

Internship proposal

Title: Robustness of Continuous Petri Nets

Location: Team Modelisation and Verification, Laboratoire d'Informatique et des Systèmes, Luminy

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Context.

Petri nets [Pet62] constitute one of the most popular formalism for the description and analysis of concurrent systems. While their state space may be infinite, many verification problems are decidable. Dealing with infinite-state systems is useful in numerous situations, such as considering an unbounded number of agents or modelling resources.

The classical semantics of Petri nets is discrete, representing consumption and production of resources, as entities, so-called tokens. The model is notoriously known as being difficult to analyse, complexity wise. For instance, the reachability problem, which consists in determining, given two markings, whether there exists a sequence of transitions allowing to go from one to the other, is Ackerman-complete, which constitutes a prohibitive complexity [LS19, Ler21].

An alternative semantics, known as the *continuous* semantics, has been introduced in [DA87], in which it is possible to consume and produce only *fractions* of tokens. It constitutes an over-approximation of the classical semantics [DA10], as new behaviours are added to the system. The main advantage of this semantics is that it is way more tractable, as reachability problem can be solved in polynomial time [FH15]. Recent work has shown that the reachability relation can be expressed in a logical formalism, which has been used to speed up the coverability analysis of Petri nets [BFHH17].

When designing systems, beside their functional correctness, an important property is their *robustness*, as highlighted in [Hen08]. Roughly speaking, robustness means that the functional correctness is preserved when the system is subject to small perturbations. These perturbations may for instance represent the slight differences that necessarily exists between the model of the system and its actual implementation. This notion of robustness has been considered for several models so far, including timed automata [BMS13] and time Petri nets [AHJR16] among others.

Objectives.

The general objective of this internship is to investigate the notion of robustness for continuous Petri nets. This notion can vary along several aspects:

- first, regarding the introduction of the perturbation in the model, different ways can be considered. One could introduce a parameter in a uniform way, on all transitions, as has been done in timed automata [Pur00]. One could also study the perturbation of a subset of transitions, possibly with different parameters.
- second, the problem considered can also vary: for instance, one could verify that some safety property is satisfied by the perturbed model, or, in a more constrained way, that the set of places that can be marked is unchanged by the perturbation, as in [AHJR16].
- third, one can consider two versions of these robustness problems, a qualitative one, which aims at determining the existence of a positive value of the perturbation, and a quantitative one, which consists in computing the largest admissible perturbation, as in [JR11].

For the resulting problems, the objective of the internship is to study how to model these problems, and how to solve them by adapting the encoding of the reachability relation in logic presented in [BFHH17]. One will also be interested in analysing the complexity of the resulting decision procedures, and in identifying matching lower bounds. Last, the definition of an adequate notion of robustness for (classical) Petri nets can also be studied, as well as its links with that for continuous Petri nets.

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