TOWARD AN INTEGRATED FRAMEWORK FOR THE SIMULATION, FORMAL ANALYSIS AND ENACTMENT OF DISCRETE EVENTS SYSTEMS MODELS

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ABSTRACT

This research proposes a framework that aggregates resources for formal investigation of different properties of systems using disparate analysis methodologies such as simulation, formal methods and code synthesis for real time enactment. There is a plethora of development environments that support individual analysis methodologies; however, those that truly support multiple methods are not common -at least for academic purposes. Therefore complete studies of systems' properties often require the mastery of several formalisms since no single methodology is sufficient to investigate all aspects of a system .We aim to provide an extensible framework that serves as a generic computational engine for studying different aspects of a broad range of systems that cut across disciplines. The kernel of the framework is a high level modeling language which acts as a generic front end that bridges the gap between all stakeholders using the state of the art in model-driven development.

1 INTRODUCTION

Model-based system engineering have been used extensively in recent decades to study, evaluate, verify, validate, and forecast different properties of complex systems. The knowledge gained from these studies usually provide useful feedbacks to provide deeper understanding of the properties of a system and the influences it may have on its environment or which the environment may have on it.

Different aspects of a system require specialized methods to investigate the properties of interest. For example; dynamic properties such as its internal behavior and responses to certain stimuli in different scenarios created by its environment can be efficiently described and analyzed using appropriate simulation methodologies. Similarly, validation of static properties such as safeness and deadlock freedom in any scenario are better handled with some appropriate formal methods. Therefore, an exhaustive study of a system often requires the specification of same system in disparate formalisms that hardly cooperate seamlessly leading to limited model reuse. This phenomenon, in addition to being burdensome for prospective domain expert users, it does not promote collaborations between practitioners of the different analysis methodologies.

The SimStudio (Traoré 2008, Touraille et al. 2011) proposed to address the aforementioned issues through a Modeling & Simulation environment based on DEVS (Discrete Event System Specification) (Zeigler et al. 2000) that integrates disparate tools for modeling, simulation and analysis in a single platform through transformations between disparate models. DEVS was chosen as the principal formalism because it is considered by many to be a universal formalism for simulation modeling(Vangheluwe 2000), it however does not serve the purpose for formal methods and other analysis methodologies; therefore complete automation of collaborations between DEVS-based models and non simulation-based analyses tools cannot be guaranteed.

In this work, we extend the SimStudio proposal through the exploration of a high level specification language that coherently integrates common and complementary system constructs from DEVS, Z (Spivey 1998) and Object Orientation (OO) to provide a more universal formalism to model Discrete Events Systems (DES) for simulation, formal analysis and enactment. Enactment in this context refers to the synthesis of program codes as a prototype for the verification of the system's behavior in real time. Our choices of Z and OO are also motivated by their considerable universalities for modeling systems for formal methods and enactment respectively. Therefore, a consistent integration of the duo with DEVS promises a universal formalism at a higher level for creating more complete universal DES models that are amenable to automated manipulations by the mechanisms of the disparate analysis methodologies.

2 APPROACH

An overview of the methodology is presented in Figure 1. At the core of the framework is a Unified Integrated Formalism (UIF) that is built from the integration of concepts from DEVS, Z and OO with a graphico-textual concrete syntax to make it usable and communicable especially for non-expert users. The UIF's semantics are provided in the disparate mechanisms for different kinds of analyses as shown in the diagram. To ensure consistent interpretations of models in the different mechanisms, the UIF's abstract syntax is fortified with a mathematical semantic to provide a common understanding for tools. We target state of the art model-driven development technologies to extract the information required by each mechanism from a unified format of data exchange in which every instance of UIF is stored.

This approach promises a single high level front end for model editing that hides the complexities of rigorous model specifications; creation and update of models are done once and complete artifacts for the disparate methodologies are (re)generated automatically.

The bottom-right corner of Figure 1 illustrates how the UIF serves as an extension point to adapt the framework as a computational engine for multi-disciplinary system analyses. Any Domain-Specific Language (DSL) can connect to the framework as long as there is a way to generate a UIF representation of its models.

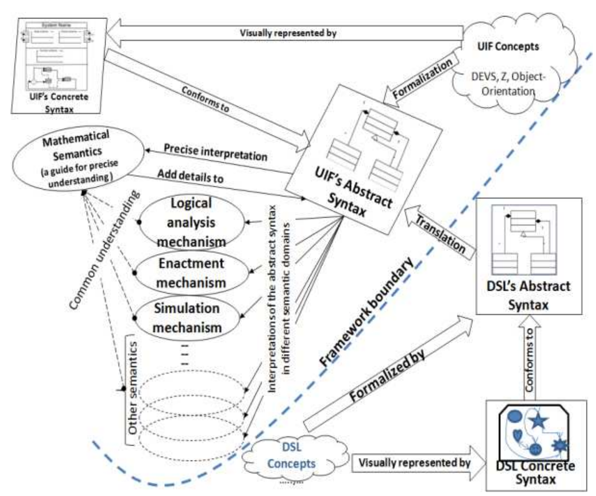

Figure 1 Overview of the methodology

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