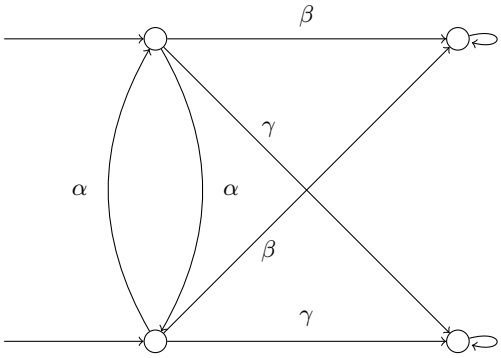
Software Modeling and Verification Chair | RWTH AACHEN UNIVERSITY

— Bachelor's Thesis —

Strategy equivalences for MDPs and nondeterministic probabilistic Programs

What is it all about?

Markov Decision Processes (MDPs) [BBKW24] are models of nondeterministic and probabilistic systems. An example of an MDP is:



The nondeterminism is modeled by different actions α, β, γ. Uncertainty is modeled by probabilisties on transtitions. In order to resolve the nondeterminism, strategies are considered. The easiest form of a strategy is a mapping from the states to the actions: $S \to \{\alpha, \beta, \gamma\}$. These are called memoryless strategies.
On the other hand side, we have nondeterministic probabilistic programs [BKWZ25] that extend deterministic programs by a nondeterministic choice about which code branch is executed next. They can be defined by the following grammar:

$$\mathrm{c} \coloneqq \mathrm{skip} \mid x \coloneqq \mathrm{a} \mid \{\mathrm{c}\}[\mathrm{p}]\{\mathrm{c}\} \mid \{\mathrm{c}\}[]\{\mathrm{c}\} \mid \mathrm{c};\mathrm{c} \mid \mathrm{if\ b\ then\ c\ else\ c\ end} \mid \mathrm{while\ b\ do\ c\ end}.$$

The nondeterministic choice in a probabilistic programs, needs to be resolved by a strategy too. In this thesis, we want to compare different kinds of strategies for a) MDPs and b) nondeterministic probabilistic programs and establish a formal relationship (equivalence) between the two different notions.

What is to be done?

The goals of this project are:

1. Create a survey about different kinds of strategies for MDPs
2. Define different kinds of strategies for nondeterministic probabilistic programs that correspond to strategies for MDPs
3. Prove equivalence of different strategy classes

This list is of course non-exhaustive! The above suggestions may be changed, shortened and/or extended while we work on our project and gain more insights on how difficult the topic is.

What we expect:

- Solid background in theoretical computer science and maths – ideally you have already taken theoretical CS electives
- Passion and endurance for solving theoretical problems

What you can expect:

- Get a chance to work on relevant problems of both theoretical and practical nature
- You can work in the student room at our chair – we have a coffee machine, lots of tea and sometimes cookies :)

Apply

- Daniel Zilken (daniel.zilken@cs.rwth-aachen.de)
  Please introduce yourself briefly and say why you're interested in this topic!

References

[BBKW24] Kevin Batz, Tom Jannik Biskup, Joost-Pieter Katoen, and Tobias Winkler. Programmatic strategy synthesis: Resolving nondeterminism in probabilistic programs. *Proc. ACM Program. Lang.*, 8(POPL), January 2024.

[BKWZ25] Kevin Batz, Joost-Pieter Katoen, Tobias Winkler, and Daniel Zilken. Verifying sampling algorithms via distributional invariants, 2025.