

ABSTRACT

Model Checking for Parametric Discrete-Time Markov Chains

by

Emmanoel Pratama Putra Hastono

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Model checking of stochastic systems, including parametric discrete-time Markov chains, is done with either numerical or statistical methods. The purpose of this research is to perform comparison of the two model checking methods in terms of execution time and accuracy and precision, and to suggest the use of one method over the other for certain conditions.

The numerical and statistical approaches for parametric discrete-time Markov chains will be compared using PRISM model checker, with IPv4 Zeroconf Protocol and Crowds Protocol as the parametric model examples. A Python program is designed to run multiple PRISM commands, collect the results, and generate data for analysis. The numerical approach will generate a probability equation for a property in terms of the parametric variables of the Markov chain, which is then used to calculate probability values for the variables. The values are then compared with the resulting values from statistical model checking to analyze the accuracy, precision, and performance. The statistical approach outcomes are generated using confidence interval.

The results of the experiments show that the numerical method has a faster execution time compared to the statistical one for verification IPv4 Zeroconf Protocol, considered a small and simple system. However, for Crowds Protocol, a large and complex model, the time taken for numerical model checking exponentially increases, rendering it ineffective in terms of time and memory. In addition, comparing statistical results to numerical ones, the accuracy for statistical results are determined to be low for probability values near 0, and the precision for statistical results are also determined to be low for probability values near 0.

Keywords: model checking, numerical model checking, statistical model checking, parametric discrete-time Markov chains, IPv4 Zeroconf Protocol, Crowds Protocol