Software Modeling and Verification Chair | RWTH AACHEN UNIVERSITY

— Bachelor's or Master's Thesis —

Probabilistic Model Reduction by Control-State Elimination

What is it all about?

Probabilistic model checking is a fully automated technique to rigorously prove correctness of a system model with randomness against a formal specification. Its key algorithmic component is computing reachability probabilities on stochastic processes such as (discrete- or continuous-time) Markov chains and Markov decision processes. These stochastic processes are typically described in some high-level imperative probabilistic modelling language. State-of-the-art tools like PRISM [KNP11], storm [HJK+20] and mcsta [HH14] support input models specified in e.g., the PRISM modeling language[1], the Jani model exchange format [BDH+17], or the probabilistic guarded command language pGCL [MM05].
Prior to computing reachability probabilities, the model checker explores all the program's possibly reachable variable valuations and encodes them into the state space of the operational Markov model. Termination is guaranteed as variables are restricted to have finite domains. In our preliminary study [WLK20], we have proposed a simple reduction technique for this model construction phase that avoids unfolding the full model prior to the actual analysis, thereby mitigating the state explosion problem. The basic idea is to unfold variables one-by-one—rather than all at once as in the standard pipeline—and apply analyses steps after each unfolding. Our technique acts as a model simplification front-end for general purpose probabilistic model checkers.

What is to be done?

The goal of this project is to extend the aforementioned approach in one or more of the following dimensions:

1. Support for parallel composition of programs.
2. Advanced heuristics: Which variable should be unfolded first?
3. Support for more general properties (beyond reachability).
4. Application to other models (e.g. continuous time Markov chains)

This list is of course non-exhaustive! All of the above suggestions require both theoretical and practical (implementation) effort.

What we expect:

- Solid background in theoretical computer science and maths – ideally you have already taken theoretical CS electives.
- Passion and endurance for solving difficult theoretical problems.
- Willingness to work with a larger C++ code base.

What you can expect:

- Get a chance to work on relevant problems of both theoretical and practical nature.

Apply

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  Please introduce yourself briefly and say why you're interested in this topic!

References

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[1] https://www.prismmodelchecker.org/manual/ThePRISMLanguage

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[KNP11] Marta Z. Kwiatkowska, Gethin Norman, and David Parker. PRISM 4.0: Verification of probabilistic real-time systems. In *Computer Aided Verification - 23rd International Conference, CAV 2011, Snowbird, UT, USA, July 14-20, 2011. Proceedings*, volume 6806 of *Lecture Notes in Computer Science*, pages 585–591. Springer, 2011.

[MM05] Annabelle McIver and Carroll Morgan. *Abstraction, Refinement and Proof for Probabilistic Systems*. Monographs in Computer Science. Springer, 2005.

[WLK20] Tobias Winkler, Johannes Lehman, and Joost-Pieter Katoen. Out of control: Reducing probabilistic models by control-state elimination. *CoRR*, abs/2011.00983, 2020.