M2 Research Internship

Parametric verification of real-time systems

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Context

Mutiprocessor real-time systems have become ubiquitous in the past few years. Some of them (e.g., automated plane and unmanned systems control, driverless cars) are critical in the sense that no error must occur. Testing these systems can possibly detect the presence of bugs, but not guarantee their absence. It is necessary to use formal methods such as model checking [BK08] so as to prove formally the correctness of a system.

Designing a correct scheduling for a set of tasks to be executed by several processors is crucial for the system safety. Such systems are characterized by a set of timing constants, such as the reading period of a sensor on an unmanned aircraft system, or the minimal or maximal time needed by a satellite to compute some result. Although numerous techniques to verify a system for *one* set of constants exist, formally verifying the system for numerous values of these constants can require a very long time, or even infinite if one aims at verifying dense sets of values.

It is therefore interesting to reason in a parametric manner, by considering that these constants are unknown, i.e., parameters, and synthesize a constraint on these parameters guaranteeing that there exists a correct scheduling for the system. Several techniques have been proposed to solve this problem [AHV93, AS13], in particular in the setting of parametric schedulability analysis [SSL+13]. Figure 1 shows an example of such a constraint, where the green (resp. red) zone depicts a set of parameter valuations for T_1 and T_2 such that the system is correct (resp. incorrect).

Internship subject

The main objective of this internship is to design parametric verification techniques for real-time systems applied to multiprocessor scheduling.

An implementation will also be performed by the intern, so as to validate the proposed approach. An option is to reuse the IMITATOR software tool [AFKS12].

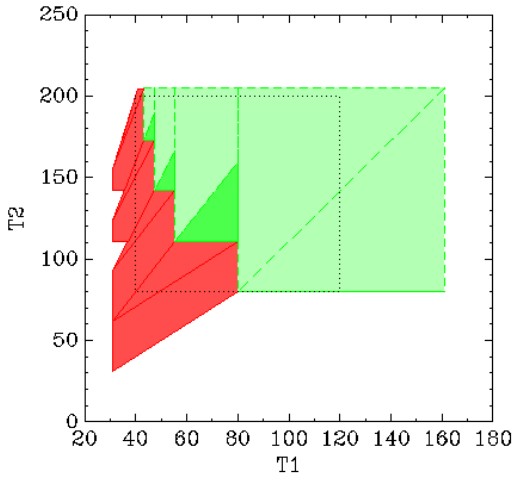

Figure 1: Example of parameter synthesis for schedulability

Keywords

Formal methods, model checking, multiprocessor systems, scheduling, real-time systems, parameter synthesis

Skills

The following skills are not compulsory, but would be welcome: parametric timed automata, scheduling, OCaml.

Conditions

Highly motivated applicants are being sought.

Depending on the applicant's preference, the internship will take place in one of the following two laboratories:

- LIFL, Université Lille 1, France, and/or
- LIPN (Laboratoire d'Informatique de Paris Nord), Université de Paris 13, Sorbonne Paris Cité (campus of Villetaneuse), France

Standard remuneration.

Depending on the candidate's motivation and wishes, this internship can lead to a PhD thesis.

References

[AFKS12] Étienne André, Laurent Fribourg, Ulrich Kühne, and Romain Soulat. IMITATOR 2.5: A tool for analyzing robustness in scheduling problems. In Dimitra Giannakopoulou and Dominique Méry, editors, *Proceedings of the 18th International Symposium on Formal Methods (FM'12)*, volume 7436 of *Lecture Notes in Computer Science*, pages 33–36. Springer, August 2012.

[AHV93] Rajeev Alur, Thomas A. Henzinger, and Moshe Y. Vardi. Parametric real-time reasoning. In *STOC 93*, pages 592–601. ACM, 1993.

[AS13] Étienne André and Romain Soulat. *The Inverse Method*. FOCUS Series in Computer Engineering and Information Technology. ISTE Ltd and John Wiley & Sons Inc., 2013. 176 pages.

[BK08] Christel Baier and Joost-Pieter Katoen. *Principles of Model Checking*. MIT Press, 2008.

[SSL+13] Youcheng Sun, Romain Soulat, Giuseppe Lipari, Étienne André, and Laurent Fribourg. Parametric schedulability analysis of fixed priority real-time distributed systems. In Cyrille Artho and Peter Ölveczky, editors, *Second International Workshop on Formal Techniques for Safety-Critical Systems (FTSCS'13)*, volume 419 of *Communications in Computer and Information Science*, pages 212–228. Springer, October 2013.