Qualitative discrete-event modelling in ecology: concepts and analysis

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Résumé

Depending on their scales or the abstract level of their description, ecological phenomena can be conceptualized and modelled differently. Traditionally in ecology, phenomena are described quantitatively, either in a discrete or continuous way. This approach offers one among several perspectives of ecological systems that is theoretically and operationally fruitful. However, while it enables thinking, it also imposes constraints limiting our ability to model certain ecological objects and phenomena. As a consequence, complementary approaches such as qualitative modelling have emerged. These approaches have found one of their most significant uses in systems biology, where complex metabolic networks are modelled as discrete-event systems, with genes and other chemical species being activated or inactivated by their mutual interactions. Despite the widespread use of this description in systems biology, it remains rare in ecology.

In my presentation, I will discuss the use of discrete-event models in ecology, particularly focusing on the Ecological Discrete-Event Network (EDEN) modelling framework. After briefly introducing the main concepts, their articulation, and the ecological interpretations that can be drawn, I will demonstrate through various applications that these models are associated with specific analysis tools (e.g., Petri net invariants, temporal logics, or causal analyses) that enable to rigorously study certain properties of ecological systems that have been little explored until now. I will discuss the complementarity of these approaches with some more traditional ones in ecology as well as some bridges between them.

Finally, building on the conceptual and methodological fertility of the convergence between systems biology and theoretical computer science, I will advocate for a better convergence of ecology with these research communities, as their potential exchanges can be mutually beneficial.

Mots-Clés: qualitative model, ecosystem dynamics, community assembly, model checking, ecological modelling

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