Research Internship – Master M2 (2016/2017)

Location : Laboratoire Spécification et Vérification (LSV)
Ecole Normale Suprieure Paris-Saclay

Title : VASS games for resource-bounded logics

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Resource-bounded logics. Alternating-time temporal logics such as the logics ATL and ATL* [AHK02] extend the temporal logics CTL and CTL* respectively (see for instance [DGL16]), by interpreting the formulae on concurrent game structures, a sophisticated extension of labelled transition systems, and by allowing modalities to quantify over strategies for a given coalition of agents. The logic ATL has many extensions, some of them have models containing transitions that produce or consume resources, depending on the actions involved to fire transitions, see e.g. the resource-bounded logics in [ALNR14]. As shown in [ABLN15], having implicitly in the models counters (i.e. variables interpreted over the set of natural numbers) and the ability to quantify over strategies for a given coalition (i.e. for a set of agents) can easily lead to undecidability even though many logics have been introduced for which the model-checking problem is shown to be decidable, possibly with a very high worst-case complexity upper bound. Reasoning about resources happens to be quite similar to the analysis of runs of vector addition systems with states (a.k.a. VASS) and more specifically with games on VASS, see e.g. [BJK10], because of the very nature of strategy modalities.

Logics in AI and verification games. In the recent work [ABDL16], formal relationships have been established between model-checking problems for resource-bounded logics and decision problems for VASS so that new decidability results can be established for logical problems or new complexity characterisations can be inherited from problems on counter machines. Of course, this should not come as a real surprise because resource values and counter values are similar objects and logics based on concurrent game structures have inherently games in the semantics. Moreover, earlier works have already explored the connections with counter machines, either to obtain undecidability results or to get complexity lower bounds, see e.g. [ABLN15].

Objectives of the research internship

(1) To become familiar with the main resource-bounded logics extending ATL and with the most standard VASS games.

(2) To improve the complexity bounds from [ABDL16] for the fragments obtained by bounding the number of counters, the number of agents, or any other reasonable measure.

(3) To design VASS games whose main decision problems are equivalent to model-checking problems based on resource-bounded logics, extending the approach presented in [ABDL16].

This research internship may be pursued as a PhD thesis, whose subject may vary according to the candidate's research interests.

Related courses at MPRI:

For your information, the following MPRI courses are related to this research internship. Students from other master programmes are welcomed to apply too.

- Course 1.22 *Basics of Verification*
- Course 2.5.1 *Automated Deduction*
- Course 2.9.1 *Mathematical foundations of the theory of infinite transition systems*
- Course 2.20.1 *Techniques de théorie des jeux en informatique*

References

[ABDL16] N. Alechina, N. Bulling, S. Demri, and B. Logan. On the complexity of resource-bounded logics. In *RP'16*, volume 9899 of *Lecture Notes in Computer Science*, pages 36–50. Springer, 2016.

[ABLN15] N. Alechina, N. Bulling, B. Logan, and H.N. Nguyen. On the boundary of (un)decidability: Decidable model-checking for a fragment of resource agent logic. In *IJCAI'15*, pages 1494–1501. AAAI Press, 2015.

[AHK02] R. Alur, Th. Henzinger, and O. Kupferman. Alternating-time temporal logic. *Journal of the Association for Computing Machinery*, 49(5):672–713, 2002.

[ALNR14] N. Alechina, B. Logan, H.N. Nguyen, and F. Raimondi. Decidable model-checking for a resource logic with production of resources. In *ECAI'14*, volume 263 of *Frontiers in Artificial Intelligence and Applications*, pages 9–14. IOS Press, 2014.

[BJK10] T. Brázdil, P. Jancar, and A. Kucera. Reachability games on extended vector addition systems with states. In *ICALP'10*, volume 6199 of *Lecture Notes in Computer Science*, pages 478–489. Springer, 2010.

[DGL16] S. Demri, V. Goranko, and M. Lange. *Temporal Logics in Computer Science*. Cambridge University Press, 2016. To appear.