Semantic Material Master Data Management at Aibel

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Aibel is a global engineering, procurement and construction (EPC) service company based in Norway, best known for its major capital contracts for building and maintaining large offshore platforms for the oil and gas industry.

Building an oil and gas platform is a complex task. It involves multiple engineering disciplines, handling a range of suppliers and vendors, large-scale logistics and warehouse management—all of which is managed by specialised IT infrastructure and tools. The design of the platform must be in accordance with the customer's build order, conform to multiple engineering standards and governmental requirements, and be materialised by products that match the design. All these different specifications are typically available only as semi-structured PDF documents that require manual assessment by experienced discipline specific engineers.

Aibel has taken significant steps to move away from the manual document-driven process to a digitalised process of selecting appropriate design artefacts and finding matching products. This is done by representing requirements and specifications in a custom-built large-scale ontology of ~80.000 classes called the *Material Master Data (MMD)* ontology, and using automated reasoning and queries over the ontology to perform matching and selection. The effect is that these tasks are performed with greater precision and less effort than with Aibel's legacy system, ultimately resulting in a design of higher quality, which again reduces the total time and cost of construction. Using the open standard language OWL to represent the information in an application-independent manner allows the MMD ontology to be applicable throughout Aibel's tool-chain and avoids locking in to specific vendor's tools and work-processes.

The project of constructing the MMD ontology started in 2012 by a team of seasoned engineers and ontology experts, and is ongoing. The system is in production use by all of Aibel's EPC projects. As the ontology is considered a competitive advantage for Aibel, it is not publicly available.

In comparison to its previous material master system, which was based on a relational database, Aibel can, as an example, document a reduction of errors in the specification of bolt lengths from 15 % of all design drawings to a low 0.5 %. (A large project can have more than 50.000 design drawings.) Such errors can be costly; each incorrect design drawing requires manual revision by affected stakeholders, and new bolts must be ordered, causing delay for depending processes.

Aibel now also experiences better storage management and reduced erroneous bulk orders. The added expressivity and flexibility of the MMD ontology support a more efficient and precise description of design artefacts. This allows all permissive variations in the design to be clearly represented, removing practically all duplicate design artefacts recorded in the system. (It is estimated that more than 30 % of the legacy system's data was duplicate data.) The lack of duplicates and added detail in design descriptions make it easier to manage the material storage and order a better selection of materials for a given project. The effect is an estimated cost reduction of ~5 % for bulk material orders, which in large projects amounts to more than € 100 million.

The MMD ontology comprises ~200 ontology documents arranged in a strict import hierarchy. On top are generic ontologies, like PAV and SKOS, and an upper level ontology based on ISO 15926 (cf. [3]). The next level of ontologies describe generic concepts in the engineering domain. These top-most ontologies are either directly imported or hand-crafted by ontology experts in cooperation with domain experts. The lower level ontologies, which contain more then 90 % of the classes in the MMD ontology, represent different industry standards and requirements, and, at the very bottom, assembled design artefacts and product descriptions. These ontology documents are generated from ~700 structurally simple spreadsheets and from simple web application *wizards*, both designed to produce specific types of product descriptions or design artefacts. The spreadsheet formats and wizards are prepared by ontology experts and experienced domain experts to let regular engineers actively participate in developing the ontology by populating the spreadsheets and using the wizards. The ontologies generated from spreadsheets are constructed via a work-flow of relational databases, R2RML mappings, ISO 15926-7 templates [3], and SPARQL queries. The wizards make continuous use of DL queries over the ontology to present the user with permissible selections in each step.

The MMD ontology is deployed in an Oracle database which serves variants of the ontology through different endpoints to support different reasoning profiles. Aibel's existing tools, such as their enterprise resource planning (ERP) system and 3D computer-aided design (CAD) tools, import data from these endpoints. The ontology may also be browsed by end-users in an easy-to-use custom-made web interface that presents the ontology in a similar fashion as linked-data front-ends. Aibel's data managers find that the expressivity and declarative nature of OWL, paired with the capabilities of ontology reasoners, make it easy to express and check complex relationships between concepts. This was practically impossible to implement and maintain in their legacy system.

Aibel will continue to develop and extend the MMD ontology and welcomes advances in tool-supported methods for constructing and maintaining large-scale ontologies. In particular tools for: high-performance OWL DL reasoning with better customisation possibilities and user feedback; lifting and lowering between tabular formats and the ontology (cf. [2]); query library management; ontology packaging, versioning and dependency management; improved ontology navigation; and hybrid systems that exploit the best of the open and closed world paradigms.

Lastly, an appeal: in order for the industry to become truly digital, industry standard organisations need to stop publishing their data only in formats that are unintelligible to computers and instead use formats equivalent to at least 4-star linked data [1] quality!

References

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