2018-00744 - Modelling and parameterized verification of mobile networks

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

About the research centre or Inria department

The Inria Rennes - Bretagne Atlantique center is one of Inria's eight centers and has more than thirty research teams. The Inria Center is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

Inria

Assignment

Parameterized verification. Parameterized models provide a powerful way of modelling and reasoning about complex systems made of arbitrarily many copies of a single component. The aim of parameterized verification is then to check properties of all instances of the model at once (i.e., for any number of copies of the component). Distributed protocols, and specifically protocols running on ad hoc networks are a motivating example for this setting, as the correctness of the protocol should not depend on the exact number of participants. Other applications include multi-threaded programmes, distributed algorithms, and different families of biological of chemical systems.

For these parameterized systems, several models and verification algorithms were proposed in the literature, mainly depending on the application: population protocols [3], threshold automata [5], broadcast protocols [1], etc.

Mobile networks. For systems such as mobile ad hoc networks, or even chemical species in a solution, the model of the system should incorporate the inherent mobility of the components of the network.

In the literature on the verification of mobile ad hoc networks, the usual assumption is that the network topology evolves non-deterministically, abstracting away the physical constraints in the movement of nodes [6, 1]. Moreover, when node or communication failures are considered, these events are non-deterministic alternatives to the perfect behaviour (in which nodes and communications are reliable) [2]. As a consequence, between two message broadcasts, arbitrary changes in the communication topology or in the set of alive nodes may occur during the reconfiguration step. Such arbitrary reconfigurations may not be realistic, especially in settings where communications are frequent enough, and mobility is relatively slow and not chaotic. As an example, a device may enter and exit the communication range of a transmitter while exchanging synchronisation messages at a very high rate. From a theoretical perspective, arbitrary topology changes are very appealing since they transform the semantics into behaviours of a well-structured transition system [4], and thus enable the verification of basic properties [1]. However, a realistic model for communication protocols on mobile ad hoc networks is lacking.

Population protocols, from the distributed algorithm community can be used to represent interactions of chemical species. Usually, interaction between the molecules are arbitrary: any pair of molecule present in the solution can "meet" to generate products from their reaction. The distance between species and the position in the solution is not considered. Here also, the mobility of molecules should be reflected in a realistic model.

Objectives. The first objective of the thesis is to propose classes of models that faithfully represent mobility in ad hoc networks, or mobility in solutions with chemical reactants. It should reflect the one hand, the placement of nodes/molecules at a given time instant, and on the other hand, their physical movement over time. Current graph-based models for the communication topology fall short at these objectives. Having a precise model of the mobility will allow us to obtain precise results and avoid false negatives in verification algorithms. Moreover, quantitative questions on
Parameterized systems have not been studied and can be more faithfully answered if the evolution of the network is modeled.

The second objective is to develop verification algorithms for the proposed models. This includes both qualitative and quantitative aspects, e.g. deciding whether some (abstract) configuration of the system will be reached, and how much time on average this may take. The PhD student is expected to study the computational complexity of these problems and develop new techniques to solve these problems efficiently.

**Keywords:** parameterized verification, mobile networks

**Supervisors:**
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**References**


**Main activities**

**PhD Thesis**

**Skills**

Technical skills and level required: Master's degree on formal verification, automata theory. Prior experience required on an internship on these topics.

Languages: English

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

**Remuneration**

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