *And/or trees: a local limit point of view*, October 2015, working paper or preprint, https://hal.inria.fr/hal-01220794

[13] R. DESSALLES, V. FROMION, P. ROBERT. *A Stochastic Analysis of Autoregulation of Gene Expression*, September 2015, working paper or preprint, https://hal.inria.fr/hal-01203076

[14] S. EUGENE, W.-F. XUE, P. ROBERT, M. DOUMIC-JAUFFRET. *Insights into the variability of nucleated amyloid polymerization by a minimalistic model of stochastic protein assembly*, September 2015, working paper or preprint, https://hal.inria.fr/hal-01205549

[15] C. FRICKER, C. BOURDAIS. *A Stochastic Model for Car-Sharing Systems*, April 2015, working paper or preprint, https://hal.inria.fr/hal-01203803

[16] C. FRICKER, F. GUILLEMIN, P. ROBERT, G. R. THOMPSON. *Analysis of an offloading scheme for data centers in the framework of fog computing*, July 2015, working paper or preprint, https://hal.inria.fr/hal-01179206

[17] C. FRICKER, D. TIBI. *Equivalence of ensembles for large vehicle-sharing models*, July 2015, working paper or preprint, https://hal.inria.fr/hal-01203789

[18] P. ROBERT, J. TOUBOUL. *On the dynamics of random neuronal networks*, May 2015, working paper or preprint, https://hal.inria.fr/hal-01075242