Research Internship – M2

Place : Laboratoire Spécification et Vérification (LSV)
Ecole Normale Supérieure Paris-Saclay, France

Title : Taming the Computational Complexity of Resource-Bounded Logics

Supervisor : Stéphane Demri (LSV, CNRS, ENS Paris-Saclay), demri@lsv.fr

Resource-bound logics. Many logical formalisms exist for specifying the strategic behaviour of agents in multi-agent systems, including the alternating-time temporal logic ATL [AHK02] and extensions in which actions may consume or produce resources, see e.g. [BF09, ALNR15, ALNR17]. The logic ATL generalises the temporal logic CTL (see survey material about branching-time temporal logics or ATL in [DGL16]) and has been subject to many extensions, including quantitative ones, see e.g. [BG13]. The logic RB±ATL, introduced in [ALNR14], is one of such extensions and the model-checking problem has been shown 2ExpTime-complete in [ABDL18]. Many other extensions exist, see e.g. [ABLN17], and not all of them lead to decidable model-checking problems as undecidability can be sometimes concluded by reduction from undecidable decision problems for counter machines such as for vector addition systems with states (VASS) or for Minsky machines.

Logics in AI and verification games. In the recent work [ABDL18], 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, see e.g. [JLS15, CJLS17]. 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 internship.

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

(2) To identify fragments of the expressive logic RB±ATL* [ABDL18] for which the current decision procedures for solving the model-checking for RB±ATL or for RB±ATL* could be drastically simplified. The ultimate goal is to design expressive fragments of RB±ATL* but restrictive enough to admit relatively low complexity. Existing fragments can be found for example in [ALNR15, AL18, BD19].

(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 [ABDL18].

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 1.39 *Logical Aspects of Artificial Intelligence*
- Course 1.22 *Basics of Verification*
- Course 2.20.1 *Techniques de théorie des jeux en informatique*

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