SOMM: Industry Oriented Ontology Management Tool[†]

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Abstract. In this demo we present the SOMM system that resulted from an ongoing collaboration between Siemens and the University of Oxford. The goal of this collaboration is to facilitate design and management of ontologies that capture conceptual information models underpinning various industrial applications. SOMM supports engineers with little background on semantic technologies in the creation of such ontologies and in populating them with data. SOMM implements a fragment of OWL 2 RL extended with a form of integrity constraints for data validation, and it comes with support for schema and data reasoning, as well as for ontology integration. We demonstrate functionality of SOMM on two scenarios from energy and manufacturing domains.

1 Introduction

Software systems in the domain of industrial manufacturing have become increasingly important in recent years. Research in this area has highlighted the need for enterprise-wide *information models*—machine-readable conceptualisations describing the functionality of and information flow between the different assets in a plant, such as equipment and production processes. The development information models based on ISA and IEC standards has now become a common practice in modern companies.

A number of companies in the manufacturing industry, including Siemens, exploit information models in deployed applications [7]. In practice, however, many different types of models co-exist, and applications typically access data from different kinds of machines and processes designed according to different models. These information models have been independently developed in different (often incompatible) formats using different types of proprietary software; furthermore, they may not come with a well-defined semantics, and their specification can be ambiguous. As a result, model development, maintenance, and integration, as well as data exchange and sharing pose major challenges in practice.

In order to address this challenge, semantic technologies have been recently adapted in industry to formalise information models using ontologies [5–7]. In particular, OWL 2 provides a rich and flexible modelling language for describing

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[†] The demo is accompanying our ISWC'16 paper [4]. Our SOMM system can be found here: https://www.cs.ox.ac.uk/isg/tools/SOMM/. This work was partially funded by the the Royal Society under a University Research Fellowship, the EU project Optique (FP7-ICT-318338) and the EPSRC projects MaSI^3, DBOnto, and ED^3.

industrial information models: it not only comes with an unambiguous, standardised, semantics, but also with a wide range of tools that can be used to develop, validate, integrate, and reason with such models. Furthermore, RDF provides a unified data format: RDF data can not only be seamlessly accessed and exchanged, but also stored directly in scalable triple stores and effectively queried in conjunction with ontologies.

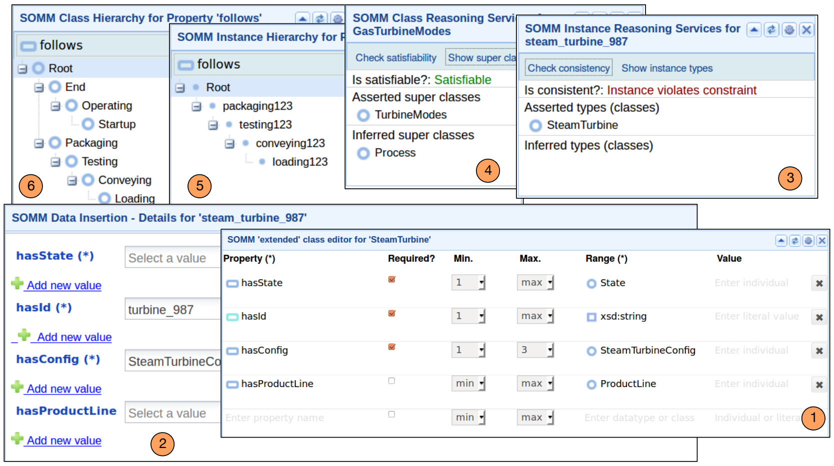
In this paper, we present the Siemens-Oxford Model Manager (SOMM) that was developed to facilitate development and maintenance of ontology-based industrial information models and resulted from an ongoing collaboration between Siemens CT in Munich and the University of Oxford. SOMM has been designed to support engineers with little background on semantic technologies in the creation and use of ontologies. SOMM provides a simple interface for ontology development and enables the introduction of instance data via automatically generated forms that are driven by the ontology and which help minimising errors in data entry. SOMM implements a fragment of the OWL 2 RL profile extended with database integrity constraints for data validation. SOMM is built on top of Web-Protégé [8], which provides built-in functionality for ontology versioning and collaborative development and extends it with important features: reasoning, constraint validation, query answering, ontology alignment and merging an ontology into an active Web-Protégé project. SOMM relies on the rule inference engine IRIS [1] for query answering and data validation, the reasoner HermiT [2] for ontology classification, and LogMap [3] for model alignment and merging.

We showcase SOMM using two industrial scenarios and for both of them we have developed ontologies using SOMM. The first ontology describes the manufacturing processes in a plant, i.e., it represents equipment, materials, as well as processes and how they are connected with each other. The second one describes the structure of power generating turbines, their functionality, and operational modes. During the demonstration the attendees will be able to modify these ontologies and to try SOMM's constraint validation and query answering functionality over realistic manufacturing and gas turbine data.

2 SOMM: Siemens-Oxford Ontology Manager

System Overview. SOMM is built on top of the Web-Protégé platform by extending its front-end with new visual components and its back-end by connecting it to IRIS, HermiT and LogMap. Our choice of WebProtégé was based on the requirements for the platform underpinning SOMM that are natural interdisciplinary requirements of engineering environments and were also obtained during the use-case study at Siemens. That is, the platform should be *(i)* accesible as a Web application; *(ii)* under active development; *(iii)* open-source and modular; *(iv)* with built-in functionality for ontology versioning and collaborative development; *(v)* offering a form-based and end-user oriented interface; and *(vi)* offering automatic form generation for data insertion.

Ontology and Constraint Language of SOMM. Based on the analyses of ISA and IEC standards as well as on Siemens requirements to industrial modelling we did several modelling choices underpinning the design of our ontologies and identify a fragment of OWL 2 RL that is sufficient to capture the basic aspects of the Siemens' information models. In particular, this fragment allows to express obligatory relationships between (pairs of) entities using SubClassOf, SubDataPropertyOf,



Is satisfiable?: Satisfiable
Asserted super classes
TurbineModes
Inferred super classes
Process

Is consistent?: Instance violates constraint
Asserted types (classes)
SteamTurbine
Inferred types (classes)

hasState (*): Select a value
Add new value
hasId (*): turbine_987
Add new value
hasConfig (*): SteamTurbineCo
Add new value
hasProductLine: Select a value
Add new value

Property (*)	Required?	Min.	Max.	Range (*)	Value
hasState	☑	1	max	State	Enter individual
hasId	☑	1	max	xsd:string	Enter literal value
hasConfig	☑	1	3	SteamTurbineConfig	Enter individual
hasProductLine	☐	min	max	ProductLine	Enter individual
Enter property name	☐	min	max	Enter datatype or class	Individual or litera

Fig. 1: Screenshots of SOMM

TransitiveObjectProperty, and InverseObjectProperties. These axioms can be readily exploited by reasoners to support query answering. Additionally, we allow to express optional relationships between entities by using AllValuesFrom. Our analysis of the models, however, also revealed the need to incorporate database integrity constraints for data validation, which are not supported in OWL 2. We express them using OWL 2 axioms that use ObjectSomeValuesFrom, ObjectMinCardinality, and ObjectMaxCardinality while we treat them as integrity constraints rather than axioms. Finally, for the purpose of data validation and query answering we capture OWL 2 RL axioms and integrity constraints by means of rules with stratified negation. We refer the reader to [4] for further details on SOMM's axioms and constraints.

SOMM Functionality. The interface of SOMM is restricted to support only the OWL 2 RL axioms and constraints discussed above. SOMM allows for insertion of axioms and constraints via a form-based interface for editing axioms and constraints, see Figure 1(1) for a screenshot of the SOMM class editor. SOMM can also automatically generate data forms, see Figure 1(2), by exploiting the capabilities of the 'knowledge acquisition forms' in Web-Protégé. The forms are automatically generated for each class based on its relevant mandatory and optional properties by considering the explicitly provided properties, the inherited properties, and the properties explicitly attached to its descendant classes. Moreover, SOMM supports reasoning by relying on the OWL 2 reasoner HermiT to support standard reasoning services such as class satisfiability and ontology classification. Data validation and query answering support is provided on top of the IRIS engine. Figures 1(3) and 1(4) illustrate instance and class reasoning interfaces. In addition to classical subsumption hierarchies, SOMM allows also for hierarchies based on arbitrary properties. These can be seen as a generalisation of partonomy hierarchies. Figures 1(5) and 1(6) show the hierarchy corresponding to the *follows* property at both class and instance level. Finally, SOMM integrates the ontology alignment system LogMap to support model alignment and merging. Users can select and merge two available Web-Protégé projects, or import and merge an ontology into the active Web-Protégé project.

3 Demonstration Scenarios

In order to demonstrate how to develop and manage industrial ontologies with SOMM and how to do data validation and query answering with SOMM, we developed a manufacturing and an energy generating scenarios. Each scenario consists of an ontology, data, and queries and we now describe them in details.

Manufacturing. Conceptual models for manufacturing applications are typically based on the international standard ISA-88/95. Our manufacturing ontology reflects these models and contains 79 standard axioms and 20 constraints. It describes specifications of products, processes and materials that can be used to manufacture these products, as well as the way these processes can be composed and executed. The data we generated simulates manufacturing of products of two types based on this ontology. We prepared data where some products were manufactured in violation of the ontology (e.g., they used too much material of some kind) and data where each product is manufactured according to the ontology. For querying the data we prepared three queries from the tracking-and-tracing application that are commonly used in practice. The first query asks for all products that use material from a given lot; the second asks for all material lots used in a given product; finally, the third one asks for the total quantity of material in lots of a specific kind.

Gas Turbine. This ontology captures an energy plant model that is based on the Reference Designation System for Power Plants (RDS-PP) and Kraftwerk-Kennzeichensysten (KKS) standards, which are in turn extensions for the energy sector of the IEC 81346 and ISO/TS 16952-10 international standards. The ontology contains 121 standard axioms and 25 constraints. The data we prepared is anonymised real data that describes the structure of 800 real gas turbines of different types, their sensor readings (temperature, pressure, rotor speed and position), and associated processes (e.g., expansion, compression, start up, shut down). The dataset was converted from a relational DB into RDF, and contains 25090 triples involving 4076 individuals. We prepared three test queries that are commonly used in practice. The first query asks for the core parts, equipment and current state of all turbines of a given type; the second asks for all components involved in a compression process; the last query asks for the temperature readings of turbines of a given type.

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