Rare Event Simulation with Fully Automated Importance Splitting

Carlos E. Budde[1(✉)], Pedro R. D'Argenio[1], and Holger Hermanns[2]

[1] FaMAF, Universidad Nacional de Córdoba – CONICET, Córdoba, Argentina
{cbudde,dargenio}@famaf.unc.edu.ar
[2] Fakultät für Mathematik und Informatik, Universität des Saarlandes, Saarbrücken, Germany
hermanns@cs.uni-saarland.de

Abstract. Probabilistic model checking is a powerful tool for analysing probabilistic systems but it can only be efficiently applied to Markov models. Monte Carlo simulation provides an alternative for the generality of stochastic processes, but becomes infeasible if the value to estimate depends on the occurrence of rare events. To combat this problem, intelligent simulation strategies exist to lower the estimation variance and hence reduce the simulation time. Importance splitting is one such technique, but requires a guiding function typically defined in an *ad hoc* fashion by an expert in the field. We present an automatic derivation of the importance function from the model description. A prototypical tool was developed and tested on several Markov models, compared to analytically and numerically calculated results and to results of typical *ad hoc* importance functions, showing the feasibility and efficiency of this approach. The technique is easily adapted to general models like GSMPs.

1 Introduction

Nowadays, systems are required to have a high degree of resilience and dependability. Determining properties that fail with extremely small probability in complex models can be computationally very demanding. Though these types of properties can be efficiently calculated using numerical tools, such as the model checker PRISM [8], this is limited to finite Markov models, and, moreover, the representation through an adequate data structure needs to fit in the computer memory. Beyond this class of models calculations are limited to Monte Carlo simulation methods. However, standard Monte Carlo simulation may easily need an enormous amount of sampling to obtain the desired confidence level of the estimated probability, in order to compensate for the high variance induced by the rare occurrences of the objective property.

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