
Editorial

Eric Coatanéa* and Mohamed Bakhouya

School of Engineering,
Aalto University,
Otakaari 4, FIN-00076 Aalto, Finland
Email: eric.coatanea@aalto.fi
Email: mohamed.bakhouya@aalto.fi
*Corresponding author

Biographical notes: Eric Coatanéa received his double doctoral degree in Engineering Design in 2005 from Helsinki University of Technology in Finland (nowadays Aalto University) and from University of West Brittany (France). He has also studied in Ecole Normale Supérieure and in INSA Toulouse. He was Marie-Curie Fellows from 2005 to 2007. He is Professor at Aalto University and leader of the research group on Early development process and system engineering. His research interests include design and manufacturing, system thinking and system engineering, eco-design, creativity and innovation. His research focus is the development of support tools for the early design phases.

Mohamed Bakhouya is a senior research scientist at the Aalto University, Finland. He received a PhD degree (2005) from UTBM. He has been a lecturer and research scientist at UTBM (2004–2006), the George Washington University (GWU-USA, 2006–2008), and UTBM (2008–2011). His research interests include various aspects on the design, implementation, and performance evaluation of distributed systems. He is a member of many international programme committees, chair of two international workshops, participated in conference organisation in different roles, and served as a guest editor for *ACM TAAS*. He is a member of IEEE and ACM.

1 Introduction

Rapid advances in technology and design tools are enabling engineers to design systems containing multiple and interacting components. The growing complexity and the tightening time-to-market constraints results in an increasing design productivity gap. Mastering the complexity and risk associated with the design process is then of increasing importance. The papers in this special issue cover some of the topics aforementioned and constitute a representative sample of the latest developments in computer-aided tools and methodologies for early design.

The everyday environment of modern system and product development engineers is filled with large-scale phenomena and systems that they cannot understand and analyse solely applying their cognitive abilities. Nevertheless, good understanding and analysis of complex systems and phenomena are crucial for the final success of development projects, good final performances, and customer and market acceptance of the developed systems. This is all the more true during the early development activities when the

development team makes decisions that will strongly influence such aspects as the final costs, technical performances, robustness and reliability of the associated equipment, systems and services.

During the early stages of the development of complex systems, designers must consider multiple levels of interactions between different types of requirements; this represents a very high level of complexity. In order to support them in their tasks, lift the restrictions caused by limited cognitive abilities, and help to cope with this ever-increasing complexity, new computer-based support tools are required. At the moment, existing commercial computer tools and methods provide rather poorly this type of interactive support for the engineering design activity, especially during the early stages. In some areas of the design process, they do not provide real added value at all. For example, it is difficult to interactively reveal the different levels of interrelations between requirements and elements of system architectures. Complex networks of interrelations are also often neither considered nor represented explicitly.

Although a few existing tools and methods provide support for automatic quality checks of individual requirements and networks of complex interactions, they are based on a very limited set of quality metrics. Most of the time, quality checks of requirements and the analysis of their fulfilment still completely rely on specialists' knowledge and can lead to silo analyses during system development. Moreover, the overall state of the art related to impact analysis, quality verification of both networks of requirements and individual requirements, and computer-aided requirements network elicitation remains very limited. Additionally, certain crucial information is not systematically exploited by support tools during the early stages of the design process, e.g. consideration of contradictory objectives imposed by requirements, benchmarking of existing solutions, and information that is not exploited during the early stages. Therefore, developing new forms of computer-aided methodologies and tools dedicated to the early design stage are required. Furthermore, because of time-to-market constraints, there is today a crucial need for new system design tools and methodologies to assist designers in designing and developing such systems.

2 Theme of the special issue

This special issue provides a comprehensive overview of the key topics and state of the art of computer-aided tools and methodologies for early design stages. The goal is to find innovative answers to some of under-represented research domains and related research questions. Five articles have been selected for this issue, several considering Systems Modelling Language (SysML) and proposing different uses for it, to help reach that goal.

Franciosa et al. in the first article present a computer tool able to statistically analyse variations that occur during the assembly processes of flexible parts. The authors propose to integrate such types of tools during the early stages of the development process to assess design solutions.

Hüsig and Waldmannstetter in the second article examine current developments in the field of innovation management and computer-aided innovation and propose a new classification scheme for innovation management software tools.

Micaëlli et al. in the third article present a concrete use of the ISO 15288 standard associated with SysML. Using four SysML diagrams, the authors propose a framework to map stakeholder requirements, link these requirements via causal relationships, and

ensure their traceability. The framework is illustrated on the design of a robotised gearbox. The article emphasises the importance of developing a systemic vision in system engineering and the main contribution lies in the formalisation of the use of SysML.

Sell and Petritsenko in the fourth article consider the concrete use of SysML in the case of the development of a mobile robot platform. SysML is applied to create different modelling aspects of the platform and to represent simulation scenarios. In this application, SysML is used to provide predefined models and simulation cases to help designers compare potential design solutions more effectively, i.e. minimising the time required to find the optimal solution while maximising the help provided by computational tools.

Huang et al. in the fifth article investigate user behaviour patterns in order to present user preferences and knowledge backgrounds to help designers evaluate design concepts and final products. The article refines this approach by discussing the different methods that can be used to identify target users during the early stages.

3 Conclusion

In this special issue, articles presented provide interesting, some even controversial, viewpoints and perspectives regarding these crucial stages of the development of a system. We hope that the readers can benefit from the perspectives developed in this special issue and will contribute to this strategically important, exciting, and fast growing area of research.

Acknowledgements

The guest editors of this special issue would like to thank all the authors who submitted their papers to this special issue. We are also very grateful to the referees for their advice and feedback to authors. As guest editors of this special issue, we would principally like to express our gratitude to the Editor-in-Chief Dr. M.A. Dorgham for the opportunity to edit this special issue, his assistance during the special issue preparation, and for giving the authors the opportunity to present their work in the *International Journal of Product Development*.