Activity Report 2017

Project-Team NEO

Network Engineering and Operations

RESEARCH CENTER
Sophia Antipolis - Méditerranée

THEME
Networks and Telecommunications

Table of contents

Project-Team NEO

Creation of the Team: 2017 January 01, updated into Project-Team: 2017 December 01

Keywords:

Computer Science and Digital Science:

A1.5. - Complex systems
A1.5.1. - Systems of systems
A1.5.2. - Communicating systems
A3.3.3. - Big data analysis
A3.5. - Social networks
A3.5.2. - Recommendation systems
A6.1.1. - Continuous Modeling (PDE, ODE)
A6.1.2. - Stochastic Modeling (SPDE, SDE)
A6.2.2. - Numerical probability
A6.2.3. - Probabilistic methods
A6.2.6. - Optimization
A6.4.1. - Deterministic control
A6.4.2. - Stochastic control
A7.1. - Algorithms
A7.1.1. - Distributed algorithms
A8.1. - Discrete mathematics, combinatorics
A8.2.1. - Operations research
A8.8. - Network science
A8.9. - Performance evaluation
A8.11. - Game Theory
A9.2. - Machine learning
A9.6. - Decision support

Other Research Topics and Application Domains:

B2.5.1. - Sensorimotor disabilities
B3.1. - Sustainable development
B3.1.1. - Resource management
B4.3.4. - Solar Energy
B4.4. - Energy delivery
B4.4.1. - Smart grids
B4.5.1. - Green computing
B6.2.1. - Wired technologies
B6.2.2. - Radio technology
B6.3.3. - Network Management
B6.3.4. - Social Networks
B8.1. - Smart building/home
B9.2.1. - Music, sound
B9.4.1. - Computer science

1. Personnel

Research Scientists
Alain Jean-Marie [Team leader, Inria, Senior Researcher]
Sara Alouf [Inria, Researcher, HDR]
Eitan Altman [Inria, Senior Researcher, HDR]
Konstantin Avrachenkov [Inria, Senior Researcher, HDR]
Giovanni Neglia [Inria, Researcher, HDR]

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Albert Sunny [Inria, from Jul 2017]
Eleni Vatamidou [Inria, until May 2017]

PhD Students
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Said Boularouk [Univ. d'Avignon et des pays du Vaucluse, from Feb 2017]
Arun Kadavankandy [Inria, until Jun 2017]
Hlib Mykhailenko [Inria, until Jun 2017]
Dimitra Politaki [Univ. de Nice - Sophia Antipolis]
Alina Tuholukova [Eurecom, until Jul 2017]

Technical staff
Gagan Deep Singh Chhabra [Inria, from Nov 2017]

Interns
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Srishti Jain [Inria, from May 2017 until Jul 2017]
Sarath Pattathil [Inria, from May 2017 until Jul 2017]
Dmytro Rubanov [Inria, from Mar 2017 until Aug 2017]

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Emilio Leonardi [Politecnico di Torino, from Feb 2017 until Mar 2017, and Oct 2017]
Nelly Litvak [Univ. Twente, from May 2017 until Jun 2017]
Vladimir Mazalov [Karelian Institute of Applied Mathematical Research, Mar 2017]
Akhil Padinhare Thalasseryveettil [IIT Bengalore, from Feb 2017 until Aug 2017]
Pawel Pralat [Ryerson Univ., from Jul 2017 until Aug 2017]
Berksan Serbetci [Univ. of Twente, from Sep 2017]
Ranbir Singh [IIT Mumbay, from Sep 2017 until Oct 2017]
Isaac Sonin [UNC Charlotte, Apr 2017]
Rajesh Sundaresan [IIS Bangalore, Feb 2017]
Gayane Vardoyan [Univ. of Massachusetts, from May 2017 until Aug 2017]
Uri Yechiali [Tel Aviv Univ., from Apr 2017 until May 2017]

2. Overall Objectives

2.1. Overall Objectives

NEO is an Inria project-team whose members are located in Sophia Antipolis (S. Alouf, K. Avrachenkov, G. Neglia), in Avignon (E. Altman) at LIA (Lab. of Informatics of Avignon) and in Montpellier (A. Jean-Marie) at LIRMM (Lab. Informatics, Robotics and Microelectronics of Montpellier). The team is positioned at the intersection of Operations Research and Network Science. By using the tools of Stochastic Operations Research, we model situations arising in several application domains, involving networking in one way or the other. The aim is to understand the rules and the effects in order to influence and control them so as to engineer the creation and the evolution of complex networks.

3. Research Program

3.1. Stochastic Operations Research

Stochastic Operations Research is a collection of modeling, optimization and numerical computation techniques, aimed at assessing the behavior of man-made systems driven by random phenomena, and at helping to make decisions in such a context.

The discipline is based on applied probability and focuses on effective computations and algorithms. Its core theory is that of Markov chains over discrete state spaces. This family of stochastic processes has, at the same time, a very large modeling capability and the potential of efficient solutions. By "solution" is meant the calculation of some *performance metric*, usually the distribution of some random variable of interest, or its average, variance, etc. This solution is obtained either through exact "analytic" formulas, or numerically through linear algebra methods. Even when not analytically or numerically tractable, Markovian models are always amenable to "Monte-Carlo" simulations with which the metrics can be statistically measured.

An example of this is the success of classical Queueing Theory, with its numerous analytical formulas. Another important derived theory is that of the Markov Decision Processes, which allows to formalize *optimal* decision problems in a random environment. This theory allows to characterize the optimal decisions, and provides algorithms for calculating them.

Strong trends of Operations Research are: a) an increasing importance of multi-criteria multi-agent optimization, and the correlated introduction of Game Theory in the standard methodology; b) an increasing concern of (deterministic) Operations Research with randomness and risk, and the consequent introduction of topics like Chance Constrained Programming and Stochastic Optimization. Data analysis is also more and more present in Operations Research: techniques from statistics, like filtering and estimation, or Artificial Intelligence like clustering, are coupled with modeling in Machine Learning techniques like Q-Learning.

4. Application Domains

4.1. Network Science

Network Science is a multidisciplinary body of knowledge, principally concerned with the emergence of global properties in a network of individual agents, from the "local" properties of this network, namely, the way agents interact with each other. The central model of "networks" is the graph (of Graph Theory/Operations Research), with nodes representing the different entities managing information and taking decisions, and the links representing the fact that entities interact, or not. Links are usually equipped with a "weight" that measures the intensity of interaction. Adding evolution rules to this quite elementary representation leads to dynamic network models, the properties of which Network Science tries to analyze.

A classical example of properties sought in networks is the famous “six degrees of separation” (or “small world”) property: how and why does it happen so frequently? Another ubiquitous property of real-life networks is the Zipf or “scale-free” distribution for degrees. Some of these properties, when properly exploited, lead to successful business opportunities: just consider the PageRank algorithm of Google, which miraculously connects the relevance of some Web information with the relevance of the other information that points to it.

4.2. Network Engineering

In its primary acceptation, Network Science involves little or no engineering: phenomena are assumed to be “natural” and emerge without intervention. However, the idea comes fast to intervene in order to modify the outcome of the phenomenon. This is where NEO is positioned. Beyond the mostly descriptive approach of Network Science, we aim at using the techniques of Operations Research so as to engineer complex networks.

To quote just two examples: controlling the spread of diseases through a “network” of people is of primarily interest for mankind. Similarly, controlling the spread of information or reputation through a social network is of great interest in the Internet. Precisely: given the impact of web visibility on business income, it is tempting (and quite common) to manipulate the graph of the web by adding links so as to drive the PageRank algorithm to a desired outcome.

Another interesting example is the engineering of community structures. Recently, thousands of papers have been written on the topic of community *detection* problem. In most of the works, the researchers propose methods, most of the time, heuristics, for detecting communities or dense subgraphs inside a large network. Much less effort has been put in the understanding of community formation process and even much less effort has been dedicated to the question of how one can influence the process of community formation, e.g. in order to increase overlap among communities and reverse the fragmentation of the society.

Our ambition for the medium term is to reach an understanding of the behavior of complex networks that will make us capable of influencing or producing a certain property in said network. For this purpose, we will develop families of models to capture the essential structure, dynamics, and uncertainty of complex networks. The “solution” of these models will provide the correspondence between metrics of interest and model parameters, thus opening the way to the synthesis of effective control techniques.

In the process of tackling real, very large size networks, we increasingly deal with large graph data analysis and the development of decision techniques with low algorithmic complexity, apt at providing answers from large datasets in reasonable time.

5. Highlights of the Year

5.1. Highlights of the Year

The NEO team underwent Inria’s project-team creation process and was officially created as a project-team on 1/12/2017. Before then, it was a research team of Inria’s research center Sophia-Antipolis Méditerranée.

5.1.1. Awards

The paper "Real-Time Fair Resource Allocation in Distributed Software Defined Networks", by Zaid Allybokus, Konstantin Avrachenkov, Jérémie Leguay and Lorenzo Maggi, received the Best Paper Award at *ITC’29*.

The paper "Ontology for a Voice Transcription of OpenStreetMap Data, The Case of Space Apprehension by Visually Impaired Persons", by Said Boularouk, Didier Josselin and Eitan Altman, received the WASET Best Paper Award.

The CEFIPRA project “Monte Carlo” received an excellent evaluation and was awarded an exceptional extension.

Eitan Altman was awarded the IEEE Technical Committee on Big Data (TCBD) the Distinguished Technical Achievement Recognition Award, for his outstanding technical leadership and achievement in stochastic modeling and big data analysis.

Giovanni Neglia has been nominated IEEE Infocom 2017 Distinguished TPC member based on "excellent performance in the review process."

BEST PAPERS AWARDS:

[17]
Z. ALLYBOKUS, K. AVRACHENKOV, J. LEGUAY, L. MAGGI. *Real-Time Fair Resource Allocation in Distributed Software Defined Networks*, in "ITC 29 - 2017 29th International Teletraffic Congress", Genoa, Italy, September 2017, https://hal.inria.fr/hal-01652533

[34]
S. BOULAROUK, D. JOSSELIN, E. ALTMAN. *Ontology for a voice transcription of OpenStreetMap data: the case of space apprehension by visually impaired persons*, in "World Academy of Science, Engineering and Technology", London, United Kingdom, May 2017, https://hal.archives-ouvertes.fr/hal-01533064

6. New Software and Platforms

6.1. marmoteCore

Markov Modeling Tools and Environments - the Core
KEYWORDS: Modeling - Stochastic models - Markov model
FUNCTIONAL DESCRIPTION: marmoteCore is a C++ environment for modeling with Markov chains. It consists in a reduced set of high-level abstractions for constructing state spaces, transition structures and Markov chains (discrete-time and continuous-time). It provides the ability of constructing hierarchies of Markov models, from the most general to the particular, and equip each level with specifically optimized solution methods.

This software is developed within the ANR MARMOTE project: ANR-12-MONU-00019.

- Participants: Alain Jean-Marie, Hlib Mykhailenko, Benjamin Briot, Franck Quessette, Issam Rabhi, Jean-Marc Vincent and Jean-Michel Fourneau
- Partner: UVSQ
- Contact: Alain Jean-Marie
- Publications: marmoteCore: a Markov Modeling Platform - marmoteCore: a software platform for Markov modeling
- URL: http://marmotecore.gforge.inria.fr/

7. New Results

7.1. Stochastic Modeling

Participants: Alain Jean-Marie, Hlib Mykhailenko, Eleni Vatamidou.

7.1.1. Semi-Markov Accumulation Processes

E. Vatamidou and A. Jean-Marie have introduced in [37] a new accumulation process, the Semi-Markov Accumulation Process (SMAP). This class of processes extends the framework of continuous-time Markov Additive Processes (MAPs) by allowing the underlying environmental component to be a semi-Markov process instead of a Markov process. They follow an analytic approach to derive a Master Equation formula of the Renewal type that describes the evolution of SMAPs in time. They show that under exponential holding times, a matrix exponential form analogous to the matrix exponent of a MAP is attained. Finally, they consider an application of these results where closed-form solutions are rather easy to achieve.

7.1.2. The marmoteCore platform

The development of `marmoteCore` (see Section 6.1) has been pursued. The software library is now mature enough to develop complex models, such as in [33]. Its architecture and main capabilities have been presented in [26]. `marmoteCore` provides the classes necessary to represent the state space of Markov models, from the elementary bricks that are interval or rectangular domains, simplices, or binary sequences. From there, the user easily programs the construction of probability transition matrices or infinitesimal generators. Structural analysis methods allow to identify recurrent and transient classes, and to compute the period of the model. Numerous methods allow the Monte Carlo simulation of the chain, the computation of transient and stationary distributions, as well as hitting times. `marmoteCore` is organized in a hierarchy of Markov models, from the simplest ones (Poisson process, two-state chains, ...) to the most general ones, including classes of models with a particular interest, such as QBDs. It is therefore possible to program solution methods specifically optimized and adapted to the level of structure of the model.

7.2. Random Graph and Matrix Models

Participants: Arun Kadavankandy, Konstantin Avrachenkov.

In [27] A. Kadavankandy and K. Avrachenkov in collaboration with L. Cottatellucci (EURECOM, France) and R. Sundaresan (IIS Bangalore, India) propose a local message passing algorithm based on Belief Propagation (BP) to detect a small hidden Erdös-Rényi (ER) subgraph embedded in a larger sparse ER random graph in the presence of side-information. The side-information considered is in the form of revealed subgraph nodes called cues, some of which may be erroneous. Namely, the revealed nodes may not all belong to the subgraph, and it is not known to the algorithm a priori which cues are correct and which are incorrect. The authors show that asymptotically as the graph size tends to infinity, the expected fraction of misclassified nodes approaches zero for any positive value of a parameter λ, which represents the effective Signal-to-Noise Ratio of the detection problem. Previous works on subgraph detection using BP without side-information showed that BP fails to recover the subgraph when $\lambda < 1/e$. These new results thus demonstrate the substantial gains in having even a small amount of side-information.

PageRank has numerous applications in information retrieval, reputation systems, machine learning, and graph partitioning. In [8] K. Avrachenkov and A. Kadavankandy in collaboration with L. Ostroumova and A. Raigorodskii (Yandex, Russia) study PageRank in undirected random graphs with an expansion property. The Chung-Lu random graph is an example of such a graph. They show that in the limit, as the size of the graph goes to infinity, PageRank can be approximated by a mixture of the restart distribution and the vertex degree distribution. They also extend the result to Stochastic Block Model (SBM) graphs, where they show that there is a correction term that depends on the community partitioning.

7.3. Data Analysis and Learning

Participants: Konstantin Avrachenkov, Hlib Mykhailenko, Giovanni Neglia, Dmytro Rubanov.

7.3.1. Unsupervised learning

In [21] K. Avrachenkov in collaboration with A. Kondratev and V. Mazalov (both from Petrozavodsk State Univ., Russia) apply cooperative game-theoretic methods for community detection in networks. The traditional methods for detecting community structure are based on selecting denser subgraphs inside the network. Their new approach is to use the methods of cooperative game theory that highlight not only the link density but also the mechanisms of cluster formation. Specifically, they suggest two approaches from cooperative game theory: the first approach is based on the Myerson value, whereas the second approach is based on hedonic games. Both approaches allow to detect clusters with various resolution. However, the tuning of the resolution parameter in the hedonic games approach is particularly intuitive. Furthermore, the modularity based approach and its generalizations can be viewed as particular cases of the hedonic games.

Kernels and, broadly speaking, similarity measures on graphs are extensively used in graph-based unsupervised and semi-supervised learning algorithms as well as in the link prediction problem. In [19] K. Avrachenkov and D. Rubanov in collaboration with P. Chebotarev (Trapeznikov Institute of Control Sciences, Russia) analytically study proximity and distance properties of various kernels and similarity measures on graphs. This can potentially be useful for recommending the adoption of one or another similarity measure in a machine learning method. Also, they numerically compare various similarity measures in the context of spectral clustering and observe that normalized heat-type similarity measures with log modification generally perform the best.

7.3.2. Semi-supervised learning

Graph-based semi-supervised learning for classification endorses a nice interpretation in terms of diffusive random walks, where the regularisation factor in the original optimisation formulation plays the role of a restarting probability. Recently, a new type of biased random walks for characterising certain dynamics on networks have been defined and rely on the γ-th power of the standard Laplacian matrix L. In particular, these processes embed long range transitions, the Levy flights, that are capable of one-step jumps between far-distant states (nodes) of the graph. In [24] K. Avrachenkov in collaboration with E. Bautista, S. De Nigris, P. Abry and P. Gonçalves (from DANTE Inria team and ENS Lyon) build upon these volatile random walks to propose a new version of graph based semi-supervised learning algorithms whose classification outcome could benefit from the dynamics induced by the fractional transition matrix. In [22] using the framework of Levy flights, they further improve the classification outcome, even in settings traditionally poorly performing such as unbalanced classes, and they derive a theoretical rule for classification decision.

In [6] K. Avrachenkov in collaboration with P. Chebotarev (Trapeznikov Institute of Control Sciences, Russia) and A. Mishenin (Saint Petersburg Univ., Russia) study a semi-supervised learning method based on the similarity graph and regularized Laplacian. They give convenient a optimization formulation of the regularized Laplacian method and establish its various properties. In particular, they show that the kernel of the method can be interpreted in terms of discrete and continuous-time random walks and possesses several important properties of proximity measures. Both optimization and linear algebra methods can be used for efficient computation of the classification functions. The authors demonstrate on numerical examples that the regularized Laplacian method is robust with respect to the choice of the regularization parameter and outperforms the Laplacian-based heat kernel methods.

7.3.3. Distributed computing

In distributed graph computation, graph partitioning is an important preliminary step, because the computation time can significantly depend on how the graph has been split among the different executors. In [30] H. Mykhailenko and G. Neglia, in collaboration with F. Huet (I3S) propose a framework for distributed edge partitioning based on simulated annealing. The framework can be used to optimize a large family of partitioning metrics. They provide sufficient conditions for convergence to the optimum as well as discuss which metrics can be efficiently optimized in a distributed way. They implemented these partitioners in Apache GraphX and performed a preliminary comparison with JA-BE-JA-VC, a state-of-the-art partitioner that inspired the new approach. They show that this approach can provide improvements, but further research is required to identify suitable metrics to optimize as well as to design a more efficient exploration phase for the algorithm without sacrificing convergence properties.

Because of the significant increase in size and complexity of the networks, the distributed computation of eigenvalues and eigenvectors of graph matrices has become very challenging and yet it remains as important as before. In [20] K. Avrachenkov in collaboration with P. Jacquet (Nokia Bell Labs) and J. Sreedharan (Purdue Univ., USA) develop efficient distributed algorithms to detect, with higher resolution, closely situated eigenvalues and corresponding eigenvectors of symmetric graph matrices. We model the system of graph spectral computation as physical systems with Lagrangian and Hamiltonian dynamics. The spectrum of Laplacian matrix, in particular, is framed as a classical spring-mass system with Lagrangian dynamics. The spectrum of any general symmetric graph matrix turns out to have a simple connection with quantum systems and it can be thus formulated as a solution to a Schrödinger-type differential equation. Taking into account

the higher resolution requirement in the spectrum computation and the related stability issues in the numerical solution of the underlying differential equation, we propose the application of symplectic integrators to the calculation of eigenspectrum. The effectiveness of the proposed techniques is demonstrated with numerical simulations on real-world networks of different sizes and complexities.

7.4. Game Theory

Participants: Eitan Altman, Konstantin Avrachenkov.

7.4.1. Dynamic potential games

In [11] K. Avrachenkov in collaboration with V. Mazalov and A. Rettieva (both from Petrozavodsk State Univ., Russia) treat discrete-time game-theoretic models of resource exploitation as dynamic potential games. The players (countries or firms) exploit a common stock on the infinite time horizon. The main aim is to obtain a potential for the linear-quadratic games of this type. The class of games where a potential can be constructed as a quadratic form is identified. As an example, the dynamic game of bioresource management is considered and the potentials are constructed in the case of symmetric and asymmetric players.

7.4.2. A Hawk and Dove game with infinite state space

In [16], E. Altman, in collaboration with A. Aradhye and R. El-Azouzi (UAPV) consider the Hawk-Dove game in which each of infinitely many individuals, involved with pairwise encounters with other individuals, can decide whether to act aggressively (Hawk) or peacefully (Dove). Each individual is characterized by its strength. The strength distribution among the population is assumed to be fixed and not to vary in time. If both individuals involved in an interaction are Hawks, there will be a fight, the result of which will be determined by the strength of each of the individuals involved. The larger the difference between the strength of the individuals is, the larger is the cost for the weaker player involved in the fight. The goal is to study the influence of the parameters (such as the strength level distribution) on the equilibrium of the game. The authors show that for some parameters there exists a threshold equilibrium policy while for other parameters there is no equilibrium policy at all.

7.5. Applications in Telecommunications

Participants: Zaid Allybokus, Eitan Altman, Konstantin Avrachenkov, Giovanni Neglia, Sarath Pattathil, Berksan Serbetci, Alina Tuholukova.

7.5.1. Caching

As cellular network operators are struggling to keep up with the rapidly increasing traffic demand, two key directions are deemed necessary for beyond 4G networks: (i) extensive cell densification to improve spatial reuse of wavelengths, and (ii) storage of content as close to the user as possible to cope with the backhaul constraints and increased interference. However, caching has mostly been studied with an exclusive focus either on the backhaul network (e.g. the “femto-caching” line of work) or on the radio access (e.g. through coded caching or cache-aided Coordinated MultiPoint, CoMP). As a result, an understanding of the impact of edge caching on network-wide and end-to-end performance is lacking. In [32] A. Tuholukova and G. Neglia in collaboration with T. Spyropoulos (EURECOM) investigate the problem of optimal caching in a context where nearby small cells (“femto-helpers”) can coordinate not just in terms of what to cache but also to perform Joint Transmission (a type of CoMP). They show that interesting tradeoffs arise between caching policies that improve radio access and ones that improve backhaul, and propose an algorithm that provably achieves an 1/2-approximation ratio to the optimal one (which is NP-hard), and performs well in simulated scenarios.

Cache policies to minimize the content retrieval cost have been studied through competitive analysis when the miss costs are additive and the sequence of content requests is arbitrary. More recently, a cache utility maximization problem has been introduced, where contents have stationary popularities and utilities are strictly concave in the hit rates. In [29] G. Neglia in collaboration with D. Carra (Univ. of Verona) and P. Michiardi (EURECOM) bridges the two formulations, considering linear costs and content popularities. They show that minimizing the retrieval cost corresponds to solving an online knapsack problem, and we propose new dynamic policies inspired by simulated annealing, including DYNQLRU, a variant of QLRU. For such policies they prove asymptotic convergence to the optimum under the characteristic time approximation. In a real scenario, popularities vary over time and their estimation is very difficult. DYNQLRU does not require popularity estimation, and realistic, trace-driven evaluation shows that it significantly outperforms state-of-the-art policies, with up to 45% cost reduction.

Still following the idea that in large communication systems it is beneficial both for the users and for the network as a whole to store content closer to users, one particular implementation of such an approach is to co-locate caches with wireless base stations. In [5] K. Avrachenkov in collaboration with X. Bai and J. Goseling (both from Univ. of Twente, the Netherlands) study geographically distributed caching of a fixed collection of files. They model cache placement with the help of stochastic geometry and optimize the allocation of storage capacity among files in order to minimize the cache miss probability. They consider both per cache capacity constraints as well as an average capacity constraint over all caches. The case of per cache capacity constraints can be efficiently solved using dynamic programming, whereas the case of the average constraint leads to a convex optimization problem. The authors demonstrate that the average constraint leads to significantly smaller cache miss probability. Finally, they suggest a simple LRU-based policy for geographically distributed caching and show that its performance is close to the optimal.

In [7] K. Avrachenkov in collaboration with J. Goseling and B. Serbetci (both from Univ. of Twente, the Netherlands) consider caching in cellular networks in which each base station is equipped with a cache that can store a limited number of files. The popularity of the files is known and the goal is to place files in the caches such that the probability that a user at an arbitrary location in the plane will find the file that she requires in one of the covering caches is maximized. They develop distributed asynchronous algorithms for deciding which contents to store in which cache. Such cooperative algorithms require communication only between caches with overlapping coverage areas and can operate in asynchronous manner. The development of the algorithms is principally based on an observation that the problem can be viewed as a potential game. Their basic algorithm is derived from the best response dynamics. The authors demonstrate that the complexity of each best response step is independent of the number of files, linear in the cache capacity and linear in the maximum number of base stations that cover a certain area. Then, they show that the overall algorithm complexity for a discrete cache placement is polynomial in both network size and catalog size. In practical examples, the algorithm converges in just a few iterations. Also, in most cases of interest, the basic algorithm finds the best Nash equilibrium corresponding to the global optimum. Two extensions of the basic algorithm areprovided, based on stochastic and deterministic simulated annealing which find the global optimum. Finally, the authors demonstrate the hit probability evolution on real and synthetic networks numerically and show that their distributed caching algorithm performs significantly better than storing the most popular content, probabilistic content placement policy and Multi-LRU caching policies.

7.5.2. Software Defined Networks (SDN)

The performance of computer networks relies on how bandwidth is shared among different flows. Fair resource allocation is a challenging problem particularly when the flows evolve over time. To address this issue, bandwidth sharing techniques that quickly react to the traffic fluctuations are of interest, especially in large scale settings with hundreds of nodes and thousands of flows. In [17] Z. Allybokus and K. Avrachenkov in collaboration with J. Leguay and L. Maggi (both from Huawei Research, Paris) propose a distributed algorithm that tackles the fair resource allocation problem in a distributed SDN control architecture. Their algorithm continuously generates a sequence of resource allocation solutions converging to the fair allocation while always remaining feasible, a property that standard primal-dual decomposition methods often lack. Thanks to

the distribution of all computer intensive operations, they demonstrate that they can handle large instances in real-time.

In [18] K. Avrachenkov in collaboration with V. Borkar and S. Pattathil (both from IIT Bombay, India) consider the Generalized Additive Increase Multiplicative Decrease (G-AIMD) dynamics for resource allocation with alpha fairness utility function. This dynamics has a number of important applications such as internet congestion control, charging electric vehicles, and smart grids. They prove indexability for the special case of MIMD model and provide an efficient scheme to compute the index. The use of index policy allows to avoid the curse of dimensionality. They also demonstrate through simulations for another special case, AIMD, that the index policy is close to optimal and significantly outperforms a natural heuristic which penalizes the strongest user.

7.5.3. Network formation games

The paper [15] deals with a network formation game while balancing multiple, possibly conflicting objectives like cost, performance, and resiliency to viruses. It is part of a collaboration between Inria (E. Altman), Delft Univ. (S. Trajanovski, F. Kuipers, P. van Mieghem) and UAPV (Y. Hayel) which started within the CONGAS European project. Each player (node) aims to minimize its cost in installing links, the probability of being infected by a virus and the sum of hop counts on its shortest paths to all other nodes. In this article the authors (1) determine the Nash Equilibria and the Price of Anarchy for the network formation game, (2) demonstrate that the Price of Anarchy (PoA) is usually low, which suggests that (near-)optimal topologies can be formed in a decentralized way, and (3) give suggestions for practitioners for those cases where the PoA is high and some centralized control/incentives are advisable.

7.5.4. User association in LTE

Within the Inria-Nokia joint labs, C.S. Chen and L. Roullet (Nokia) N. Trabelsi (former member of MAESTRO) and E. Altman, and R. El-Azouzi (UAPV) have proposed a distributed algorithm for optimizing user Association and resource allocation in LTE networks. The solution is based on a game theoretic approach, which permits to compute Cell Individual Offset (CIO) and a pattern of power transmission over frequency and time domain for each cell. Simulation results show significant benefits in the average throughput and also cell edge user throughput of 40% and 55% gains respectively. Furthermore, we also obtain a meaningful improvement in energy efficiency.

7.5.5. Matching games for solving the association problem in WIFI

Matching games are a powerful framework for formulating and for solving user association problems. In [13], M. Touati (Orange Labs) and M. Coupechoux (Telecom ParisTech), R. El-Azouzi (UAPV), E. Altman and J. M. Kelif (Orange Labs) have considered the problem of association in a particular complex context of matching games with externalities in which the ranking of various associations by a player depends on association decisions of other player. This situation occurs in multi-rate IEEE 802.11 WLANs. traditional user association based on the strongest received signal and the well known anomaly of the MAC protocol can lead to overloaded Access Points (APs), and poor or heterogeneous performance. They show that theit proposed association scheme can greatly improve the efficiency of 802.11 with heterogeneous nodes. The mechanism can be implemented as a virtual connectivity management layer to achieve efficient APs-user associations without modification of the MAC layer.

7.5.6. A stochastic game for competition over relay opportunities in DTN networks

In [12], K. P. Naveen (Indian Institute of Technology, Madras) and E. Altman in collaboration with A. Kumar (IISc Bangalore) consider an opportunistic wireless communication setting, in which two nodes (referred to as forwarders) compete to choose a relay node from a set of relays, as they ephemerally become available (e.g., wake up from a sleep state). Each relay, when it becomes available (or arrives), offers a (possibly different) " reward " to each forwarder. Each forwarder's objective is to minimize a combination of the delay incurred in choosing a relay and the reward offered by the chosen relay. As an example, the authors develop the reward structure for the specific problem of geographical forwarding over a common set of sleep-wake cycling relays.

They formulate the model as a stochastic game theoretic variant of the asset selling problem studied in the Operations Research literature. They study two variants of the generic relay selection problem, namely, the completely observable and the partially observable cases. These cases are based on whether a forwarder (in addition to observing its reward) can also observe the reward offered to the other forwarder. The structure of Nash Equilibrium Policy Pairs is studied and characterized.

7.5.7. Aid for visually inpaired persons

S. Boularouk, D. Josselin (UAPV) and E. Altman pursue in [34], [35] the design of a geographic recommendation and alarm system for visually impaired persons. In [34] they propose a vocal ontology of Open-StreetMap (OSM) data for the apprehension of space by visually impaired people. They propose a simple but usable method to extract data from OSM databases in order to send them using Text To Speech technology. They focus on how to help people suffering from visual disability to plan their itinerary, to comprehend a map by querying computer and getting information about surrounding environment in a mono-modal human-computer dialogue. In [35] they further study the benefit of IoT for people with disabilities, particularly for visually impaired and blind people mobility. They propose a simple prototype using OpenStreetMap data combined to physical environment data measured from sensors connected to a Arduino board through Speech recognition.

7.5.8. Routing games over the line

In [28] A. Karouit, M. Haddad, A. El Matar (UAPV) and E. Altman study a sequential routing game where several users send traffic to a destination on a line. Each user arrives at some time epoch with a given capacity. Then, he ships its demand over time on a shared resource. The state of a player evolves according to whether he decides to transmit or not. The decision of each user is thus spatio-temporal control. The authors provide an explicit expression for the equilibrium of such systems and compare it to the global optimum case. In particular, they compute the price of anarchy of such schemes and identify a Braess-type paradox in the context of sequential routing games.

7.5.9. Multicriteria Games of congestion

In [23], A. Boukoftane and M. Haddad (UAPV) in collaboration with E. Altman and N. Oukid (Univ. de Saad Dahlab) consider a routing game in a network that contains lossy links. They consider a multi-objective problem where the players have each a weighted sum of a delay cost and a cost for losses. They compute the equilibrium and optimal solution (which are unique). They discover here in addition to the classical Kameda type paradox another paradoxical behavior in which higher loss rates have a positive impact on delay and therefore higher quality links may cause a worse performance even in the case of a single player.

7.5.10. Speed estimation in cellular networks

The paper [25], is part of a joint ongoing work within the Inria-Nokia joint lab on the SelfNet ADR which focused on speed estimation. It involved E. Altman, M. Haddad (UAPV), D.G. Herculea, C.S. Chen and V. Capdevielle (Nokia). The authors provide a new online algorithm for mobile user speed estimation in 3GPP Long Term Evolution (LTE)/LTE-Advanced networks. The proposed method leverages on uplink sounding reference signal power measurements performed at the base station, also known as eNodeB, and remains effective even under large sampling period. Extensive performance evaluation of the proposed algorithm is carried out using field traces from realistic environment. The on-line solution is proven highly efficient in terms of computational requirement, estimation delay, and accuracy.

7.6. Applications in Social Networks

Participant: Eitan Altman.

7.6.1. Posting behavior

In [10], Eitan Altman, together with A. Masson (SAFRAN Group, formerly with MAESTRO) and Y. Hayel (UAPV), pursue two objectives. First they model the posting behaviour of publishers in Social Networks which have externalities. Secondly, they propose content active filtering in order to increase content diversity from different publishers. By externalities, is meant that when the quantity of posted contents from a specific publisher impacts the popularity of other posted contents. The authors introduce a dynamical model to describe the posting behaviour of publishers taking into account these externalities. This model is based on stochastic approximations and sufficient conditions are provided to ensure its convergence to a unique rest point. A closed form of this rest point is provided, and it is shown that it can be obtained as the unique equilibrium of a non-cooperative game. Content Active Filtering (CAF) are actions taken by the administrator of the Social Network in order to promote some objectives related to the quantity of contents posted in various contents. An objective of the CAF can be maximizing the diversity of posted contents. Finally, the authors illustrate their results through numerical simulations and they validate them with real data extracted from social networks.

7.7. Applications to Renewable Resources and Energy

Participants: Sara Alouf, Alain Jean-Marie, Dimitra Politaki.

7.7.1. Stochastic models for solar power

In [31], D. Politaki and S. Alouf develop a stochastic model for the solar power at the surface of the earth. They combine a deterministic model of the clear sky irradiance with a stochastic model for the so-called clear sky index to obtain a stochastic model for the actual irradiance hitting the surface of the earth. Their clear sky index model is a 4-state semi-Markov process where state durations and clear sky index values in each state have phase-type distributions. They use per-minute solar irradiance data to tune the model, hence they are able to capture small time scales fluctuations. They compare this model with the on-off power source model developed by Miozzo et al. (2014) for the power generated by photovoltaic panels, and to a modified version that they propose. Computing the autocorrelation functions for all proposed models, they find that the irradiance model surpasses the on-off models and it is able to capture the multiscale correlations that are inherently present in the solar irradiance. The power spectrum density of generated trajectories matches closely that of measurements. This new irradiance model can be used not only in the mathematical analysis of energy harvesting systems but also in their simulation.

In [45], D. Politaki, S. Alouf and A. Jean-Marie in collaboration with F. Hermenier (Nutanix) aim at the performance analysis of a data center feb by renewable energy recources. They describe the data center system, proposing a new queuing model BMAP/PH/c which represents the queue length in a system having c servers, where arrivals are determined by a Batch Markov Arrival process and service times have a phase-type distribution. They validate this model using real traces. Next, they characterize the data center google workload traces which are available in the web and they validate that the jobs arrive to the system in groups (batches) and wait at the queue. The waiting time is diverse according to the available resources, job size etc. The authors then compute the empirical CDF of the service time and try to fit it with well-known distributions like exponential, Pareto etc. However, the Kolmogorov-Smirnov test rejects the null hypothesis at the 1% significance level which shows that service time doesn't fit with any well-known distribution.

7.7.2. Sustainable management of water consumption

Alain Jean-Marie, Mabel Tidball (INRA, Montpellier, France), Fernando Ordóñez and Victor Bucarey López (Univ. de Chile, Chile), consider in [36] a discrete time, infinite horizon dynamic game of groundwater extraction. A Water Agency charges an extraction cost to water users, and controls the marginal extraction cost so that it depends linearly on total water extraction (through a parameter n) and on rainfall (through parameter m). The water users are selfish and myopic, and the goal of the agency is to give them incentives them so as to, at the same time, improve their total welfare and improve the long-term level of the resource.

This problem is studied in two situations for a linear-quadratic model. In the first situation, the parameters n and m are considered to be fixed over time, and the Agency selects the value that maximizes the total discounted welfare of agents. A first result shows that when the Water Agency is patient (discount rate close to one), the optimal marginal extraction cost asks for strategic interactions between agents.

In the second situation, the authors look at the dynamic Stackelberg game where the Agency decides at each time what cost parameter they must announce in order to maximize the welfare function. This becomes a highly non-linear optimal control problem. Some preliminary results are presented.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

NEO members are involved in the

- Inria-Nokia Bell Labs joint laboratory: the joint laboratory consists of six ADRs (Action de Recherche/Research Action) in its second phase (starting October 2012). NEO members participate in one ADR (see §8.1.1);
- Inria-Orange Labs joint laboratory;
- Inria-ALSTOM joint laboratory: the joint laboratory consists of four projects. NEO members participated in project P11.

8.1.1. ADR "Network Science" (June 2013 – March 2017)

Participants: Konstantin Avrachenkov [coordinator], Giovanni Neglia.

- Contractor: Nokia Bell Labs (http://www.bell-labs.com)
- Collaborators: Philippe Jacquet (coordinator), Alonso Silva.

"Network Science" aims at understanding the structural properties and the dynamics of various kind of large scale, possibly dynamic, networks in telecommunication (e.g., the Internet, the web graph, peer-to-peer networks), social science (e.g., community of interest, advertisement, recommendation systems), bibliometrics (e.g., citations, co-authors), biology (e.g., spread of an epidemic, protein-protein interactions), and physics. The complex networks encountered in these areas share common properties such as power law degree distribution, small average distances, community structure, etc. Many general questions/applications (e.g., community detection, epidemic spreading, search, anomaly detection) are common in various disciplines and are being analyzed in this ADR "Network Science". In particular, in the framework of this ADR we were interested in efficient network sampling.Related publication: [20]

8.2. Bilateral Grants with Industry

8.2.1. Huawei CIFRE on the topic "Scalable Online Algorithms for SDN controllers" (June 2016 – May 2019)

Participants: Zaid Allybokus, Konstantin Avrachenkov.

- Contractor: Huawei Technologies (http://www.huawei.com/en/about-huawei/research-development)
- Collaborators: Jérémie Leguay and Lorenzo Maggi

Software-Defined Networking (SDN) technologies have radically transformed network architectures. They provide programmable data planes that can be configured from a remote controller platform.

The objective of this CIFRE thesis is to provide fundamental answers on how powerful SDN controller platforms could solve large online flow problems to optimize networks in real-time and in a distributed or semi-distributed fashion. We use methods from both optimization and dynamic programming.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Marmote

Participants: Alain Jean-Marie, Eleni Vatamidou.

ANR Program: Modèles Numériques (MN) 2012, number ANR-12-MONU-0019
Project title: MARkovian MOdeling Tools and Environments
Duration: January 2013 - June 2017
Coordinator: Alain Jean Marie (Inria)
Partners: Inria (project-teams DYOGENE, NEO and POLARIS), Univ. Versailles-Saint-Quentin (DAVID lab.), Telecom SudParis (SAMOVAR lab.), Univ. Paris-Est Créteil (LACL), and Univ. Pierre-et-Marie-Curie (LIP6)
Abstract: ANR MARMOTE aimed, among other goals, at realizing the prototype of a software environment dedicated to modeling with Markov chains. It brought together seven partner teams, expert in Markovian analysis, who developed advanced solution algorithms and applications in different scientific domains: reliability, distributed systems, physics and economics. See Section 6.1, Section 7.1.2. Related publications: [26],[33],[37].

https://wiki.inria.fr/MARMOTE/Welcome

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

Participant: Konstantin Avrachenkov.

Program: EU COST
Project acronym: **ACROSS**
Project title: Autonomous Control for a Reliable Internet of Services
Duration: November 2013 - November 2017
Coordinator: Rob Van Der Mei (CWI) and J.L. Van Den Berg (TNO), The Netherlands
Other partners: see http://www.cost-across.nl/
Abstract: Currently, we are witnessing a paradigm shift from the traditional information-oriented Internet into an Internet of Services (IoS). This transition opens up virtually unbounded possibilities for creating and deploying new services. Eventually, the ICT landscape will migrate into a global system where new services are essentially large-scale service chains, combining and integrating the functionality of (possibly huge) numbers of other services offered by third parties, including cloud services. At the same time, as our modern society is becoming more and more dependent on ICT, these developments raise the need for effective means to ensure quality and reliability of the services running in such a complex environment. Motivated by this, the aim of this Action is to create a European network of experts, from both academia and industry, aiming at the development of autonomous control methods and algorithms for a reliable and quality-aware IoS.
Program: EU COST
Project acronym: **COSTNET**
Project title: European Cooperation for Statistics of Network Data Science
Duration: May 2016 - April 2020
Coordinator: Ernst Wit (NL), Gesine Reinert (UK)
Other partners: see http://www.cost.eu/COST_Actions/ca/CA15109
Abstract: A major challenge in many modern economic, epidemiological, ecological and biological questions is to understand the randomness in the network structure of the entities they study: for example, the SARS epidemic showed how preventing epidemics relies on a keen understanding of random interactions in social networks, whereas progress in curing complex diseases is aided by a robust data-driven network approach to biology.

Although analysis of data on networks goes back to at least the 1930s, the importance of statistical network modelling for many areas of substantial science has only been recognized in the past decade. The USA is at the forefront of institutionalizing this field of science through various interdisciplinary projects and networks. Also in Europe there are excellent statistical network scientists, but until now cross-disciplinary collaboration has been slow.

This Action aims to facilitate interaction and collaboration between diverse groups of statistical network modellers, establishing a large and vibrant interconnected and inclusive community of network scientists. The aim of this interdisciplinary Action is two-fold. On the scientific level, the aim is to critically assess commonalities and opportunities for cross-fertilization of statistical network models in various applications, with a particular attention to scalability in the face of Big Data. On a meta-level, the aim is to create a broad community which includes researchers across the whole of Europe and at every stage in their scientific career and to facilitate contact with stakeholders.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. MALENA

Title: Machine Learning for Network Analytics

International Partner (Institution - Laboratory - Researcher):

Indian Institute of Technology Bombay (India) - Electrical Communication Engineering - Vivek Borkar

Start year: 2017

See also: http://www-sop.inria.fr/members/Konstantin.Avratchenkov/MALENA.html

In the past couple of decades network science has seen an explosive growth, enough to be identified as a discipline of its own, overlapping with engineering, physics, biology, economics and social sciences. Much effort has gone into modelling, performance measures, classification of emergent features and phenomena, etc, particularly in natural and social sciences. The algorithmic side, all important to engineers, has been recognised as a thrust area (e.g., two recent Nevanlinna Prize (J. Kleinberg 2006 and D. Spielman 2010) went to prominent researchers in the area of network analytics). Still, in our opinion the area is yet to mature and has a lot of uncharted territory. This is because networks provide a highly varied landscape, each flavour demanding different considerations (e.g., sparse vs dense graphs, Erdös-Rényi vs planted partition graphs, standard graphs vs hypergraphs, etc). Even adopting existing methodologies to these novel situations is often a nontrivial exercise, not to mention many problems that cry out for entirely new algorithmic paradigms. It is in this context that we propose this project of developing algorithmic tools, drawing not only upon established as well as novel methodologies in machine learning and big data analytics, but going well beyond, e.g., into statistical physics tools.

9.3.1.2. THANES

Title: THeory and Application of NEtwork Science

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - Department of Computer and Systems Engineering - Daniel Ratton Figueiredo

Purdue University (USA) - Department of Computer Science - Bruno Ribeiro

Start year: 2017

See also: https://team.inria.fr/thanes/

During the 3-year lifetime of this joint team we plan to move beyond the study of a single network and focus on multiplex networks, i.e. multiple interacting networks. Multiplex networks have recently raised as "one of the newest and hottest themes in the statistical physics of complex networks." They originate from the observation that many complex systems, ranging from living organisms to critical infrastructures, operate through multiple layers of distinct interactions among their constituents. In particular work on the co-evolution of the different layers of a multiplex network and on how epidemics spread in such setting.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

NEO has continued collaborations with researchers from GERAD, Univ. Montreal (Canada), Flinders Univ. (Australia), National Univ. of Rosario (Argentina), Technion - Israel Institute of Technology (Israel), Univ. of Arizona (USA), Univ. of Illinois at Urbana-Champaign (USA), Univ. of Liverpool (UK), Univ. of Massachusetts at Amherst (USA), Univ. of Florence (Italy), Univ. of Palermo (Italy), Univ. of Twente (The Netherlands), Petrozavodsk State Univ. (Russia) and Ghent Univ. (Belgium).

9.3.3. Participation in Other International Programs

9.3.3.1. SticAmSud project DyGaMe

Title: Dynamic Games Methods: theory, algorithmics and application

International Partners (Institution - Laboratory - Researcher):

Univ. de Chile (Chile) - Department of Industrial Engineering - Fernando Ordóñez

Univ. Nacional de Rosario (Argentina) - Facultad de Ciencias Exactas, Ingeniería y Agrimensura - Eugenio Della Vecchia

CNRS (France) - LIP6 - Emmanuel Hyon

Duration: 2016 - 2017

Start year: 2016

See also: https://project.inria.fr/dygame

Stochastic Dynamic Game Theory is developing in Engineering sciences and is in need of more theoretical results, algorithms and applications. This project brings together researchers from Applied Mathematics, Operations Research and Economics, with the objective of contributing to these aspects. It will more specifically concentrate on agent rationality and the game structure, look for efficient solution algorithms by crossing Applied Mathematics and Operations Research techniques, and apply the results to problems originating from, on the one hand, security/conservation concerns, and on the other hand, sustainable development problems.

9.3.3.2. CEFIPRA Grant Monte Carlo, no.5100-IT1

Title: Monte Carlo and Learning Schemes for Network Analytics

International Partners (Institution - Laboratory - Researcher):

IIT Bombay (India) - Department of Electrical Engineering - Prof. V.S. Borkar;

IIS Bangalore (India) - Department of Electrical Engineering - Prof. R. Sundaresan.

Duration: 2014 - 2017

Start year: 2014

The project aims to approach various computation problems in network analytics by means of Markov Chain Monte Carlo (MCMC) and related simulation techniques as well as machine learning algorithms such as reinforcement learning, ant colony optimization, etc. This will include network diagnostics such as ranking, centrality measures, computation on networks using local message passing algorithms, resource allocation issues pertaining to networks and network-based systems such as the internet, peer-to-peer networks, social networks. The work will involve both development of analytical tools and extensive validation thereof using simulation studies. The research will draw upon techniques from graph theory, probability, optimization, and distributed computation.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Professors / Researchers

Damiano Carra

Date: 6-8 December 2017

Institution: Univ. of Verona (Italy)

Koen de Turck

Date: 13-17 November 2017

Institution: CentraleSupelec (France)

Eugene Feinberg

Date: 1 June 2017

Institution: Stony Brook Univ. (USA)

Daniel Figueiredo

Date: 17-21 July 2017

Institution: UFRJ (Brazil)

Giulio Iacobelli

Date: 21-25 August 2017

Institution: UFRJ (Brazil)

Emilio Leonardi

Date: 21 February 2017 - 3 March 2017

Date: 9-20 October 2017

Institution: Politecnico di Torino (Italy)

Nelly Litvak

Date: 23 May 2017 - 2 June 2017

Institution: Twente Univ. (The Netherlands)

Vladimir Mazalov

Date: 19-17 March 2017

Institution: Karelian Institute of Applied Mathematical Research (Russia)

Fernando Ordóñez

Date: 15-19 May 2017

Institution: Univ. of Chile (Chile)

Pawel Pralat

Date: 2 July 2017 - 4 August 2017

Institution: Ryerson Univ. (Canada)

Bruno Ribeiro

Date: 17-21 July 2017

Institution: Purdue Univ. (USA)

Isaac Sonin

Date: 1-13 April 2017

Institution: Dept. of Mathematics and Statistics, UNC Charlotte (USA)

Rajesh Sundaresan

Date: 13-25 February 2017

Institution: IIS Bangalore (India)

Uri Yechiali

Date: 24 April 2017 - 5 May 2017

Institution: Tel Aviv Univ. (Israel)

9.4.1.2. Post-doc / Ph.D. students

Víctor Bucarey López

Date: 15-19 May 2017

Institution: Univ. of Chile (Chile)

Akhil Padinhare Thalasseryveettil

Date: 20 February 2017 - 20 August 2017

Institution: IIT Bengalore (India)

Berksan Serbetci

Date: 20 September 2017 - 20 December 2017

Institution: Univ. of Twente (The Netherlands)

Ranbir Singh

Date: 18 September 2017 - 26 October 2017

Institution: IIT Mumbay (India)

Gayane Vardoyan

Date: 16 May 2017 - 10 August 2017

Institution: Univ. of Massachusetts (USA)

Geetika Verma

Date: 20-30 June 2017

Institution: Univ. of South Australia (Australia)

9.4.1.3. Internships

Ilya Bogdanov

Date: 3 July 2017 - 18 September 2017

Institution: Moscow High School of Economics (Russia)

Supervisor: Konstantin Avrachenkov

Konstantinos Dermentzis

Date: 20 November 2017 - 19 May 2018

Institution: National Technical Univ. of Athens (Greece)

Supervisor: Giovanni Neglia

Srishti Jain

Date: 9 May 2017 - 26 Jul 2017

Institution: IIT Kampur (India)

Supervisor: Eitan Altman

Sarath Pattathil

Date: 3 May 2017 - 3 July 2017

Institution: IIT Bombay (India)

Supervisor: Konstantin Avrachenkov

Dmytro Rubanov

Date: 1 March 2017 - 31 August 2017
Institution: Master IFI Ubinet, UNS
Supervisor: Konstantin Avrachenkov

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Konstantin Avrachenkov
Date: 1 - 9 February 2017
Institution: IIT Bombay and IIS Bangalore (India)
Date: 11 - 19 March 2017
Institution: Novosibirsk State Univ. (Russia)
Date: 18 - 25 April 2017
Institution: Univ. of Liverpool (UK)
Date: 18 - 19 September 2017
Institution: Univ. of Warsaw (Poland)
Date: 30 October - 4 November 2017
Institution: IIT Bombay (India)

Alain Jean-Marie
Date: 2 - 20 November 2017
Institution: Univ. of Montreal (Canada)
Date: 28 October - 27 November 2017
Institution: National Univ. of Rosario (Argentina)

Giovanni Neglia
Date: 8 - 11 November 2017
Institution: Northeastern Univ., Boston and Univ. of Massachusetts, Amherst (USA)
Date: 13 - 18 November 2017
Institution: Purdue Univ. (USA)
Date: 14 - 15 December 2017
Institution: Florence Univ. (Italy)

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. Member of the Organizing Committees

- D.Politaki was member of the organization committee of the workshop “Monde des mathematiques industrielles (MOMI)”, Inria Sophia Antipolis, 27-28 February 2017.

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- International Conference on Computing, Networking and Communications (ICNC 2018), symposium on Communication QoS and System Modeling (CQSM) (**G. Neglia**)

10.1.2.2. Member of the Conference Program Committees

- 18th Conference of the Société Française de Recherche Opérationnelle et d'Aide à la Décision (ROADEF 2017, Metz, France) (**A. Jean-Marie**)
- 8th Conference on Decision and Game Theory for Security (GameSec 2017, Vienna, Austria) (**K. Avrachenkov**)
- IFIP Networking 2017 Conference and Workshops: IFIP/TC6 Networking Poster and Demo Session (Stokholm, Sweden) (**G. Neglia**)
- IEEE Intl. Conference on Computer Communications (INFOCOM 2018, Honolulu, Hawaii, USA) (**G. Neglia**)
- 24th Intl. Conference on Analytical & Stochastic Modelling Techniques & Applications (ASMTA 2017, Newcastle Upon Tyne, UK) (**K. Avrachenkov**)
- 7th Intl. Conference on Game Theory for Networks (GameNets 2017, Knoxville, Tennessee, USA) (**K. Avrachenkov**)
- 29th Intl. Teletraffic Conference (ITC 2017, Genoa, Italy) (**S. Alouf**)
- 14th Workshop on Algorithms and Models for the Web Graph (WAW 2017, Toronto, Canada) (**K. Avrachenkov**)
- 19th Workshop on Mathematical Performance Modeling and Analysis (MAMA 2017, Urbana-Champaign, Illinois, USA) (**A. Jean-Marie**)

10.1.2.3. Reviewer

The members of the team reviewed numerous papers for numerous international conferences.

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- *ACM Transactions on Modeling and Performance Evaluation of Computing Systems (ACM ToMPECS)* (**K. Avrachenkov** since 2015);
- *Wiley Transactions on Emerging Telecommunications Technologies* (ETT) (**S. Alouf** since July 2016);
- *Elsevier Computer Communications journal* (COMCOM) (**G. Neglia** since February 2014);
- *Elsevier International Journal of Performance Evaluation* (**K. Avrachenkov** since 2008).

10.1.3.2. Reviewer - Reviewing Activities (list in alphabetical order of journal name)

- *Elsevier Transportation Research Part C* (**G. Neglia**);
- *IEEE Transactions on Mobile Computing* (TMC) (**S. Alouf**);
- *IEEE/ACM Transactions on Networking* (ToN) (**S. Alouf**, **G. Neglia**);
- *Mathematical Methods of Operations Research* (MMOR) (**S. Alouf**);
- *Performance Evaluation* (PEVA) (**S. Alouf**, **G. Neglia**);
- *Wiley Transactions on Emerging Telecommunications Technologies* (ETT) (**S. Alouf**).

10.1.4. Invited Talks

- G. Neglia gave an invited talk at the GdR ISIS workshop "PHY-Aware Edge Caching in 5G: Convergence of Network and Information Theory in Cache-aided Wireless Networks" on "Implicit Coordination of Caches in Small Cell Networks under Unknown Popularity Profiles".

10.1.5. Leadership within the Scientific Community

- E. Altman is a fellow member of IEEE (Class of 2010).
- E. Altman and A. Jean-Marie are (elected) members of IFIP WG7.3 on "Computer System Modeling". E. Altman is also Member of WG 6.3 of IFIP on Performance of Communication Systems.

10.1.6. Research Administration

S. Alouf

- is member of the scientific committee of the joint laboratory Inria-Alstom since May 2014;
- is vice-head of project-team NEO since January 2017.

K. Avrachenkov

- together with Arnaud Legout (DIANA team) and Fabien Gandon (WIMMICS team) is co-responsible of the multi-disciplinary research theme (Action Transversale) "Semantic and Complex Networks" at Inria Sophia Antipolis - Méditerranée.

A. Jean-Marie

- is the scientific coordinator of Inria activities in Montpellier (since 2008); as part of this duty, he represents Inria at: the Scientific Council of the Doctoral School "Sciences and Agrosciences" of the Univ. of Avignon; at the Regional Conference of Research Organisms (CODOR);
- is a member of the Steering Committee of the GDR RO, a national research initiative on Operations Research sponsored by the CNRS;
- is Head of project-team NEO since January 2017.

G. Neglia

- is the scientific delegate for European partnerships for Inria Sophia Antipolis – Méditerranée since 2014;
- is member of the Inria COST GTRI (International Relations Working Group of Inria's Scientific and Technological Orientation Council since 2016;
- is member of the scientific animation committee for the IDEX UCA^{JEDI} research program "Social Interactions and Complex Dynamics" since 2017.

NEO members are in the following committees of Inria Sophia Antipolis-Méditerranée

- CLFP: Training Committee (**S. Alouf**, since November 2014);
- CSD: Doctoral Committee (**S. Alouf**, until February 2017);
- MASTIC: a commission in charge of popularization and regional and internal scientific animation (**D. Politaki**, since July 2016);
- PhD Seminars organizing committee of CRISAM (**D. Politaki**, since November 2016);
- NICE: Invited Researchers Committee (**K. Avrachenkov**, since 2010).

NEO members are in charge of the following tasks for the research center:

- Supervision and validation of the project-teams' yearly activity reports (**K. Avrachenkov**, since 2010).

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence:

S. Alouf, "Probability", 33H, Undergraduate Water Engineering degree (L3), Univ. of Nice Sophia Antipolis (UNS), France.

G. Neglia, "Probability", 33.5H, Undergraduate Water Engineering degree (L3), Univ. of Nice Sophia Antipolis (UNS), France.

D. Politaki, "Langage de programmation Java", 21H, L1, IUT, France.

D. Politaki, "Programmation Avancée", 42H, M1, UNS, France.

Master:

S. Alouf, "Performance Evaluation of Networks", 31.5H, M2 IFI Ubinet, UNS, France.

A. Kadavankandy, "Random-walk based algorithms for complex network analysis" at "Winter School on Complex Networks", 2H, M1 Computer Science, UNS, France.

G. Neglia, "Distributed Optimization and Games", 31.5H, M2 IFI Ubinet, UNS, France.

G. Neglia, responsible for the "Winter School on Complex Networks", 22.5H, M1 Computer Science, UNS, France.

Doctorat:

A. Jean-Marie, "Markov Chains" and "Optimal Stochastic Control", 20h, Facultad de Ciencias Económicas y Empresariales, Univ. Valladolid, Spain.

10.2.2. Supervision

HDR defended:

Sara Alouf, Université Côte d'Azur, "From Wireless Networks to Green IT: A Journey Through Stochastic Models and Tools", 20 December 2017.

Giovanni Neglia, Université Côte d'Azur, "Delay Tolerant Networks: from modeling to optimization", 27 February 2017.

PhD defended:

Arun Kadavankandy, "Spectral analysis of random graphs with application to clustering and sampling", Université Côte d'Azur, 18 July 2017, advisors: Konstantin Avrachenkov and Laura Cottatellucci (EURECOM).

Hlib Mykhailenko, "Distributed Edge Partitioning", Université Côte d'Azur, 14 June 2017, advisor: Fabrice Huet (SCALE team).

PhD in progress:

Said Boularouk, "Helping space apprehension by visually impaired people", 1 October 2015, advisors: Eitan Altman and Didier Josselin (UAPV).

Zaid Allybokus, "Scalable Online Algorithms for SDN Controllers", 1 July 2016, advisors: Konstantin Avrachenkov and Lorenzo Maggi (Huawei).

Dimitra Politaki, "Greening data center," 1 February 2016, advisors: Sara Alouf and Fabien Hermenier (UNS).

PhD interrupted:

Alina Tuholukova, "Caching at the Edge: Distributed Phy-aware Caching Policies for 5G Cellular Networks," 1 July 2016 – 31 July 2017.

10.2.3. Juries

NEO members participated in the Ph.D. committees of (in alphabetical order):

- George Arvanitakis, "An Analytical Model for Flow-level Performance in Heterogeneous Wireless Networks", Télécom ParisTech, 27 September 2017, (**S. Alouf** as jury member)
- Victor Bucarey López, "Addressing Problem Size in Stackelberg Security Games", Univ. of Chile, 1 September 2017, (**A. Jean-Marie** as jury member)
- Justina Gianatti, "Métodos numéricos para resolver problemas de control óptimo", National Univ. of Rosario, 30 October 2017, (**A. Jean-Marie** as jury member)
- Arun Kadavankandy, "Spectral analysis of random graphs with application to clustering and sampling", Univ. Côte d'Azur, 18 July 2017, (**A. Jean-Marie** as jury president)
- Christelle Rovetta, "Simulation parfaite de réseaux fermés de files d'attente et génération aléatoire de structures combinatoires", Univ. Paris Sciences Lettres, 20 June 2017, (**A. Jean-Marie** as reviewer)
- Luigi Vigneri, "Vehicles as a Mobile Cloud: Modelling, Optimization and Performance Analysis", Univ. Côte d'Azur, 11 July 2017, (**G. Neglia** as jury member)
- Jingjing Zhang, "Interplay between caching, feedback and topology in the wireless broadcast channel", Télécom ParisTech, 26 April 2017, (**K. Avrachenkov** as jury president)

10.3. Popularization

- S. Alouf gave a radio interview to journalist J. Colombain; the interview aired on France Info on 6 August 2017 and is available here (audio + abstract): http://www.francetvinfo.fr/replay-radio/nouveau- monde/nouveau-monde-faut-il-dire-le-ou-la-wi-fi_2294141.html;
- D. Politaki participated to the "Fête de la science", Antibes Juan-les-Pins (7-8 October). She animated two games based on the pythagorean theorem and finding the shortest path respectively, Thymio and scratch.
- D. Politaki participated in the organization of MOMI: Le MOnde des Mathématiques Industrielles. This is a two-day event organized by PhD candidates of Inria's center in Sophia-Antipolis, dedicated to discovering how Mathematics are useful in the Industrial world.
- D. Politaki participated to Stage MathC2+ (18-21 Juin 2017) which is organised by Inria (SAM).

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Publications of the year

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[2] A. KADAVANKANDY. *Spectral analysis of random graphs with application to clustering and sampling*, Université Côte d'Azur, July 2017, https://tel.archives-ouvertes.fr/tel-01618579

[3] H. MYKHAILENKO. *Distributed edge partitioning*, Université Côte d'Azur, June 2017, https://hal.inria.fr/tel-01551107

[4] G. NEGLIA. *Delay Tolerant Networks: from modeling to optimization*, Université Côte d'Azur, February 2017, Habilitation à Diriger des Recherches

Articles in International Peer-Reviewed Journals

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