— Bachelor's or Master's Thesis —
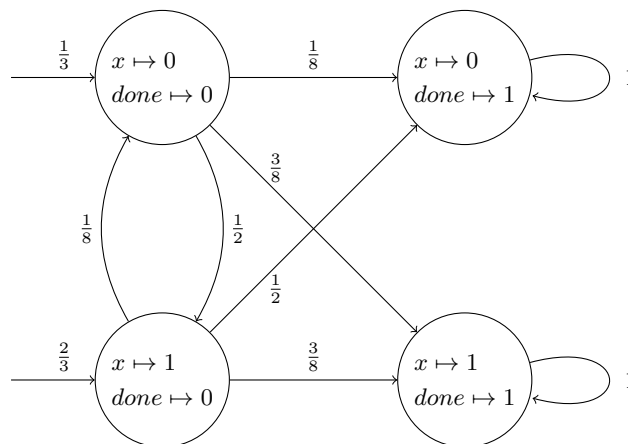
Model Checking Markov Chains as Distribution Transformers

What is it all about?

Probabilistic programs extend deterministic programs by a random choice about which code branch is executed next. They can be defined by the following grammar:

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

Markov chains are models of probabilistic programs and there exists an automatic translation from probabilistic programs to their underlying Markov chain (see e.g. [BBKW24], however, the translation from the paper also regards nondeterminism, we would consider a simpler version without nondeterminism). An example for a Markov chain is:

Markov chains yield a unique stream of distributions and we are interested in model checking temporal properties for this stream of distributions. The paper [ABK$^+$24] examines this problem and finds conditions under which the model checking problem is efficiently solvable.

What is to be done?

The goals of this project are:

1. Understand and apply the model checking problem to multiple examples
2. For a given translation from probabilistic programs to Markov chains: Examine under which conditions for the program, the model checking problem is efficiently solvable

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

[ABK+24] Rajab Aghamov, Christel Baier, Toghrul Karimov, Joris Nieuwveld, Joël Ouaknine, Jakob Piribauer, and Mihir Vahan-
          wala. Model checking markov chains as distribution transformers, 2024.

[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):2792–2820, 2024.