FAIR for Digital Twins

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With the push towards digitization, data exchange across institutional borders is becoming an essential driver of economical success. However, a growing number of stakeholders inevitably leads to at least as many opinions about how things are supposed to be labeled or described. In a response, the FAIR-principles (Findable, Accessible, Interoperable, and Reusable) have emerged in science as guidelines towards a sustainable data landscape [1]. While these criteria are more and more embraced within the scientific community, their transfer to industry has not yet received similar attention.

In the area of (aero)space engineering, model-based systems engineering (MBSE)[2] and in particular Digital Twins are widely used approaches to describe systems by models and data instead of documents. However, each organization has their own modelling approach — OCDT, VSD, RangeDB or Virtual Satellite (to name a few) are all used to model spacecraft, but it is not possible to share information between them. This leads to the effect that information between different parties is again exchanged via documents; especially in the communication with suppliers. The suppliers want to describe their products — preferable in a way that makes them findable by others. Customers on the other hand want to find fitting products — but the determination, which product fits which requirement is currently done by hand (or rather brain).

To automate this process, not only models of products or manufacturability are needed, but also models of requirements, including a definition of when the requirement is fulfilled (does it always have to be 100% — or can that be remedied by, e.g., over-fulfilling another requirement?). Over the time, it would also be helpful to be able to trace back why a certain component was selected — Which requirement does it fulfill, how did it fare during tests and during operations? These questions concern the provenance of a product, but also the provenance of data is relevant — does the description of a product come directly from the manufacturer or did someone edit it, how old is the last update, etc.? Besides exchanging "just" the information, all involved parties need to be sure they share the same semantics, i.e. "mean the same thing". For example, some parties call a property "mass", others "weight" — do they mean the same? Or, if two parties exchange data about a "diameter" — are they sure both understand it with/without insulation of the component?

At the core of the FAIR-principles are semantic vocabularies that capture the relations across concepts. They do not prescribe any particular structure on (meta)data but provide a set of terms to be be used. The uptake of the FAIR-principles also gives rise to the development of many domain-specific vocabularies. While domains like medicine or biology have a long standing tradition of maintaining such knowledge graphs, other domains are starting just now. In the field of engineering particularly initiatives like NFDI4Ing[1] and MaterialDigital[2] strive to collect the knowledge of their domain and formalize it into ontologies and knowledge graphs. These semantic artefacts are not isolated from one another. This so called Semantic Web allows to interlink knowledge graphs and thus step by step create a comprehensive body of knowledge not just for single domains but also in interdisciplinary settings.

We argue to transfer the experiences made in science to address current data management challenges in industry. Improving the interoperability of data exchanges also in business settings will lower costs and open up new opportunities both in advertising ones own products and services as well as finding proper suppliers and partners.

References

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[1] https://nfdi4ing.de/
[2] https://www.materialdigital.de/