2021 ACM/IEEE International Conference on Model Driven Engineering Languages and Systems Companion (MODELS-C) | 978-1-6654-2484-4/21/$31.00 ©2021 IEEE | DOI: 10.1109/MODELS-C53483.2021.00036

MoDDiT 2021: 1st International Workshop on Model-Driven Engineering for Digital Twins

Francis Bordeleau
École de techonologie supérieure (ETS) Canada
francis.bordeleau@etsmtl.ca

Loek Cleophas
Eindhoven University of Technology, The Netherlands
l.g.w.a.cleophas@tue.nl

Benoit Combemale
University of Rennes 1, France
benoit.combemale@irisa.fr

Romina Eramo
University of L'Aquila, Italy
romina.eramo@univaq.it

Mark van den Brand
Eindhoven University of Technology, The Netherlands
m.g.j.v.d.brand@tue.nl

Manuel Wimmer
JKU Linz, Austria
manuel.wimmer@jku.at

Andreas Wortmann
University of Stuttgart, Germany
wortmann@isw.uni-stuttgart.de

***Abstract*—Digital twins (DT) are emerging and gaining attention in several disciplines to support different phases of the system life-cycle such as design-space exploration, runtime adaptation, and predictive maintenance of cyber-physical systems (CPSs). The term DT refers to the capability to clone an actual system into a virtual counterpart, that reflects the important properties of the system for a specific purpose. While benefits of DT have been demonstrated in many domains, their development, operation, and evolution, trigger major challenges. Part of these may be addressed from a Model Driven Engineering (MDE) perspective. MoDDiT'21 aims at bringing together researchers and practitioners in the DTs area to shape the future of systematically designing, engineering, evolving, maintaining, and evaluating DTs.**

***Index Terms*—MDE, Digital Twins, Model-Driven Engineering**

I. Introduction

Digital twins (DTs) promise tremendous potential to better understand and make use of cyber-physical systems (CPSs) in automotive, avionics, manufacturing, medicine, and many more domains. Despite many of the twinned systems being developed using models, engineering DTs currently is ad-hoc and demands integrating different piecemeal technologies, which effectively hinders the application of DTs. The focus of many DTs and frameworks to create DTs is on data acquisition and visualisation via dashboards. Current research on DTs focuses on specific implementations (bottom-up) or abstract models on how DTs could be conceived (top-down). Yet, there is a huge gap between both views that only research on model-driven engineering (MDE) can reduce. Hence, MDE is crucial to fully and systematically leverage the potential of DTs. MoDDiT aims to be the venue in which researchers on and developers of DTs come together to shape the future of systematically designing, engineering, evolving, maintaining, and evaluating DTs.

The concept of DT is intimately linked to modelling. Each DT is defined in terms of one or more models of the system, or part of it [1]. Such engineered models are combined with data acquisition and employed to support engineering, monitoring, controlling, and optimising of the system. In this context, the highly heterogeneous nature of the systems being described requires that a number of general-purpose as well as domain-specific languages will enable the integrated development, harnessing, and evolution of DTs. Model composition, aggregation, and evolution will help addressing these challenges as well as the continuous evolution of modelling mechanisms. This workshop offers to the modelling community the possibility to identify various model-driven methods and techniques which can contribute to tackle DT challenges as well as outline a set of open research challenges for MDE that have to be addressed in order to establish a DT engineering discipline. Furthermore, DT enables cross-disciplinary opportunities, like promoting the cooperation with other scientific and industrial organisations and communities (e.g., systems engineering, data science and artificial intelligence, Industry 4.0).

II. Goal of the workshop

The goal of MoDDiT is to gather researchers and practitioners to share opinions, propose solutions to open challenges and generally explore the application and use of MDE for DTs. Hence, MoDDiT aims at attracting contributions related to the subject at different levels, from deriving DTs in the presence of engineering models, to modelling and analysing these, to the consistencies of the engineering models, their reuse and composition, their connection to CPS, and to modelling languages for DTs. The topics of interest for MoDDiT include, but are not limited to, the following:

- Modelling concepts and languages, methods, and tools for developing DTs;
- DTs for DevOps;

978-1-6654-2484-4/21/$31.00 ©2021 IEEE
DOI 10.1109/MODELS-C53483.2021.00036

- Quality assurance for and evaluation of DTs;
- Deployment and operation of DTs;
- Model consistency, management, and evolution of engineering models;
- Architectural patterns for DTs;
- DTs for continuous learning and improvement;
- Combining models and data in DTs;
- DTs for dynamic (re)configuration and optimisation;
- Case studies, experience reports, comparisons.

III. Summary of the workshop

For ModDiT'21, we solicited regular research, short, tool demonstration, and exemplar papers. Based on this, we received 12 submissions, out of which the following six were accepted for publication in the proceedings and presentation during the workshop (1 regular paper, 3 short papers, and 2 exemplar papers):

- Matthew Bonney, Marco De Angelis, Mattia Dal Borgo and David Wagg. *Digital Twin Operational Platform for Connectivity and Accessibility using Flask Python* (exemplar paper).
- Istvan David, Jessie Galasso and Eugene Syriani. *Inference of Simulation Models in Digital Twins by Reinforcement Learning* (short paper)
- Hari Govindasamy, Ramya Jayaraman, Burcu Taspinar, Daniel Lehner and Manuel Wimmer. *Air Quality Management: An Exemplar for Model-Driven Digital Twin Engineering* (exemplar paper).
- David Manrique Negrin, Loek Cleophas and Mark van den Brand. *Using Ptolemy II as a framework for virtual entity integration and orchestration in digital twins* (short paper).
- Paula Muñoz, Javier Troya and Antonio Vallecillo. *Using UML and OCL Models to Realize High-Level Digital Twins* (regular paper).
- Mark van den Brand, Loek Cleophas, Raghavendran Gunasekaran, Boudewijn Haverkort, David Manrique Negrin and Hossain Muhammad Muctadir. *Models Meet Data: Challenges to Create Virtual Entities for Digital Twins* (short paper).

IV. Acknowledgement

We would like to thank the MODELS 2021 organization for giving us the opportunity to organize this workshop, especially to the workshops chairs Huseyin Ergin (Ball State University, US) and Xiaoxing Ma (Nanjing University, China), who supported the organisation of the workshop with their prompt and helpful messaging. Many thanks to all those who trusted the MoDDiT workshop and submitted papers. Last but not least, our thanks go to the reviewers and the members of the Program Committee, for their timely and accurate reviews and for their help in choosing and suggestions for improving the selected papers.

V. Workshop Program Committee

- Shaukat Ali (Simula Research Lab, Norway)
- Johann Bourcier (University of Rennes 1, France)
- Jeff Gray (University of Alabama, USA)
- Georg Grossmann (UniSA STEM, Australia)
- Djamel Eddine Khelladi (IRISA-INRIA, Université Rennes 1, France)
- Jérôme Pfeiffer (University of Stuttgart, Germany)
- Alfonso Pierantonio (University of L'Aquila, Italy)
- Pascal Poizat (Université Paris Nanterre, France)
- Michel Reniers (Eindhoven University of Technology, the Netherlands)
- Bernhard Rumpe (RWTH Aachen University, Germany)
- Julien Schmaltz (ICT Automatisering, The Netherlands)
- Massimo Tisi (Institut Mines-Telecom Atlantique, France)
- Michael Vierhauser (JKU Linz, Austria)
- Alois Zoitl (JKU Linz, Austria)
- Steffen Zschaler (King's College London, UK)

Two additional sub-reviewers helped with the papers during the reviewing process:

- Joel Charles (RWTH Aachen University, Germany)
- Flo Drux (RWTH Aachen University, Germany)

References

[1] F. Bordeleau, B. Combemale, R. Eramo, M. van den Brand, and M. Wimmer, "Towards model-driven digital twin engineering: Current opportunities and future challenges," in *Systems Modelling and Management - First International Conference, ICSMM 2020, Bergen, Norway, June 25-26, 2020, Proceedings*, ser. Communications in Computer and Information Science, Ö. Babur, J. Denil, and B. Vogel-Heuser, Eds., vol. 1262. Springer, 2020, pp. 43–54. [Online]. Available: https://doi.org/10.1007/978-3-030-58167-1_4