Third International Workshop on Multi-Paradigm Modeling for Cyber-Physical Systems (MPM4CPS)

1 General Information

Organizers:
Moussa Amrani, (primary contact) University of Namur, moussa.amrani@unamur.be
Dominique Blouin, Télécom Paris, Institut Polytechnique de Paris, dominique.blouin@telecom-paris.fr
Moharram Challenger, University of Antwerp - Flanders Make, moharram.challenger@uantwerpen.be
Julien Deantoni, Université Nice - Sophia Antipolis, julien.deantoni@univ-cotedazur.fr
Robert Heinrich, Karlsruhe Institute of Technology (KIT), robert.heinrich@kit.edu
Manuel Wimmer, JKU Linz, CDL-MINT, manuel.wimmer@jku.at

Steering Committee:
Hans Vangheluwe, University of Antwerp – Flanders Make, hv@cs.mcgill.ca
Pieter J. Mosterman, The Mathworks, Pieter.Mosterman@mathworks.com
Jeff Gray, University of Alabama, gray@cs.ua.edu
Vasco Amaral, Universidade NOVA de Lisboa, vasco.amaral@fct.unl.pt

Desired Length of the Workshop: Full Day

Abstract: The networked combination of multi-physics systems (mechanical, electrical, hydraulic, biochemical, among others) with computational systems (control systems, signal processing, logical inference, planning, among others), often interacting with human actors, in uncertain environments, in a socio-economic context, has led to so-called Cyber-Physical Systems (CPS). The CPS that are engineered today are reaching a previously unseen level of complexity. To date, no unifying theory nor systematic design methods, techniques and tools exist for such systems. Individual (mechanical, electrical, network or software) engineering disciplines only offer partial solutions. Multi-Paradigm Modeling (MPM) proposes to *model* every part and aspect of such complex systems *explicitly*, at the most appropriate level(s) of abstraction, using the most appropriate modeling formalism(s). This includes the explicit modeling of the often complex engineering workflows. Modular modeling language engineering, including model transformation and the study of modeling language semantics, are used to realize MPM, which has the potential to be an effective answer to the challenges of designing CPS. This third edition is aimed at furthering the state-of-the-art as well as defining the future directions of this emerging research area by bringing together international experts in the field for an intense one-day workshop.

2 Objectives and Scope

2.1 Motivation

Tackling the complexity involved in developing truly complex, designed systems is a topic of intense research and development. In the past, system complexity has drastically increased once software components were introduced in the form of embedded

systems, controlling physical parts of the system, and has only grown in CPS, where the networking aspect of the systems and their environment are also taken into account. The complexity faced when engineering CPS is mostly due to the plethora of cross-disciplinary design alternatives and inter-domain interactions. To date, no unifying theory nor system design methods, techniques, or tools to design, analyze, and ultimately deploy CPS exist. Individual (physical systems, network, software) engineering disciplines offer only partial solutions and are no match for the complexity observed in CPS. Multi-Paradigm Modeling (MPM) offers a foundational framework for gluing the several disciplines together in a consistent way. The inherent complexity of CPS is broken down into different levels of abstraction and views, each expressed in appropriate modeling formalisms. MPM offers processes and tools that can integrate the views, abstractions and components that make up a CPS.
MPM encompasses many research topics: from language engineering (for DSLs, including their (visual) syntax and semantics), to processes to support multi-view and multi-abstraction modelling, simulation for full-system analysis, and deployment. The added complexity that CPS bring compared to embedded and software-intensive systems requires consideration of how MPM techniques can be applied or adapted to these new applications, tying together multiple domains. Many remaining research questions require answers from researchers in different domains, as well as a unified effort from researchers that work on supporting techniques and technologies. The community needs a workshop setting to meet up and align past and future research activities.

2.2 Objectives

The purpose of this workshop is to bring together researchers and practitioners in the area of MPM (specifically applied to developing CPS) in order to identify possible points of synergy, common problems and solutions, tool building aspects and the vision for the future of the area. The goal is to organize a highly interactive workshop. A significant portion of the Workshop will be dedicated to **discussions**. **"Regular" Research papers** from academic and industry authors will present novel research results on the Workshop's topics of interest. We will encourage the submission of out-of-the-box presentations, which are not deeply researched yet, but can lead to new insights, discussions, and future collaborations. **"Lightning Talks"**, submitted in the form of a two-page papers following the recommended format, not published in the proceedings, will foster discussions and encourage interactions between participations. We will invite the submission of **Exemplars**, i.e., typical yet relatively tractable use cases of CPS systems demonstrating typical activities required for CPS Engineering, and explicitly detailing the underlying formalisms, languages and tools deployed to support such activities, all expressed in a similar way to enable comparison and extract CPS Engineering common practices and design patterns.

2.3 Context

The MPM community has been actively researching new techniques for system design for over a decade, through many related events. One-week Computer Automated Multi-Paradigm Modeling (CAMPaM) workshops have been organized yearly since 2004 at

McGill University's Bellairs campus, Barbados. Additionally, the International Summer School on Domain-Specific Languages - Theory and Practice (DSM-TP), focused on the education of language engineering techniques, and has been organized since 2009. Its target audience includes Ph.D. students, researchers, and software industry professionals. Most recently, a European Cooperation in Science and Technology (COST) research network has been active since 2015 on the use of MPM techniques for designing CPS, bringing together 29 European partner countries[1]. The chair and co-chair of this network (Hans Vangheluwe and Vasco Amaral) are members of the steering committee for this workshop. The first edition of the workshop has lead to the preparation of a theme section on the topic of MPM4CPS for the SoSyM journal (which has been recently published[2]). These initiatives demonstrate both the continued relevance of the topic and the potential impact of the workshop.

2.4 Intended Audience

The intended audience includes researchers as well as practitioners who are interested in MPM techniques in the context of CPS development. We expect to attract many attendees of earlier MPM-related events, those who contributed to the COST action, as well as a broader audience. This encompasses researchers that work on the fundamentals of language engineering, (visual) modeling environment construction, (co-)simulation techniques, as well as tool builders and users of these tools. The MODELS conference is an ideal venue for organizing MPM4CPS since it brings together researchers that aim to advance the state-of-the-art in model-driven engineering and practitioners who have valuable application experiences to share.

2.5 Need

The MPM4CPS workshop (series) follows the successful series of nine MPM workshops that were organized as part of the MODELS conference during the years 2006 through 2015. These workshops attracted many participants in the past, and we saw that the topic is still relevant, since the previous editions attracted many submissions and lively discussions. These two reasons make this workshop worth organizing at MODELS this year.

Historically, GeMoC and EXE, now merged into the MLE (Modeling Language Engineering and Execution), were the closest workshops planned to be organised in MoDELS this year. They focus mainly on two topics: the globalization of modeling techniques, which include techniques and processes to create and integrate heterogeneous languages, and the execution, animation and debugging of modeling languages. While both are concerned with specific aspects of *software* language engineering, MPM includes modeling languages for physical domains (e.g., electrical, mechanical, etc.) that require continuous-time solvers for simulation, and clean integration with other (SW/HW) languages. MPM4CPS further differentiates from those workshops by focusing on CPS. We believe that both workshops can strengthen each other by focusing on different (specialized) aspects of challenges within the MODELS community.

[1] https://www.cost.eu/actions/IC1404/ and http://mpm4cps.eu/

[2] https://link.springer.com/article/10.1007/s10270-021-00882-1

The challenges to design and develop CPS, with a focus on MPM techniques as a foundational framework for supporting the multi-domain models, tools, and processes are fundamental enough to warrant a focused workshop.

3 Organization Details

Moussa Amrani obtained his Ph.D. in 2013 from the University of Luxembourg. He is currently a postdoctoral researcher at the University of Namur and the Namur Digital Institute in Belgium. He is (co-)author of over 50 papers on MDE, IoT and formal verification published in international conferences (MODELS, SLE, ECMFA, ASE, ETAPS, NFM, CAiSE, ...) and journals (SoSyM, JSS, TSE, ToSEM, JoT, IST, ComLan, ...). He co-founded and co-organized the VoLT workshop at MoDELS from its inception in 2013, and co-organised the previous editions of the MPM4CPS Workshop.
Dominique Blouin is a research engineer at Telecom Paris, Institut Polytechnique Paris (France). He obtained an M.Sc. in Physics (Canada) and a Ph.D. in Computer Science (France) in 2013. He worked for many years in industry as a software architect and was the vice-chair of the Foundational Aspects Working Group in the MPM4CPS COST Action. He has been an active member of the SAE AADL standardization committee for the past 10 years. His research interests are MPM, model management, model transformation and (bi-directional) synchronization, requirements engineering, CPS.
Moharram Challenger is a research professor at the University of Antwerp, Belgium. He was the CTO of a software company involved-in/leading several national or international software intensive projects. He has served as an organisation committee member for SummerSim'20, ICSMM'20, AnnSim'21, IWCPS@FedCSIS'21, and AMSC'21. Also, he played the role of co-chair for several workshops organised in MoDELS and STAF 2020-21 (MDE-Intelligence, MPM4CPS, MDE4IoT, SERP4IoT, SEDES, MESS, EMAS, etc.)
Julien Deantoni obtained his Ph.D. in 2007 from INSA Lyon, France. He is currently an Associate Professor at University of Côte d'Azur in Nice Sophia-Antipolis, France and associated with the Kairos research team (INRIA & I3S). His research interest concerns the use and the definition of formal methods and tools for MDE. He served as track-chair at the Computational science track at IEEE RIVF'19, co-chair of the GeMoC Workshop series hosted at MODELS (2013–2017), chair of the Doctoral Symposium at the Summer School on Real-Time Systems (2007) and co-organizer of a Specific Action on Heterogeneity from Modeling until Simulation in 2011.
Robert Heinrich holds a Ph.D. from Heidelberg University, and is head of the Quality-driven System Evolution research group at KIT. His research interests include modularization and composition of model-based analysis for performance, confidentiality and maintainability, etc. applied to information systems, business processes and automated production systems. One core asset of his work is the Palladio software architecture simulator. He is involved in the organization committees of several international conferences, established and organized various workshops, is reviewer for international premium journals (IEEE TSE and IEEE Software), and academic funding agencies.
Manuel Wimmer is full professor at the Department of Business Informatics - Software Engineering at JKU Linz, Austria and is the head of the Christian Doppler Labora-

tory CDL-MINT. He is/was involved in several national and international projects dealing with the application of model engineering techniques for domains such as tool interoperability, versioning, Cloud computing, IoT, and factory and building automation. He has served as PC co-chair for ICMT'15, SEAA'20, workshop co-chair for ICWE'12, STAF'16 and MODELS'16, track co-chair for ICWE'14, CBI'18 and SEAA'17–19, poster co-chair for MODELS'14 and ICWE'16, and organized MDWE'13, VOLT'13–15, CMSEBA'14, MULTI'17&19–20, MDEbug'17–18, PNSE'19, MDE Intelligence'19–20, MPM4CPS'19–20, and MDE4IoT'17–20.

3.1 Program committee: to be contacted, cf. CfP in Appendix

3.2 Possibility to merge with another workshop

We request that MPM4CPS be run on its own and we plan half a day of discussions. We can merge with another workshop if this is a condition from the organization and the topics are similar enough.

4 Workshop Format

4.1 Planned Deadlines & Intended Paper Format: cf. CfP in appendix

4.2 Evaluation Process

At least three reviewers will evaluate each submission. Full research papers will be reviewed using standard scientific criteria: alignment with the workshop topic(s), novelty, evaluation, and ability to generate discussion. Short papers and extended abstracts will be evaluated based on their likelihood to spark lively discussions at the workshop.

4.3 Intended Workshop Format

The Workshop will include keynotes, ideally one from academia and the other from industry (depending on how people are available). A morning keynote will set the stage for the rest of the day, followed by paper presentations. A second keynote after the lunch break will set the discussion around exemplar presentations and lightning talks, which will foster discussions and out-of-the-box ideas. Talks throughout the day will be followed by discussions. The afternoon will reserve time to discuss the examplars, by starting discussions around identifiable patterns, common practices, popular formalisms/languages/tools, etc. The workshop will end with a wrap-up discussion to formulate the workshop's conclusion, identify open challenges, and outline future work. A summarizing publication will be included in the proceedings.

4.4 Number of expected participants: 25-35 (similar to last year's virtual ed.)

4.5 Equipment: Virtual Room with shared virtual blackboard

5 Additional Material

See Appendix for **Draft Call for Papers** & **Webpage**

Third International Workshop on Multi-Paradigm Modeling for Cyber-Physical Systems – MPM4CPS'21

10 – 13 October 2021 – Satellite event at MoDELS 2021 – Virtual Event
https://msdl.uantwerpen.be/conferences/MPM4CPS/

Organizing Committee

Moussa Amrani, Université de Namur
Dominique Blouin, Télécom ParisTech
Moharram Challenger, University of Antwerp
Julien Deantoni, Université Nice - Sophia Antipolis
Robert Heinrich, Karlsruhe Institute of Technology
Manuel Wimmer, JKU Linz

Steering Committee

Hans Vangheluwe, University of Antwerp – Flanders Make and McGill University
Pieter J. Mosterman, The Mathworks
Jeff Gray, University of Alabama
Vasco Amaral, Universidade Nova de Lisboa

Program Committee

(tentative, to be contacted)

Rima Al-Ali, Charles University
Shaukat Ali, Simula Research Laboratory
Francis Bordeleau, École de Technologie Supérieure
Frédéric Boulanger, CentraleSupélec and Laboratoire de Recherche en Informatique (LRI)
Loli Burgueño, Open University of Catalunia
Antonio Cicchetti, Mälardalen Research and Technology Centre (MRTC)
Federico Ciccozzi, Mälardalen University
Andrea d'Ambrogio, University of Rome Tor Vergata
Juan de Lara, Universidad Autónoma de Madrid
Joachim Denil, University of Antwerp
Juergen Dingel, Queen's University
Ferhat Erata, UNIT IT R&D Ltd.
Rahele Eslampanah, University of Antwerp
Holger Giese, Hasso Plattner Institute for Digital Engineering
Martin Gogolla, University of Bremen
Esther Guerra, Universidad Autónoma de Madrid
Sebastian Herzig, Caltech/Jet Propulsion Laboratory
Gabor Karsai, Vanderbilt University
Thomas Kühne, Victoria University of Wellington
Letitia W. Li, BAE Systems
Levi Lúcio, Fortiss
Eva Navarro-Lopez, University of Manchester
Oksana Nikiforova, Riga Technical University
Patrizio Pelliccione, Chalmers University, Gothenburg
Ahsan Qamar, Ford Motor Company
Akshay Rajhans, The Mathworks
Arend Rensink, Universiteit Twente
Rick Salay, University of Toronto
Bran Selic, Malina Software Corporation
Martin Törngren, KTH Royal Institute of Technology
Antonio Vallecillo, Universidad de Málaga
Tijs van der Storm, CWI
Daniel Varró, McGill University
Clark Verbrugge, McGill University
Andreas Wortmann, RWTH Aachen University
Tao Yue, Simula Research Laboratory
Justyna Zander, NVIDIA

Scope of the Workshop

Tackling the complexity involved in developing truly complex, designed systems is a topic of intense research and development. System complexity has drastically increased once software components were introduced in the form of embedded systems, controlling physical parts of the system, and has only grown in CPS, where the networking aspect of the systems and their environment are also considered. The complexity faced when engineering CPS is mostly due to the plethora of cross-disciplinary design alternatives and inter-domain interactions. To date, no unifying theory nor system design methods, techniques, or tools to design, analyze, and ultimately deploy CPS exist. Individual (physical systems, software, network) engineering disciplines offer only partial solutions and are no match for the complexity observed in CPS. Multi-Paradigm Modeling (MPM) offers a foundational framework for gluing the several disciplines together in a consistent way. The inherent complexity of CPS is broken down into different levels of abstraction and views, each expressed in appropriate modeling formalisms. MPM offers processes and tools that can combine, couple, and integrate each of the views that compose a system.

MPM encompasses many research topics - from language engineering (for DSLs, including their (visual) syntax and semantics), to processes to support multi-view and multi-abstraction modeling, simulation for system analysis, and deployment. The added complexity that CPS bring compared to embedded and software-intensive systems requires to look at these new applications and how MPM techniques can be applied or adapted to them, tying together multiple domains. Many remaining research questions require answers from researchers in different domains, as well as a unified effort from researchers that work on supporting techniques and technologies.

Topics of interest (including, but not limited to)

- **Heterogeneous models:** multi-domain and multi-physics modeling, multi-view modeling, multi-abstraction modeling;
- **Heterogeneity in modeling languages:** "blended" textual/visual modeling, modular design of modeling languages, the modeling/formal analysis/simulation/synthesis of user interfaces;
- **Multi-Paradigm Modeling techniques:** model transformation, model composition and integration, modeling cross-domain interactions, model-based detection of unanticipated interactions in heterogeneous systems, (co-)simulation of heterogeneous models, machine learning applied to the design of CPS or their languages in an MPM context;
- **Applications of and experience** with current MPM techniques, with a focus on Cyber-Physical Systems in domains such as automotive, aerospace, manufacturing, …

Contributions should clearly address the foundations of multi-paradigm modeling by demonstrating the use of models to achieve the stated objectives and discuss the benefits of explicit modeling.

Important dates

Paper submission deadline 28 July 2021
Notification of acceptance 14 August 2021
Workshop dates September 18-19 October 2021

Submission procedure

Papers should be submitted via EasyChair as a PDF document for one of the following topics. Each submission will be peer-reviewed by at least three PC members.

- **Full research papers** (10 pages max) present a novel, innovative approach;
- **Short papers** (5 pages max) present new ideas or early-stage research, extensively discuss the experiences of the researchers with an MPM approach or demonstrate a tool;
- **Extended abstracts** (1 page) for a "lightning talk" (possibly accompanied with a Poster), i.e. a short, focused talk that can spark lively debate.
- **Examplar descriptions** (10 pages max) describing a CPS Engineering practice, highlighting both the processes at play and the formalisms, languages and/or tools used to support these activities, all expressed using the language described in the Workshop's webpage.

All papers, except Extended Abstracts, will be published with the main conference's workshop proceedings; authors submitting examplars will eventually be invited to contribute to a Special Issue.