

Petri net modelling of regulatory networks

E.Remy

IML - Institut de Mathématiques de Luminy
Campus de Luminy Case 907, 13288 Marseille France

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When facing a complex regulatory network, the biologist needs new means to check the coherence of tentative models with the observed dynamics, to better understand the logics of the interactions and to simulate the system behaviour for various kinds of perturbations. In this respect, and because precise quantitative data are rarely available, qualitative approaches are well-suited. Moreover, they can further open the way for more detailed models. One qualitative approach consists in modelling regulatory networks in terms of logical equations (using either Boolean or multi-level discretisation). Petri Nets (PNs) and their extensions constitute a complementary framework to analyse the dynamical properties of concurrent systems.

After a brief presentation of the logical approach for the modelling of regulatory networks, I will introduce our proposal of a PN framework for the logical modelling of gene regulatory networks, covering both coloured and standard Petri net representations. It first consists in the definition of a rigorous mapping of multi-level logical regulatory models into specific colored Petri nets, called *Colored Regulatory Petri Nets* (CRPN). These CRPN provide an intuitive graphical representation of regulatory networks, relatively easily to grasp by biologists. We further deploy these CRPN into standard Petri nets, which are more amenable to algebraic analyses. Using standard Petri net tools, it is then possible to identify interesting dynamical properties (invariants), or to check the consistency of the model with dynamical data (model checking).

This methodological scheme is illustrated by the PN translation and the analysis of a multi-level logical model of the core regulatory network controlling the differentiation of T-helper lymphocytes into Th1 and Th2 types.