Digital twins for IoT systems: exploiting synergies between industry and academia (extended abstract)

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Context The increasing adoption of IoT systems unleashes more and more potential use cases to make use of the massive amount of data omitted by these devices. On the other side, the increasing complexity of IoT systems also poses new challenges on developing and maintaining such use cases. Software developed to realize these use cases has to process data from heterogeneous devices and their simulations, and interact with these different devices to proactively influence their behavior. Digital twins (DTs) are one tool to cope with the resulting challenges. They provide a uniform, virtual representation of the heterogenuous hardware and simulations used in IoT systems. When developing software for our IoT systems, we can use this uniform representation to retrieve live data and interact with devices, instead manually crafting the connections with each individual device and simulation.

Digital Twins in industry The success of several standardization efforts, together with the increasing availability of software to support DT development, currently drive the wide-scale, cross-industry adoption of DTs. The Asset Administration Shell (AAS)[1] is a standardized representation of digital twins maintained by the Industrial Digital Twin Association (IDTA). The AAS is currently widely adopted in different tools that support the development of DTs, such as the Bosch Semantic Stack[2], Class.Room[3] or twinsphere[4]. Additionally, the IDTA also provides an open-source implementation of the AAS via the Eclipse digital twins project[5] The Digital Twin Consortium (DTC) proposes the Digital Twin Definition Language (DTDL)[6] together with OPC-UA[7] as an alternative to the AAS. Whereas the DTDL is supported in commercial tools such as Azure Digital Twins[8], there are also competing digital twin tools such as the AWS TwinMaker that use their own, proprietary representation of digital twins.

In previous work, we investigated these industrial digital twin representations and found that they usually provide a UML class diagram-like syntax to model data emitted by a device [1].

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We believe that reusing the knowledge that we developed in the model-driven engineering (MDE) community over the last decades on modeling such data, e.g., through models@runtime, can raise the maturity of these industrial initiatives. Furthermore, tools developed in academia for efficiently developing DTs, e.g., through low-code techniques [2], can benefit the efficient engineering of DTs in practice.

Digital Twins in the MDE research community Despite their successful adoption in industry, the above-mentioned DT standards and tools are currently still mostly neglected in research on MDE of DTs. In the MDE research community, we tend to use our own infrastructure, such as the Eclipse Modeling Framework[9] or MontiCore[10] in our work. In the context of DTs, there are also powerful platforms available which are developed in academia, such as the DTaaS platform [3]. Even though we have provided numerous outstanding scientific contributions using these platforms in recent years, the divergence from industrial standardization efforts makes it hard to transfer these contributions to industrial use cases. As a result, practitioners are currently often missing the knowledge from the scientific community, using inefficient approaches to DT development and maintenance, and reinventing the wheel when providing tools to support the engineering of DTs.

Aligning Industry and Academia To better align the adoption of DTs in industry with the research efforts of the MDE community in the future, we propose the following action points. (1) Evaluate research using industrial DT solutions. This makes it easier for practitioners to transfer the knowledge generated by this research to their specific use cases. It also allows academics to reuse existing industrial models and use cases provided for these platforms to easily assess their work in a more realistic setting. (2) Provide transformations between academic and industrial platforms. By implementing standards in academic platforms, companies can leverage the full potential of research tooling available in these platforms for their existing models. Automatically transferring DT solutions developed in academic settings to industrial platforms allows to easily evaluate research for these industrial settings, as described above. (3) Provide structured assessments of existing DT tooling. Detailed insights into the current landscape of DT standards and their implementations, together with existing knowledge and tools available in academia, can be used by both practitioners and scholars as guidance for selecting the toolkit they use to efficiently implement DTs in their specific context.

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