High-Level Extensions for Stochastic Activity Networks: Theories, Tools and Applications

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Ph.D. Dissertation,
Submitted to Department of Computer Engineering,
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Nov. 2005

Abstract

Stochastic activity networks (SANs) are a powerful and flexible extension of *Petri nets*. These models are supported by several powerful modeling tools and have been used for the evaluation of *performance*, *dependability* and *performability* of a wide range of systems. In spite of their power and flexibility, SANs are not *high-level* models. The most important limitations of SANs are as follows: (1) Weakness in *structures for composed and hierarchical models*; (2) The lack of facilities for *data manipulation*; and (3) No integration with *object-orientation*. The above limitations are the important reasons for why SANs have not been used for modeling and analysis in some fields such as *software systems*.

On the other hand, several high-level extensions have been introduced for Petri nets. These extensions add *hierarchy*, *time* or *colour* to these models. *High-level Petri nets* have been proposed to obtain the analyzable models as a product of the project specification. However, the generation of huge models, which are not optimized for evaluation purposes, is an important problem of high-level Petri nets.

In this dissertation three high-level extensions are introduced for SANs. The first extension is called *hierarchical stochastic activity networks* (HSANs). HSANs define *well-defined* and *encapsulated* submodels, which do not limit a modeler to some pre-defined structures of hierarchy. The second extension is called *coloured stochastic activity networks* (CSANs). The main goal of CSANs is to enhance SANs with facilities for data manipulation and generating more compact models. CSAN models can be solved by state space analysis or simulations methods. The concept of *measure-adaptive analysis* is introduced for efficient solution of CSAN models. The third extension is called *object stochastic activity networks* (OSANs). The main motivations of OSANs are as follows: (1) integrating object-orientation with SAN models, (2) introducing a formalism that is useful for *object-oriented modeling* (OOM) of software systems and (3) the generated models are still optimized for analysis purposes. It is possible to construct hierarchical models in both latter extensions, which are called *HCSANs* and *HOSANs*. For all extensions, three settings are defined: *nondeterministic*, *probabilistic* and *stochastic*. This makes the high-level extensions useful for both *functional analysis* (i.e. *verification*) and *operational analysis* (i.e. *evaluation*).

For modeling with a new definition of SANs and the above mentioned high-level extensions, *SharifSAN* and *SANBuilder* modeling tools are developed. Some efficient analysis methods and techniques are used in these tools. To demonstrate the appropriateness of the above mentioned extensions and tools, they have been used in several case studies in high-speed networks and software systems. The main specifications and features of the above tools and results of the case studies are also presented in this dissertation.