

MoDDiT'21 – 1st International Workshop on Model-Driven Engineering for Digital Twins

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Abstract. Digital twin (DT) is an emerging concept that is gaining attention in many disciplines to support engineering, monitoring, controlling, and optimizing cyber-physical systems (CPSs). It refers to the ability to clone an actual system into a virtual counterpart, that reflects all the important properties and characteristics of the original system within a specific application context. While benefits of DT have been demonstrated in many contexts, their development, maintenance, 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.

1 Motivation

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. Currently, a

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venue bringing together experts from the modelling community on this topic is missing: MoDDiT’21 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—and this venue has to be at MODELS.

1.1 Objectives and Topics of interest

The goal of MoDDiT’21 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’21 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’21 include, but are not limited to, the following:

- Modelling concepts and languages, methods, and tools for developing DTs;
- DTs for DevOps;
- 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 continual learning and continuous improvement;
- Combining models and data in DTs;
- DTs for dynamic (re)configuration and optimisation;
- Case studies, experience reports, comparisons.

1.2 Intended audience and scope

The targeted audience includes researchers and practitioners with focus on exploiting MDE for engineering, deploying, and operating DTs from a variety of application domains to capture the breadth of the topic.

1.3 Relevance for MODELS

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. 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 may offer 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 need to be addressed in order to move towards 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 community, data science and artificial intelligence communities, Industry 4.0).

1.4 Context

This proposal is intended to set up the first edition of the MoDDiT'21 workshop. The workshop will be organised by experienced members of the community representing a variety of backgrounds across model-based and model-driven engineering, software architecture, language engineering, models@runtime, modelling assistants, business informatics, software quality, verification and validation, who perform research in DTs for automotive, Industry 4.0, robotics, healthcare, aviation, and smart city. This will ensure strong support across the community.

Moreover, the authors of this proposal are recently involved in scientific research (e.g., [1–7]), national and international projects ^{8 9 10 11} and collaborations with industry (e.g., Airbus, ASCon Systems GmbH, ISG DT Store, Safran) in the DTs area.

1.5 Need

Recently, the researchers (including the Modeling community) and practitioners are paying attention to the design and development of large and complex systems and CPS, as well as to DTs (as demonstrated by the presence of several research contributions and conference topics). Furthermore, DT technologies have a wide range of uses in the industry and in the context of system engineering. Thus, the researchers need a venue at which to aggregate and create cooperation between sectors that are so different from each other. As a consequence, we believe the proposed topic matches well with current and futures issues relevant to the Modeling community: the workshop will provide a focused vehicle for facilitating exchange and cross-pollination in this area.

2 Organization

2.1 Details on the organizers

Francis Bordeleau. Francis is professor at École de technologie supérieure (ETS) in Montréal. More information is available at: <https://www.etsmtl.ca/en/news/2018/francis-bordeleau/>

Loek Cleophas is Assistant Professor for Engineering of Software-Intensive Systems at the Department of Mathematics and Computer Science at the Eindhoven University of Technology. More information is available at: <https://www.tue.nl/en/research/researchers/loek-cleophas/>

Benoit Combemale is Full Professor of Software Engineering at the University of Rennes 1. More information is available at: <https://people.irisa.fr/Benoit.Combemale/>.

⁸ Internet of Production, Foundational research project on DTs, RWTH Aachen, Germany: <https://www.iop.rwth-aachen.de/cms/gpfz/Produktionstechnik/?lidx=1>

⁹ EASI DT Lab, TU/e, The Netherlands: <https://www.tue.nl/en/research/institutes/eindhoven-artificial-intelligence-systems-institute/digital-twin-lab>

¹⁰ Trust preserving continuous co-evolution of DTs (project proposal under evaluation), PRIN 2020, Research Projects of National Relevance, Italy, <https://prin.miur.it/>

¹¹ European project ECSEL-JU AIDoArt: AI-augmented automation for efficient DevOps (Use cases application on DT): <http://www.es.mdh.se/projects/574-AIDoArt>

Romina Eramo is Assistant Professor at the Department of Information Engineering, Computer Science and Mathematics (DISIM) of the University of L'Aquila. More information is available at: <http://people.disim.univaq.it/romina.eraimo/>.

Mark van den Brand is Full Professor at the Department of Mathematics and Computer Science at the Eindhoven University of Technology. More information is available at: www.tue.nl/en/research/researchers/mark-van-den-brand/.

Manuel Wimmer is Full Professor at the Department of Business Informatics - Software Engineering at JKU Linz, Austria. More information is available at: <https://se.jku.at/manuel-wimmer/>.

Andreas Wortmann is Associate Professor at the Institute for Control Engineering of Machine Tools and Manufacturing Units at the University of Stuttgart, Germany. More information is available at: www.isw.uni-stuttgart.de/.

2.2 Workshop program committee

The CfP details the tentative program committee. This list includes well-renowned experts in the MDE and Industry 4.0 communities.

3 Workshop Format

3.1 Planned deadlines

- July 16, 2021, Abstract submission
- July 23, 2021, Paper submission
- August 21, 2021, Author notification
- August 28, 2021, Camera ready

3.2 Intended paper format

Papers must be submitted in PDF format and strictly adhere to the IEEE proceedings format. We advocate these types of papers:

- **Regular papers (max 8 pages):** Novel research contributions on MDE for DTs.
- **Short papers (max 4 pages):** Forward-looking papers about ideas that will interest the workshop attendees but which are not currently at an advanced level of research. These might be about new research avenues, research statements or positions, or about integrating existing research ideas or technologies.
- **Tool demonstration papers (max 4 pages):** Papers focusing on the tooling for MDE of DTs. A good tool paper focuses on practical insights that are likely to be useful to other implementers or users of DTs in the future. Any of the aforementioned topics of interest are appropriate areas for tool demonstrations. They may optionally come with an appendix with a demo outline / screenshots and/or a short video/screencast illustrating the tool.
- **Exemplar papers (max 4 pages):** Papers describing implementations or detailed specifications of DTs that pose and highlight fundamental or characteristic challenges for the modelling community. They may optionally come with an appendix with further materials, or a short video/screencast illustrating the exemplar.

3.3 Evaluation process and intended publication

Each submitted paper will undergo a formal peer review process by at least 3 PC members. Accepted papers will be published in a pre-conference edition on the workshop's website, and in the joint MODELS workshop proceedings published by the IEEE. Furthermore, we intent to invite selected papers to revise and submit extended versions for publication in a well-known journal.

3.4 Intended workshop format

Due to MODELS going virtual this year, we will devise a full-day workshop format suitable to mitigating the time differences between participants. We plan to include:

- two keynotes from users and developers of DTs from industry and academia,
- paper presentations with dedicated discussants,
- invited presentations on the use of DTs from our network,
- interactive breakout sessions or a world café on the foundations, engineering, and use of DTs using mural for interaction support.

For the organisation, we plan to use a virtual meeting platforms (such as toast.ai, GatherTown, or wonder.me) to engage with participants. We intend for the workshop to produce a position paper on foundations and engineering of DTs and aim for a follow-up workshop at Dagstuhl or similar.

3.5 Expected number of participants

We expect 20-40 attendees. However, more attendees can be expected since the conference will take place virtually.

3.6 Required equipment

If anything, a Zoom room in meeting mode, with possibly subgroups and polls.

4 Additional material

- Preliminary web page <http://gemoc.org/events/moddit2021.html>
- Draft call for papers attached

References

1. Tim Bolender, Gereon Bürvenich, Manuela Dalibor, Bernhard Rumpe, and Andreas Wortmann. Self-adaptive manufacturing with digital twins. *CoRR*, abs/2103.11941, 2021.
2. Francis Bordeleau, Benoît Combemale, Romina Eramo, Mark van den Brand, and Manuel Wimmer. Towards model-driven digital twin engineering: Current opportunities and future challenges. In *ICSMM 2020*, volume 1262, pages 43–54, 2020.
3. Andreas Wortmann, Olivier Barais, Benoît Combemale, and Manuel Wimmer. Modeling languages in industry 4.0: an extended systematic mapping study. *Softw. Syst. Model.*, 19(1):67–94, 2020.
4. Pascal Bibow, Manuela Dalibor, Christian Hopmann, Ben Mainz, Bernhard Rumpe, David Schmalzing, Mauritius Schmitz, and Andreas Wortmann. Model-driven development of a digital twin for injection molding. In *CAiSE 2020*, volume 12127, pages 85–100, 2020.
5. Daniel Lehner, Sabine Wolny, Alexandra Mazak-Huemer, and Manuel Wimmer. Towards a reference architecture for leveraging model repositories for digital twins. In *ETFA 2020*, pages 1077–1080, 2020.
6. Manuela Dalibor, Judith Michael, Bernhard Rumpe, Simon Varga, and Andreas Wortmann. Towards a model-driven architecture for interactive digital twin cockpits. In *ER 2020*, volume 12400, pages 377–387, 2020.
7. Jörg Christian Kirchhof, Judith Michael, Bernhard Rumpe, Simon Varga, and Andreas Wortmann. Model-driven digital twin construction: synthesizing the integration of cyber-physical systems with their information systems. In *MoDELS 2020*, pages 90–101, 2020.

Call for Papers
1st International Workshop on Model-Driven Engineering for Digital Twins (MoDDiT'21)
Co-located with MODELS 2021, October 10-15, 2021 (Virtual)
<http://gemoc.org/events/moddit2021.html>

Important Dates

Abstract submission: July 16, 2021
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Motivation

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Topics

Topics of interest include, but are not restricted to:

- Modelling concepts and languages, methods, and tools for developing digital twins
- Digital twins for DevOps
- Quality assurance for and evaluation of digital twins
- Deployment and operation of digital twins
- Model consistency, management, and evolution of engineering models
- Architectural patterns for digital twins
- Digital twins for continual learning and continuous improvement
- Combining models and data in digital twins
- Digital twins for dynamic (re)configuration and optimization
- Case studies, experience reports, comparisons

Submission Guidelines

- Regular papers (max 8 pages): These are "traditional" papers detailing research contributions to model-driven development of digital twins.
- Short papers (max 4 pages): These are forward-looking papers about ideas that will interest the workshop attendees, but which are not currently at an advanced level of research. These might be about new research avenues, research statements or positions, or about integrating existing research ideas, or technologies.

- Tool demonstration papers (max 4 pages): These are papers which focus on the tooling aspects. A good tool paper focuses on practical insights that are likely to be useful to other implementers or users of digital twins in the future. Any of the aforementioned topics of interest are appropriate areas for tool demonstrations. Submissions must not exceed 4 pages. They may optionally come with an appendix with a demo outline / screenshots and/or a short video/screencast illustrating the tool.
- Exemplar papers (max 4 pages): These are implementations or detailed specifications of digital twins that pose and highlight fundamental or characteristic challenges for the modelling community. Submissions must not exceed 4 pages. They may optionally come with an appendix with further materials, or a short video/screencast illustrating the exemplar.

Submissions that do not adhere to these limits or that violate the formatting guidelines will be desk-rejected without review. Accepted papers will be published in the workshop proceedings published of MODELS. Submissions URL: <https://easychair.org/conferences/?conf=moddit2021>

Organizers

- Francis Bordeleau, (ETS, Canada)
- Loek Cleophas (TU/e, The Netherlands)
- Benoit Combemale (University of Rennes 1, France)
- Romina Eramo (University of L'Aquila, Italy)
- Mark van den Brand (TU/e, The Netherlands)
- Manuel Wimmer (JKU Linz, Austria)
- Andreas Wortmann (University of Stuttgart, Germany)

Program committee (to be confirmed)

- Shaukat Ali (Simula Research Lab, Norway)
- Johann Bourcier (University of Rennes 1, France)
- Jeff Gray (University of Alabama, USA)
- Georg Grossmann (UniSA STEM, Australia)
- Øystein Haugen (HIOF, Norway)
- Matthias Jarke (RWTH Aachen University, Germany)
- Dimitris Kolovos (University of York, UK)
- Anne Koziolk (KIT, Germany)
- Alfonso Pierantonio (University of L'Aquila)
- Pascal Poizat (Université Paris Nanterre, France)
- Jan Post (Philips Personal Care, the Netherlands)
- Bernhard Rumpe (RWTH Aachen University, Germany)
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