













About Opportunities and Challenges in Model-Driven Engineering for Digital Twins – (Extended Abstract)


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Abstract: Modelling is essential in the engineering of digital twins: A digital twin includes models and data representing the real-world entity ('models *in* digital twins') and models describing and operating the digital twin as a software system ('models *of* digital twins'). Consequently, we need

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to systematically develop and manage these different kinds of models over time. Model-driven Engineering (MDE) offers methods to address these challenges. Here, we provide an overview of the article 'Model-Driven Engineering for Digital Twins: Opportunities and Challenges' [Mi25], published in the INCOSE Systems Engineering journal. It summarizes outcomes from the Dagstuhl Seminar 22362 'Model-Driven Engineering of Digital Twins' and provides insights into the digital twin life cycle, the use and re-use of different model kinds across life cycle stages, and a research roadmap covering six key aspects of digital twin research using MDE.

Keywords: Digital Twin, Model-Driven Engineering, Systems Engineering, Cyber-Physical Systems

1 Summary

Motivation. The Dagstuhl Seminar 22362 'Model-Driven Engineering of Digital Twins' revealed several challenges in digital twin engineering across various application domains: a) digital twins are largely developed ad-hoc, b) high system complexity of the actual system, c) integration of heterogeneous artifacts, d) differing stakeholder needs and required views, e) long actual system lifetimes with frequent changes requiring digital twin evolution, f) gaps between system design and operation, and g) high complexity in composing digital twins. As modelling is central to digital twin engineering (models *in* digital twins represent the actual system, while models *of* digital twins describe and operate the digital twin software system), we explored these challenges from a model-driven engineering perspective.

Contribution. In our INCOSE Systems Engineering article [Mi25], we distinguish three categories of actual systems: engineered, biological or natural, and socio-technical systems (incl. processes and organizations). We discuss their requirements as well as life-cycle phases relevant for digital twins that come along with these categories. In addition, we describe the use of heterogeneous modelling formalisms and the purposes models are constructed for. We further elaborate on the life-cycle of a digital twin as a software system and the role of models in relationship to the lifecycle of the actual system and of the digital twin.

Conclusion. Important future research areas are: A) development guidelines and standardisation, B) digital twin interoperability [Co25], C) multi-paradigm and multi-view modelling, D) evolution of models, actual system, and digital twin [AI25], E) model-based DevOps for digital twins, and F) digital twin composition. All areas require further investigation across application domains, using heterogeneous artefacts and varying states of practice.

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