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Examiner's Report
on the dissertation entitled
"Towards a modelling framework with temporal and uncertain data for adaptive systems"
by Ludovic MOULINE

Linz, 20th October 2019

Topic of the dissertation

The dissertation of Mr. Ludovic MOULINE deals with the fast growing research area of adaptive (cyber-physical) systems especially targeted to the modelling of temporal data (e.g., for long-running actions) and uncertain data (e.g., for measurements) aspects.

Context of the dissertation

Model-based software and systems engineering has grown to a major research area in software development since the late nineties. The major idea being using models as primary software development artefact, thus, allowing to reason, to verify, and to execute (beside others) the software to be developed on a high-level of abstraction without having to deal with low-level implementation issues and rapidly changing technological platforms. However, recent advances in system development challenge existing model-based engineering approaches and accompanying modelling languages, especially in the area of technical systems known as cyber-physical systems. Here, appropriate and practical abstractions and corresponding modelling languages are needed to effectively and efficiently develop and maintain such systems taking into consideration temporal and uncertain data aspects such as outlined in the thesis.

Content of the dissertation

This thesis proposes a dedicated modelling framework which provides two extensions with respect to traditional modelling frameworks.

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- First, it introduces Ain'tea for managing data uncertainty at the language level. It is a language which provides dedicated types to represent uncertain data as well as operations which are capable of manipulating such uncertain data. Ain'tea comes as a textual language and allows for uncertainty-aware type checking as well as sampling of distributions.
- Second, the thesis introduces a temporal knowledge metamodel which allows to reason over unfinished or long-running actions to understand the adaptive behaviour of a system. It allows to represent the core concepts of adaptation processes and the structure to store the state and behaviour of running adaptive systems with a high-level API. The resulting framework allows to abstract decisions, circumstances, and effects based on a temporal model representation.

The contributions of this thesis are evaluated with real use cases (from the smart grid domain) which clearly demonstrate the benefits of the proposed language and the proposed knowledge metamodel. The tool support is publicly available as Github projects which contributes to the general field of open science.

The thesis provides a good overview on the necessary background for the research fields addressed by the dissertation. As expected, adaptive systems, model-driven engineering (MDE), software language engineering (SLE), and probability theory are introduced at first. The applicant discusses the various topics and provides clearly which concepts are used by the thesis later on as a basis for his own contributions. With this chapter, the applicant impressively demonstrates his knowledge on necessary background material and his ability to put various research areas into context.

The state of the art evaluation is another impressive part of the thesis. A lot of approaches for modeling adaptive systems with long-term actions and uncertainty aspects are evaluated in a systematic manner (e.g., based on snowballing) by using well-established criteria catalogues. The evaluated approaches are coming from several different research fields which only partly tackle the stated requirements. This becomes clearly evident by the systematic evaluation approach, and thus, the need for this thesis is clearly motivated.

Concluding Evaluation

The framework proposed and developed by the dissertation is novel, theoretically sound, and with high potential for practical use. The dissertation also identifies some promising avenues of further research. In the increasingly growing model-driven software and systems engineering area, new means for developing domain-specific modeling languages for truly supporting cyber-physical systems in an agile way is a must. The results of this dissertation provide interesting solutions in this respect.

In summary it has to be said that the scientific work done by Ludovic MOULINE is impressive. His findings have been published in peer-reviewed, internationally renowned conferences. Especially, it has to be mentioned that he published papers on his PhD topic, e.g., at MODELS, ICAC, and SAC, and this clearly shows the capabilities of the candidate to publish in competitive venues. Also the general list of publications is very good for researcher of his age. **Thus, I strongly suggest to accept the dissertation.**

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