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Reachability in Parametric Interval Markov Chains using Constraints

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Abstract

Parametric Interval Markov Chains (pIMCs) are a specification formalism that extend Markov Chains (MCs) and Interval Markov Chains (IMCs) by taking into account imprecision in the transition probability values: transitions in pIMCs are labeled with parametric intervals of probabilities. In this work, we study the difference between pIMCs and other Markov Chain abstractions models and investigate three semantics for IMCs: once-and-for-all, interval-Markov-decision-process, and at-every-step. In particular, we prove that all three semantics agree on the maximal/minimal reachability probabilities of a given IMC. We then investigate solutions to several parameter synthesis problems in the context of pIMCs – consistency, qualitative reachability and quantitative reachability – that rely on constraint encodings. Finally, we propose a prototype implementation of our constraint encodings with promising results.

Keywords: Markov chains, abstract models, reachability, parameter synthesis, constraint programming

Discrete time Markov chains (MCs for short) are a standard probabilistic modelling formalism that has been extensively used in the literature to reason about software [1] and real-life systems [2]. However, when modelling real-life systems, the exact value of transition probabilities may not be known precisely. Several formalisms abstracting MCs have therefore been developed. Parametric Markov chains [3] (pMCs for short) extend MCs by allowing parameters to appear in transition probabilities. In this formalism, parameters are variables and transition probabilities may be expressed as polynomials

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