Time-Lengths in Time Petri Net Models for Steady States in Biochemical Systems

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Abstract

In this paper we are interested in situations of biochemical reaction systems (BioRSs) in which all species have constant concentrations and all reactions have constant rates. Such a situation is called steady state and usually achieved after some time has elapsed since the system's beginning.

We start with a model of a BioRS presented as a stochastic Petri net (SPN). This is originally obtained from a system of ordinary differential equations (ODEs) achieved using simulation and interpolation.

The concentrations and rates modeling the steady state in the BioRS can be established by simulation of the SPN-model. A steady state in the BioRS signifies also that on the model level only a subset of all possible reachable states is relevant to this situation. It would be of interest to isolate formally and constructively this subset of states.

Considering the SPN model we propose an approach to calculate the part of the state space corresponding to a steady state in the BioRS. To do so, we map the SPN-model onto a Time Petri Net-model (TPN) with the same behaviour as that formerly observed one during the simulation of the SPN attaining the steady state. Finally, the TPN can be analyzed qualitatively and quantitatively. Notably, the time length of the cycle(s) representing the steady state can now be computed. To our knowledge there is no way to achieve this using the SPN-model or the ODE-model.

In addition, this approach helps for validating the correctness of the calculated (and used) rates in the steady state in the BioRS and of the parameters used in the original ODEs, fixed by experiments in the wet labs, both being -a priori- subject to a certain degree of uncertainty.

We thank the PC for inviting us to present our work at this workshop so that we can help to build a bridge between traditionnal MecBIC themes and Petri Nets. All details of this work can be found in http://ceur-ws.org/Vol-724.