Replication of (Un)sound Multi-Objective Probabilistic Model Checking Algorithms

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Probabilistic model checkers formally verify the behaviour of a system. We can analyse a quantitative property like the chance of success, the expected costs, or system uptime. Traditionally, only one property is considered at once. However, in most real-world processes, multiple properties influence each other. For example, if we consider the maximum uptime of a system, we might be able to achieve a 99.99% uptime, but aiming for a 99.9% uptime instead might only require half the costs. To incorporate such trade-offs into probabilistic model checkers, we need to support multi-objective properties.

We have replicated two classes of techniques for multi-objective model checking on Markov decision processes. First, we implemented a technique that does not provide guarantees of the output but is supposed to deliver good approximations [3]. This is better known as an unsound algorithm. Then we also replicated sound approaches [2,8], where we get guarantees on our output. We replicated all our approaches in the Modest Toolset [5]. During the replication process, we found several curiosities in the papers that describe these methods and their implementations in ePMC [4], PRISM [7], and Storm [6]. This is not only limited to multi-objective properties, but we also found models where these tools provide incorrect answers for single-objective properties.

Although previous studies have noted inconsistencies between different tools [1,8], we went further by identifying minimal models that lead to these inconsistent results and reported incorrect behaviour to the authors of the relevant tools. Therefore, we have helped improve existing tooling while also bringing support for multi-objective model checking to the Modest Toolset.

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