Position paper

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Introduction

The Health Care and Life Science (HCLS) industry is generally considered as the first (and currently only real) example where Semantic Web technologies have been used to enclose a wide range of information sources across boundaries. Other industries struggle with seemingly similar challenges. One of these is the Oil and Gas industry, where increasingly larger amounts of data and information are becoming available for decision making during the life of an asset.

Although huge similarities seem to exist between these industries in terms of their reliance on masses of heterogeneous and dispersed information, some important differences can be seen. These differences can be best explained by making a distinction between qualifying and structural elements of knowledge representation. In Life Sciences, the progress can be described as mainly altering the qualifying elements, to be embedded or extended on an existing structure of terminology, while on the other hand in the Oil and Gas industries, new concepts are constantly introduced during the life-cycle of an asset that will adjust the structure as well. This means that the semantics of the terms that are a part of the ontology will tend to change over time. In comparison with Life Sciences, where ontologies will be primarily extended, and new concepts will be mainly added to the end of existing paths as science is progressing. On the contrary in the Oil and Gas industry, new concepts tend to alter the existing structure of concepts. In practice this means that the application of ontologies in the Oil and Gas industry should allow continuous semantic modification of an ontology.

A solution to this problem is to apply ontologies as descriptive or qualifying concepts on data that is structurally independent, i.e. to apply the ontology as a reference standard rather then a to-be instantiated class. In this paper we will first discuss two alternative approaches to building an ontology, and then propose a combined approach that we feel may be of particular relevance to the Oil and Gas industry for making optimal use of the large amounts of data, information and knowledge that is generated over the total life-cycle of an asset.

Two approaches for building ontologies

Theoretically speaking, there are two approaches for building ontologies, which can be roughly described as either top-down or bottom-up. In a top-down approach, the ontology i.e. the concepts and their relationships, are developed by specialists in the field, representing their domain-specific knowledge. This approach leads to a semantically rich vocabulary of terms and relationships. The implicit expectation of this approach is that it will allow a full description of all possible real-life occurrences. The bottom-up approach on the other hand, builds an ontology by step-wise adding concepts that are used as descriptive entities of real world examples. With this approach, the ontology is assumed to be incomplete but sufficient to describe the known examples.

The top-down approach can be viewed as one that is focused on representing knowledge, whereas the bottom-up approach may be viewed as one that is aimed at representing experience. Both strategies in building ontologies have their own advantages and disadvantages. The advantage of the top-down approach is that it organizes and structures all available knowledge in a field, whereas the advantage of the bottom-up approach is that it remains close to the application and usage of knowledge in a field. An additional advantage of the bottom-up approach, as experienced in various application domains, is that it is more flexible in adopting the evolutionary development of knowledge in a field, while still maintaining the possibility to formally express this knowledge.

Experiences with a top-down approach – ISO 15926

ISO 15926 is an example of a top-down designed ontology. The purpose of the ISO 15926 standard is to facilitate the exchange of complex plant and project information in the Oil and Gas industry. The intention is to be able to use the standard for the integration of information over the whole life-cycle of a petroleum asset; i.e. from design over production and maintenance to decommissioning. Part two of the ISO 15926 can be viewed as an upper ontology which can be used for facilitating the interoperability of data about equipment and systems used in industrial processes. Upper ontologies typically define top-level concepts from which more specific classes and relations can be defined. A brief overview of the upper ontology can be found in [1]. In our system we make use of the standard as a reference classification system for real world objects.

Experiences with a bottom-up approach

In the period from 1987 up until now, we have used a bottom-up approach for building ontologies in different projects. The data model structure was developed during a research project on the application of AI in CAD. The basic idea is to 'qualify' available data by creating and reusing concepts and relationships between these concepts and store these in one or more dynamically extendable vocabularies. So instead of building these concepts and their relationships beforehand, with this approach the concept is defined on-the-fly and depends on the existence of its instances. The approach depends on the assumption that experts have concepts concerning their expertise in mind and only require a means to store it in some formal way.

Several systems have been built on this concept, varying from industrial design systems to a crime investigation analysis tool. One of the aims of these systems is to generate ontologies on the fly. As such being a means to abstract domain-specific knowledge. After a period of 20 years, we currently have to conclude that although a lot of experience has been captured in the various model builds of these systems, the higher level of abstraction as can be expected from an ontology is still mainly lacking. The ontologies generated by this approach are in general fairly simple. Although the system provides functionality for step-wise development of the ontology, most of the users turn out to prefer the application of pattern mechanisms in order to reuse knowledge embedded in the models. Experience however also has shown that if a rich ontology is provided with the system, users gladly make use of it. We claim that this necessitates an integrated approach where both strategies are being combined.

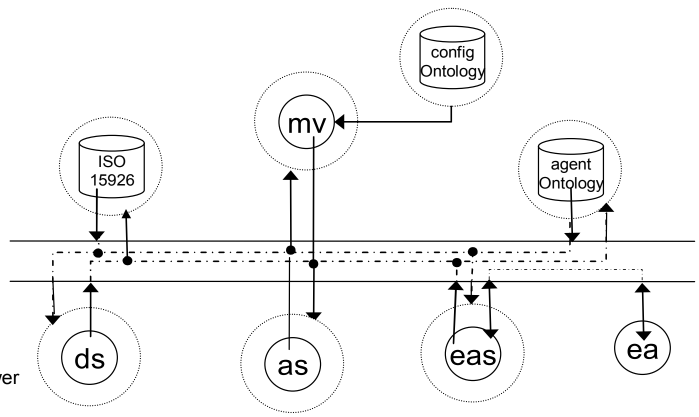
Epsis´ combined approach

At Epsis we are currently working on a decision support tool called ERA Decide. This tool is intended to help operators make decisions based on the vast amount of real-time data that is available with an option to perform some tasks autonomously in the future if so desired. The system is designed using several different techniques including the use of ontologies, agent technology and makes these functionalities available as interoperable services.

Combination of top-down and bottom-up ontology

The kernel of the system will be the same data model structure as has been used in the systems built using the bottom-up approach, but instead of building an ontology from scratch, as was the approach with the previous systems, we will use the ISO 15926 ontology as a base for reference.

The intent of this combined top-down and bottom-up approach is twofold. On one hand the combination will allow us to build and use models of real world objects that are interoperable and we will have a flexible way to cope with some expected further development of the standard. The kernel structure makes it possible to modify and improve the standard ontology without having to rebuild the existing models whenever the standard is evolving. On the other hand we may contribute to the further extension of this standard by testing and commenting on its applicability when building models of real world objects. Some parts of the ontology generated with the bottom-up approach may also be candidates for enrichment and inclusion in the top-down ISO 15926 ontology. The configuration of the system is shown in Figure 1.



mv - model viewer

ds - data server

as - agent server

eas - external application access server

ea - external application

ISO15926 - web service on ISO 15926

config ontology – model viewer configuration settings as an instantiated ontology

agent ontology – collection of agents and their properties represented as an ontology

Figure 1: High level System Configuration

Interoperability

An important feature of the ERA-Decide tool will be its ability to interoperate with other external applications. The different functionalities provided by the tool will be packaged as interoperable services, allowing for a high degree of modularization. To further facilitate interoperability the tool provides a translation of the platform model data to an OWL/RDFS data structure. It will then be possible to leverage a number of existing technologies and make connections to other open data sets. In this way we make the model data in ERA-Decide fit into a much larger set of concepts. Moreover, other systems might incorporate the open source SESAME or Jena for storage and inference. Such application independent stores allow the data to be easily shared with other applications that are SESAME aware. In addition, it might be possible to use existing DL reasoners to check for model consistency, and so on. The translation will also allow the development of queries (e.g. SPARQL) that might become necessary for the operations to be supported by an application. Jena, the Semantic Web framework, can also be used to make the data further accessible to any other ISO 15926 compliant applications.

Summary

By combining different semantic technologies, we are building a very flexible system that will be open, highly modular and interoperable in nature. Using a combined approach to ontology building, we will be able to make use of the best of both ontology worlds; i.e. combining the rich and well-structured ISO 15926 ontology capturing the knowledge in a specific domain with the flexibility of ontologies generated by the bottom-up approach capturing experiences and remaining close to the application and usage of knowledge in a field.

We are currently working towards the application of this system in a real-time decision support system for reservoir and production engineering functions. This development will partly be done in connection to a large joint industry project called Integrated Operations in the High North [2], where the intention is to demonstrate the use of semantic web technologies for the Oil and Gas industry.

We are also working towards the first commercial application of this technology. We see that semantic web technologies will be instrumental in making more intelligent and autonomous systems that will be able to adapt to a changing environment and allowing for a tighter integration between the different business processes, across disciplines and organizational boundaries. This will have the potential to drastically change the way the industry is operating.

References

[1] Batres R, West M, Leal D, Price D, Masaki K, Shimada Y, Fuchino T, Naka Y. (2007): An upper ontology based on ISO 15926, Computers & Chemical Engineering, Vol. 31, No. 5-6. pp. 519-534.

[2] Verhelst F. (2008): A unified ontology for Reservoir and Production, Presentation at Semantic Days 2008, Stavanger, Norway. http://www.posccaesar.org/UserFiles/File/Fredrik%20Verhelst%20-%20Session%204%20-%20Reservoir%20and%20Production.pdf