Master's thesis topics

Here is the outline of two master's thesis topics. Please contact Gilles Geeraerts (gigeerae@ulb.ac.be) for more information. In both cases, the candidate will have the opportunity to interact with the researchers of the Formal Methods and Verification Group of the CS department, composed of 15+ post-doc researchers, and which is funded by several national and international research projects. See the following webpages for more information:

http://www.ulb.ac.be/di/verif/
http://www.cassting-project.eu/
http://www.ulb.ac.be/di/verif/inVEST.html

Implementation and evaluation of an algorithm for solving total payoff games

Game theory is now a prominent formalism in computer science. It can be used to model the antagonistic interactions between two or more components of a computer system. A typical application is controller synthesis: one of the players models a computer system, and the other, a hostile environment. One wants to compute automatically (i.e., synthesise) the right choice of actions for the computer the system, that will guarantee it to avoid problematic behaviours whatever the environment does. This amounts to playing a game between those two players and computing a winning strategy for the computer system.

Having efficient algorithms to solve different classes of games is thus very important. We have recently introduced a new algorithm to solve total-payoff reachability games: this game is played on a graph, and the players interact to build a path in the graph. Each action has a cost (positive or negative) that Player 1 must pay. Its aim is to ensure reaching a give target node in the graph with a minimal cost, whatever Player 2 does. This problem thus nicely generalises the classical shortest path problem in a graph to a two player setting.

The student will be required to:

- read and understand the contribution (available at http://arxiv.org/abs/1407.5030)
- research the literature to establish a state-of-the-art on this problem and related ones
- implement the algorithm(s) of http://arxiv.org/abs/1407.5030 and maybe other solutions for the sake of comparison.
- integrate those algorithm(s) in the Prism model checker (http://www.prismmodelchecker.org/)
- adapt some Prism benchmarks and run the algorithm(s) on those benchmarks.
Implementation and evaluation of an algorithm for Markov decision processes

Markov decision processes (MDPs) are a classical model extending finite automata with probabilities. An MDP can be understood as a game between two players: in each state, the first player chooses a letter, and the second selects the successor state according to some distribution probability. A natural question is thus compute the minimal and maximal probabilities to reach a target set of states in an MDP.

Several algorithms exist to solve this problem. One of them, called the value iteration algorithm amounts to computing successive approximations of those probabilities until some convergence criterion is reached. This algorithm is implemented in a widely used tool, called Prism (http://www.prismmodelchecker.org/).

Unfortunately, it has been shown recently (by Haddad and Monmege, see the article at http://link.springer.com/chapter/10.1007%2F978-3-319-11439-2_10) that the approximation computed by this algorithm might not be precise at all in some cases. In the same article, they propose an alternative algorithm that offers strong guarantees on the converge rate and the preciseness.

The student will be required to:

- read and understand the contribution (of Haddad and Monmege.
- research the literature to establish a state-of-the-art on this problem and related ones
- implement the algorithm and other solutions for the sake of comparison.
- integrate those algorithm(s) in the Prism model checker (http://www.prismmodelchecker.org/)
- run benchmarks on the implementation.