> Semantic Web Use Cases and Case Studies

Use Case: Ontology-Driven Information Integration and Delivery
A Survey of Semantic Web Technology in the Oil and Gas Industry

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April 2007

Introduction

The purpose of this paper is to survey some significant applications of Semantic Web technology in the oil and gas industry, and describe a use case on how the industry can leverage this technology.

Key Business Drivers

- "There is a million miles of spaghetti eaten every day!" The same can be said about data in the oil and gas Industry. A large amount of data is generated every day from multiple sources such as seismic data, well data, drilling data, transportation data, and marketing data. Integrating these heterogeneous data to capitalize on their information value has been complex and costly.
- These data exist in a structured form in databases, and in semi-structured forms in spreadsheets and documents such as reports and multimedia collections. To deal with the flood of information, as well as the heterogeneous data formats of the data, we need a new approach for information search and access.
- For the major capital projects (see application examples below) in the industry, information needs to be standardized and integrated across systems, disciplines and organizational boundaries. This information integration will enable better decision making within collaborations, as high quality data will be accessible in a timely fashion.

"Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries."[1] The Semantic Web technology provides a standard for machine-operational declarative specification of the meaning of terms based on the Resource Description Framework (RDF).

Application of Semantic Web Technology within the Oil and Gas Industry

Applications of Semantic Web Technology generally fall under the following categories:

- Standardization for information exchange between business partners
- Information Integration across applications within a company
- Enable sharing across applications within a company, and with partners and customers[2]
- Collaborative knowledge management for supporting distributed operations and teams

Below are some real Semantic Web implementations within the industry:

- Leveraging RDF/OWL and ISO 15926[3] Part 4 Reference Data Library, Fluor Corporation's Accelerating Deployment of ISO 15926 (ADI) project[4] targets integration, exchange, and hand-over of information between all parties involved in the process industries during the entire life cycle of a plant. ISO 15926 Part 4 is a text book of references that is organized by disciplines (rotating, piping, instrumentation, activities, etc.) with over 12,000 core definition of plant objects. By providing equipment definitions in RDF/OWL, this project will enable a platform for interoperation (equipment

specification and requests for quotes, purchase order, vendor drawings and models, fabricate, deliver and install) based on ISO standards with a global knowledge base of domain experts from participating companies.

- The Norwegian Daily Production Report (DPR) project[5] has a goal to standardize production data reporting, thereby making it more accessible for authorities and license partners. The project is being tested on Hydro's Åsgård field, and includes Shell, BP, Chevon, Exxon, Statoil, ConocoPhillips, and Total as initial project partners. TietoEnator has developed the DPR package using the Semantic Web with the ISO 15926 ontology. The DPR also conforms, to the Wellsite Information Transfer Standard Markup Language (WITSML) standard.
- The Active Knowledge Systems for Integrated Operations (AKSIO) project[6, 7] is developing an integrated system in knowledge management to support drilling operations in offshore oilfields. This requires that data is linked together from, databases, applications, and specialist knowledge networks. This then needs to be combined with real-time data from the field to provide timely and contextual knowledge for collaborative work processes. Core functionality of the AKSIO system is provided by application of Semantic Web technology, including ontology-based annotation and smart retrieval of content.
- The Integrated Information Platform (IIP) project[8, 9] sponsored by the Norwegian Research Council (NRC), aims to create an information platform for the industry by integrating ontologies from several industrial data and technology standards and also by creating new ontologies. This project integrates data and information for subsea seismic equipment, drilling, production, onshore operations and maintenance for vendors and operators, and expert centers with taxonomies and ontologies that support real-time exchange of data as well as optimization of processes across domains. IIP includes information from Petrotechnical Open Software Corporation's POSC Caesar, which is an industry driven research and development project under the name of Caesar Offshore Program, currently has some 60,000 classes about oil field equipments that are described in ISO 15926-7 using OWL. Rules in OWL specify properties of the equipment used and what actions should be taken if a constraint has been violated.
- InfoWeb, a plant data specialist in the Netherlands, leverages the Semantic Web for developing the ISO 15926 knowledge base. 15926.org is dedicated to information for the development of guides, procedures, and software for information handover and data exchange on capital facilities projects. Capital facilities include industrial facilities such as refineries and chemical plants, power plants, etc. 15926.org contains vocabularies in RDF, and they form the foundation for information exchange and integration for the process industry.
- The Geosciences Network (GEON Grid) seismic infrastructure is a federation of ArcIMS (a server-based application for delivering dynamic maps and GIS data and services via the web) servers supporting the National Carbon Sequestration database, a component of the North American Cyberinfrastructure—an electronic grouping of various geological resources across the USA. GEON's CHRONOS is a national stratigraphic portal providing access to the distributed databases across the country. It leverages OWL ontologies for knowledge representation, registration and access of controlled vocabularies, hierarchies and more complex relationships (ontologies) among scientific terms.

Ontology-Driven Information Integration and Delivery Use Case

The oil and gas industry is a potentially rich domain for Semantic Web technology. Ontological-Driven Information Integration and Delivery involves using a rich domain ontology (as opposed to a flat keyword list) to index a collection of resources that may have overlapping metadata. Ontologies are important because they provide a shared and common understanding of data within a problem/solution domain, and by organizing and sharing enterprise information, as well as managing content and knowledge, they allow "better interoperability and integration of intra- and inter-company information systems."[10]

A portal can be use to provide search, navigation and delivery of the underlying resources by exploiting the structure of the domain ontology (also called ontology-driven information retrieval[11]). This is different from a traditional portal because it establishes stable and reusable domain indexes that are separate from the organization of the portal, i.e., the navigation view provided by the access portal and the domain semantics are loosely coupled. The portal may easily be reorganized to suit different user needs. The ontology-driven navigation to information provides unanticipated relationships discovery, supports advanced drill down capabilities, and allows structured and unstructured information to be aggregated, organized and filtered.

Figure 1 is a model depiction of this use case. The stick figure represents an "actor" that uses or interacts with the use case, or information systems/subsystems, databases, and applications, etc. that the use case communicates with.

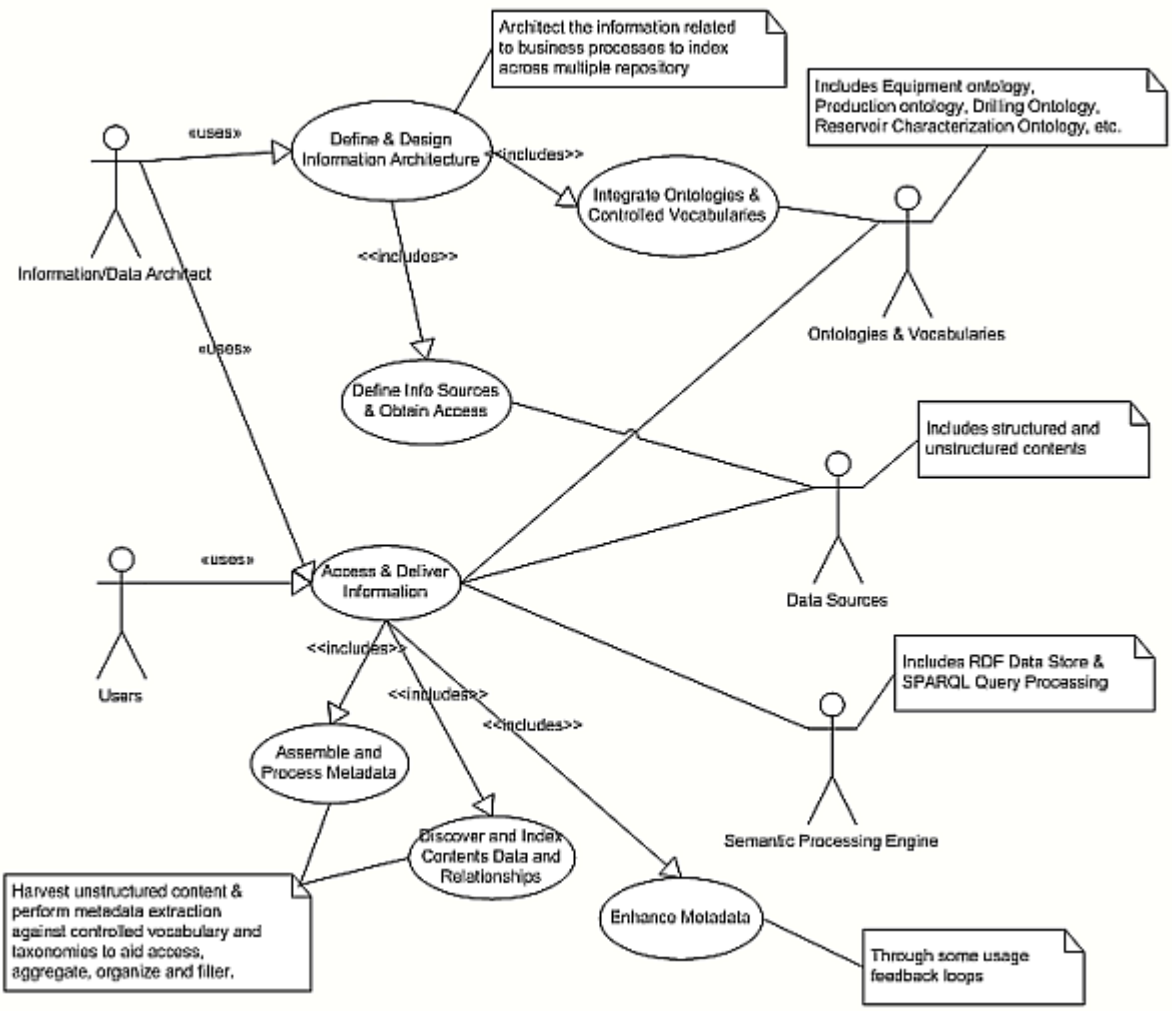

Figure 1: Ontology-Driven Information Integration & Delivery Use Case

Looking Ahead

Coupled with Service Oriented Architecture (SOA)[12], ontologies provide a shared and common understanding of data, services and processes thus leading to more accurate representation of concepts. This enables a higher level of automation of tasks such as discovery, invocation and composition of Web Services. As we are seeing more oil and gas applications exposing their capabilities through Web Services, this will help facilitate agility in integration. Semantic Web Services (SWS) can also be integrated into an ontology language (e.g., OWL-S)[13] providing a service-enabled ontology mechanism capable of connecting arbitrary services to ontologies. This can provide efficient domain-specific reasoning services to complex oil and gas applications.

Benefits of using SW

Ontology-driven information integration and delivery leverage rich extensible domain ontologies found in the oil & gas industry, and combine them with industry standard definitions and controlled vocabularies. This results in meaningful metadata that reflects the concepts relevant to the domain. This approach is extensible, as different domain ontologies can be linked together via common elements. As this approach is not hierarchical, there isn't a single root. This means that new data and ontologies can be integrated with much flexibility, and the solution can grow incrementally. It also makes it easy to reuse elements of the repository in other contexts.

As we build more semantic descriptions of documents and content, we are making it easier to find, access and make use of the vast amount of information that are so typical in the oil and gas Industry.

Acknowledgement

The author would like to thank Roger Cutler of Chevron for his support without which this effort would not have been possible.

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