Control of Adaptive Systems using Game Theory

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

About the research centre or Inria department
Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world's top universities, Inria’s 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

Context
The PhD student will be based in Inria Rennes in the SUMO team and will make regular visits to Nokia Bell Labs in Nozay (Paris).

Assignment
PhD thesis

Main activities
In this PhD thesis, we will be interested in developing algorithms for automatically synthesizing controllers for adaptive systems and building correct-by-construction systems. Here, adaptive systems generally refer to complex systems such as a networks of connected objects (e.g. through Internet of Things), which is not only dynamic (objects can arrive or leave the system) but also evolving with changing environment conditions and specifications (e.g. user constraints and requests can be updated).

In this collaboration between Inria – Inria and Nokia Bell Labs, we will build algorithms based on game theory and model checking techniques to synthesize policies to ensure that crucial safety and security conditions are respected in the evolving system while satisfying the user requirements.

One specific application of these algorithms will be on software-defined network (SDN) systems. In this setting, we consider a set of devices connected on a network, with predefined groups of devices. Devices that belong to a group can have privileged operations, e.g. access to some set of data. The user specifies constraints involving these groups: one can require, for instance, that guest devices do not access sensitive data. Such systems can evolve in many ways: devices can join or leave the network, existing devices can join or leave groups, the user can add modify the security constraints. Under each such change, the groups and the network must be updated using the SDN framework with minimal human intervention. The ultimate goal of the PhD is to show that such updates can be made completely automatic and efficient thanks to controller synthesis techniques.

Other similar applications will also be considered, provided by our partner Nokia Bell Labs, which will co-supervise the PhD thesis. Once new algorithms are developed, the candidate will implement the technique within Nokia Bell Labs’ existing framework to validate the approach on a real system.

Further theoretical developments include the study of hierarchical controllers, taking potential failures into account and adding diagnosis abilities. One can also consider the modeling of systems for which some part of the behavior is not known on-line. The goal would then be to understand how such modeling can be articulated with the use of a constructive formal methods like controllersynthesis.

In particular, how one can compute on-line controllers ensuring some dynamic properties that depend on the current configuration of the system. All these methods will possibly be implemented with Heptagon/BZR and Reax [4], possibly considering the opportunity to extend these tools.

Aside from theoretical algorithms, the candidate is expected to learn about model checking techniques such as state-space abstraction, symmetry reduction, partial-order reduction etc. and find the right encoding for the specific problem to achieve efficient implementation of algorithms (see e.g. [5,6,7]).

This is thus a PhD thesis with a strong theoretical part and a systematic implementation and application part.

Requirements
The candidate is not expected to have prior knowledge about software-defined networks. However they are expected to be motivated to learn about it. Good theoretical background in automata theory and model checking, and good programming skills are necessary. A prior experience in a research
The candidate is expected to pursue a PhD thesis at Inria Rennes (with regular visits to Nokia Bell Labs). The PhD grant is already available.

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**Keywords**: Formal methods, automata theory, model checking, game theory, supervisory control theory, reactive systems, Internet of Things, distributed systems, software-defined networks

**Website** of the team at Inria: [http://www.irisa.fr/sumo/index.html](http://www.irisa.fr/sumo/index.html)

**Bibliography**


**Skills**

Technical skills and level required:

A prior experience in a research internship (L3, M1, M2) and good references are mandatory.

Good theoretical background and good programming skills

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Sports facilities

**Remuneration**

Monthly gross salary amounting to 1982 euros for the first and second years and 2085 euros for the third year.