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Ilias Gerostathopoulos, Doctoral Thesis – Advisor's Reference

The submitted doctoral thesis concentrates upon the main topic of architecture design of software-intensive cyber-physical systems (siCPS) according to high-level requirements. The work has been done partially in the scopes of the EU FP7 projects ASCENS and Marie Curie ITN RELATE. The ASCENS project aimed at providing methods for analysis, design and development of large collective adaptive systems comprised of dynamic collaboration groups (ensembles) of software components, while ITN RELATE focused on engineering and provisioning of service-based cloud applications. The thesis is focused on two main goals: (i) to propose an architecture design process, consisting of dedicated methods and models, for siCPS modeled as ensemble-based component systems, and (ii) to map the proposed design models to implementation-level abstractions in order to allow for model-driven development of siCPS.

The thesis starts with a description of the domain of siCPS with the help of an example focusing on coordinated navigation of electric vehicles. The author emphasizes the challenges in the design and development of siCPS and states the research goals of the thesis (Chapter 1). Then, the state of the art in the areas of goal-oriented requirements engineering (Section 2.1) and agent-based methodologies and component-based systems (Section 2.2) is discussed in an effort to pinpoint the limitations and advantages of existing approaches when applied in the domain of siCPS. In the light of this discussion, the thesis's goals are refined into concrete objectives (Section 2.3). In Chapter 3, the author provides an overview of the contribution along the identified concrete objectives. The main contribution is the introduction and elaboration of a novel design method based on iterative refinement of system requirements captured in terms of invariants over components' knowledge (IRM). IRM is also extended to allow the specification of alternative refinements (IRM-SA). This in turn provides the basis for runtime self-adaptation by means of switching between alternative architecture configurations at runtime according to the satisfaction of invariants belonging to different refinement branches. IRM concepts are mapped to concepts of the DEECo component model, allowing for automatic generation of implementation artifacts. The individual contributions of the author's work were published

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separately in a collection of seven papers included in Chapter 4. There, each paper is prefaced by a summary and comments on authorship. The text then continues by explaining the evaluation strategy used in the work leading to the thesis (Chapter 5). The work is evaluated in terms of (i) the applicability of the design method in modeling real-world applications, (ii) the feasibility of the IRM-SA model-driven development based on implementation of design and model manipulation tools, (iii) the feasibility of IRM-SA self-adaptation of DEECo systems based on implementation of a jDEECo plugin, and (iv) the effectiveness of the IRM-SA design process based on a controlled experiment with students. Finally, Chapter 5 concludes the thesis and provides the author's personal account on the open challenges in the area of model-based software engineering for siCPS.

The thesis is based on a number of peer-reviewed papers published at international conferences and workshops. In particular these include the CompArch CBSE'13 conference (proceedings by ACM), MODELS'14 ACM student research competition (proceedings by CEUR) and SASOW '13 conference (proceedings by IEEE).

In my view, Ilias Gerostathopoulos proved the ability of performing high-quality research with internationally relevant results. This thesis only confirms this fact. Thus, I strongly recommend the thesis for defense and to grant the Doctor degree to Ilias Gerostathopoulos.

doc. RNDr. Petr Hnětynka, Ph.D.
Advisor