

Workshop on Tools and Methods for Management and Engineering of CPSoS

February 9th, 2015 the “*Workshop on Tools and Methods for Management and Engineering of CPSoS*” took place at TU/e, Eindhoven, The Netherlands. The purpose of this workshop was to discuss research challenges in the area of Engineering of Cyber-Physical Systems of Systems. These research challenges are proposed by the FP7 Support and Communication Action CPSoS (www.cpsos.eu). CPSoS – *Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-physical Systems of Systems* – is a 30-month Support Action supported by the European Commission under the FP7 programme. Its main goal is to provide a European Research and Innovation agenda on Cyber-Physical Systems of Systems.

CPSoS provides a forum and an exchange platform for Systems of Systems-related communities and ongoing projects, focusing on the challenges posed by the engineering and the operation of technical systems in which computing and communication systems interact with large complex physical systems. Its approach is simultaneously integrative, aiming at bringing together knowledge from different communities, and applications driven.





The program was composed of presentations by members of Working Group 3, by representatives of local industry and a presentation and discussion of the research challenges that have been identified by the project. The program of this workshop is provided below and a short summary of each of the presentation is provided afterwards.

Programme		
10:30 - 11:00	Introduction to the CPSoS project	<u>SEBASTIAN ENGELL, TUDO & HAYDN THOMPSON, HAYDN CONSULTING</u>
11:00 - 11:45	Modeling, analysis and co-design of control tasks over wireless networking protocols: state-of-the-art and challenges	<u>ALESSANDRO D'INNOCENZO & MARIKA DI BENEDETTO, UNIVERSITA AQUILA</u>
11:45 - 12:30	Model Driven Engineering for high-performance servo control -- from research to industrial practice	<u>JEROEN VOETEN & RAMON SCHIFFELERS, ASML</u>
13:30 - 14:15	Real-time capable mobile devices as a platform for CPSoS implementations	<u>STEFAN KOWALEWSKI, RWTH AACHEN</u>
14:15 - 14:45	Cyber-Physical Systems Challenges -- A Needs Analysis for Collaborating Embedded Software Systems	<u>GARETH THOMAS & JAN WILLEM POLDERMAN, THE MATHWORKS</u>
15:15 - 16:30	Key CPSoS Research and Innovation Challenges	<u>SEBASTIAN ENGELL, TUDO & MICHEL RENIERS, TU/E</u>
16:30 - 17:15	The Future of Model Driven Software Engineering	<u>ROBERT HOWE, VERUM SOFTWARE TOOLS</u>

Summary of presentations

10:30 - 11:00 Introduction to the CPSoS project ([SEBASTIAN ENGELL, TUDO & HAYDN THOMPSON, HAYDN CONSULTING](#))

Sebastian Engell presented briefly the CPSoS project¹, its goals and structure, for the participants in the audience that were unfamiliar with the project. Haydn Thompson informed about recent developments of ideas of the European Commission in the areas of Internet of Things and Cyber-Physical Systems.

11:00 - 11:45 Modeling, analysis and co-design of control tasks over wireless networking protocols: state-of-the-art and challenges ([ALESSANDRO D'INNOCENZO & MARIKA DI BENEDETTO, UNIVERSITA AQUILA](#))

Alessandro D'Innocenzo discussed the state-of-the-art and challenges for modelling, analysis and co-design of control tasks over wireless networking protocols. Advantages of the use of wireless communications are their low cost, broader scope of sensing and control, and reconfiguration enabledness. Drawbacks are increased complexity of the overall system, nonideal behaviour, and security issues. Reported challenges are the formal specification of interfaces (for both control and communication), quality of experience metric of control, robustness to package loss, formal verification and automatic co-design of networked systems, absence of acceptable co-simulation tools for control and communication, and real-time protocols for wireless communication and control.



11:45 - 12:30 Model Driven Engineering for high-performance servo control -- from research to industrial practice ([JEROEN VOETEN & RAMON SCHIFFELERS, ASML](#))

Schiffelers illustrated the challenges in the realization of high-end servo control in lithography applications. A platform-based and model-driven engineering approach was proposed. Platform-based design offers a separation of concerns of application configuration data and platform configuration data through a mapping of configuration data. For convenient specification, domain-specific languages are proposed. By means of (automated) model transformations models are transformed to general purpose formalisms that can be used for analysis and synthesis.

¹ See <http://www.cpsos.eu> for more information on the project.

13:30 - 14:15 Real-time capable mobile devices as a platform for CPSoS implementations [\(STEFAN KOWALEWSKI, RWTH AACHEN\)](#)

Kowalewski demonstrated how the integration of control systems with the cloud / web may be achieved and which hurdles need to be taken. Devices with the operating system Android can be used for control if real-time behaviour can be assured. It was shown how Android can be made real-time capable, however at the expense of lower energy efficiency. The second part of the talk focused on on-the-spot validation of PLC code applying techniques from model checking using invariants and over-approximation techniques such as value sets and intervals, bit sets and k sets to obtain the necessary abstraction for scalability purposes. The last part of talk demonstrated the software architecture of a system for extra-corporal membrane oxygenation.

14:15 - 14:45 Cyber-Physical Systems Challenges – A Needs Analysis for Collaborating Embedded Software Systems [\(GARETH THOMAS & JAN WILLEM POLDERMAN, THE MATHWORKS\)](#)

Thomas presented three focal points from which several needs for collaborating embedded systems are identified by The Mathworks. These focal points are (1) research in CPS is fundamental, (2) identifying needs/challenges is key in moving the needle, and (3) software tools play a key role in connecting academia and industry. The identified needs are the following: (1) collaborative planning, guidance and control, (2) distributed multi-rate architectures (extracting and deriving specific value from general information), (3) multi-use functionality post deployment and feature extraction, and (4) systematic test suite generation and automated test evaluation (test results reproduction under minimum uncertainty). From the discussion afterwards it was noted that tools should fit into industrial workflows, otherwise they are not taken up.

15:15 - 16:30 Key CPSoS Research and Innovation Challenges [\(SEBASTIAN ENGELL, TU DORTMUND & MICHEL RENIERS, TU/E\)](#)

Engell and Reniers presented the current status of the research agenda of the CPSoS project. Three main research and innovation challenges were presented:

- Distributed, reliable and efficient management of CPSoS,
- Engineering support for the design-operation continuum of CPSoS, and
- Cognitive CPS.

From the discussion with the audience it is noted that the challenges seem very ambitious. For example in the area of verification scalability is known to be a problem for systems much simpler than CPSoS already. It was agreed that an ordering into short, medium and long-term challenges is needed.

16:30 – 17:15 The Future of Model Driven Software Engineering [\(ROBERT HOWE, VERUM SOFTWARE TOOLS\)](#)

Howe stated that software is increasingly embodying the value of a product and that conventional software engineering is failing to meet the needs of the businesses that depend on it. Model driven software engineering must be used to improve the engineering process. For this to be successful it must be easy for customers to adopt the approach, it must cope with legacy software, offer a total solution and foremost provide compelling, measurable benefits. Model driven software engineering needs to be about people, customer business cases and making money. There are enough workable model driven design technologies around. All the elements to be successful are in place. We just need a determined drive to bring them all together.

List of participants

In total 31 participants from different backgrounds were present among which 12 representatives of the local industry² and 9 [members of Working Group 3](#).

1. Robert Howe (Verum Software Tools)
2. Gareth Thomas (The MathWorks)
3. Rachid Kherrazi (Nspyre)
4. Ivo ter Horst (ASML)
5. Vincent Gijssen (Alewijnse)
6. Joost van Eekelen (Vanderlande Industries)
7. Willem van Veggel (ASML)
8. Maarten Kuijper (FEI)
9. Paul Hoogendijk (Verum Software Tools)
10. Amin Mannani (Alten Mechatronics)
11. Lou Somers (Océ)
12. Matti Kinder (ASML)
13. Stefan Kowalewski (RWTH Aachen)
14. Erwin Schoitsch (AIT – Austrian Institute of Technology)
15. Alessandro D’Innozenzo (Universita l’Aquila)
16. Martin Törngren (KTH Stockholm – Delegate FP7 project CyPhERS)
17. Michel Reniers (TU/e, Department of Mechanical Engineering)
18. Christian Sonntag (TUDO, euTexoo)
19. Wan Fokkink (TU/e, Department of Mechanical Engineering)
20. Bertrand Copigneaux (inno TSD)
21. Sebastian Engell (TUDO)
22. Radoslav Paulen (TUDO)
23. Haydn Thompson (Haydn Consulting, Think)
24. Svetlana Klessova (inno TSD)
25. Maurice Heemels (TU/e, Department of Mechanical Engineering)
26. Bram van der Sande (PhD student ASML from TU/e, Department of Electrical Engineering)
27. Ernesto Romero Sahagún (Master student ASML from TU/e, Department of Mechanical Engineering)
28. Bert van Beek (TU/e, Department of Mechanical Engineering)
29. Yorrick Vissers (Master student ASML from TU/e, Department of Mechanical Engineering)
30. Robinson A. Medina Sánchez (PhD student, TU/e, Department of Electrical Engineering)
31. Lennart Swartjes (PhD student Vanderlande Industries from TU/e, Department of Mechanical Engineering)

² For sending out invitations to local industry an address file was used provided by the [High Tech Systems Center](#).

