2018-00381 - PhD - Stochastic control and optimization in large-scale multi-server distributed queueing systems

Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

About the research centre or Inria department

The core component of our scientific agenda focuses on the development of statistical and probabilistic methods for the modeling and the optimization of complex systems. These systems require mathematical representations which are in essence dynamic and stochastic with discrete and/or continuous variables. This increasing complexity poses genuine scientific challenges that can be addressed through complementary approaches and methodologies:

- **Modeling**: design and analysis of realistic and tractable models for such complex real-life systems taking into account various probabilistic phenomena
- **Estimation and evaluation**: developing theoretical and computational methods in order to estimate the parameters of the model and to design the performance of the system
- **Optimal Control**: developing theoretical and numerical control tools to optimize the performance

Context

**Scientific priorities**: The core of this project concerns the optimization of large scale stochastic networks, which is part of the strategic plan.

**Scientific research context**: Computer systems and networks such as data centers, computer clouds, social networks, smart cities, cyber-physical systems are nowadays large-scale, fast evolving and become increas-ingly complex to control. Managing these systems to optimize performance, minimize operational costs while maintaining a predictable and robust behavior is in fact a non-trivial problem. In this respect, mathematical analysis, especially coupled with stochastic modeling and optimization theory, is an effective tool allowing one to design robust resource management, scheduling and allocation algorithms, and to investigate fundamental tradeoffs underlying the distributed system. On the other hand, mathematical models for the dynamics of computer systems and networks are usually difficult to study and therefore a scientific research effort is needed.

Assignment

The objective is to find simple and effective mechanisms able to provably drive dynamics of distributed systems to a desired (optimal) behavior and to investigate fundamental tradeoffs between the performance experienced by users (e.g., mean delays) and infrastructure costs. These types of results will be achieved using mathematical models and methods from applied probability and operations research: specifically, Markov decision processes and Markov chains will be the main tools to model dynamics, and large-deviations, fluid limits and stochastic comparison will be the main techniques to analyze these models.

The project focuses on dynamic resource allocation problems (e.g., bandit problem) both in discrete and continuous time. Typically, the problem consists in optimizing the functioning of parallel systems whose evolution is random (Markovian) and dependent on the decisions taken by a central or distributed controller.

Classically, the controller is central and has complete information, in which case it has been shown in the literature that this optimization problem can be explicitly solved by introducing the notion of Gittins index. In contrast, this thesis will focus on distributed controllers having partial observations. In this context, optimal solutions of this optimization problem cannot be written in an explicit form and it is then necessary to develop approximation methods in order to provide feasible solutions. The objective of this thesis is to work in this framework and to propose and study such techniques.

Main activities

**Keywords**: distributed systems, randomized load balancing, Markov processes, asymptotic optimality, fluid and mean-field limit

**References**:
1) P. Robert, Stochastic Networks and Queues, New York: Springer-Verlag, 2003
Required knowledge and background: The highly motivated candidate must have a master degree in mathematics with a strong background in applied probability.

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport

Remuneration
1982€ / month (before taxs) during the first 2 years, 2085€ / month (before taxs) during the third year.