Semantic Web Technology for Petroleum Industry

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Abstract: Petroleum Industry is one of the major industries with huge investment with high level technical complexities. Petroleum companies produce vast amount of complex data/information in regular course of business. Proper maintenance of this complex data/information for effective and fast searching/analyzing in order to promote better value for the business is a crucial and ever increasing challenge. Semantic Web technologies offer various tools and techniques for proper maintenance of data/information and promote effective search/analyze features. Hence, this paper presents the various concepts of Semantic Web Technologies and their significance for Petroleum Industry.

Keywords: Semantic Web Technologies, Petroleum Industry, Data, Information, Searching, Analyzing.

I. INTRODUCTION

Petroleum companies produce a vast amount of technical and business data/information through various activities such as drilling, exploration and production, reservoir management, major capital projects, facility and downstream operations etc. This data/information could be in various formats such as structured, semi structured and un-structured more over it doubles for every 6-12 months [1]. Due, to the problem of information explosion and overload it is estimated a typical petroleum engineer spends 60% of his time for information searching [2]. Proper maintenance of this data/information would increase the search and analyzing features and promotes the better value for the business. Semantic web is a new form of web content that is meaningful to computers will unleash a revolution of new possibilities [3]. Semantic web technologies offer various tools and techniques for efficient integration and maintenance of heterogeneous data/information with improved search and analyzing features. Hence this paper presents various concepts of Semantic web technologies and its significance in Petroleum industry. The paper is organized as follows Section 2 presents the various concepts of Semantic web technologies Section 3 presents various Semantic web applications in petroleum industry. Finally, conclusion follows.

II. SEMANTIC WEB TECHNOLOGIES – CONCEPTS

Semantic web is the next generation web where computers are capable of analyzing all data on the web [3]. The Semantic Web will bring structure to the meaningful content of Web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users (Berners-Lee, T., Hendler, J., & Lassila, O. , 2001). Semantic Web is supposed to create a universal medium for exchanging information in a way understood by computers (Wikipedia), (J. Hendler and O. Lassila, 2006). Consequently, browsing and searching in the cyberspace is simplified. The World Wide Web Consortium (W3C) has proposed a set of Semantic web standards to address various issues such as knowledge representation, querying, security etc. The following diagram depicts the structure of the Semantic web as developed by the W3C.
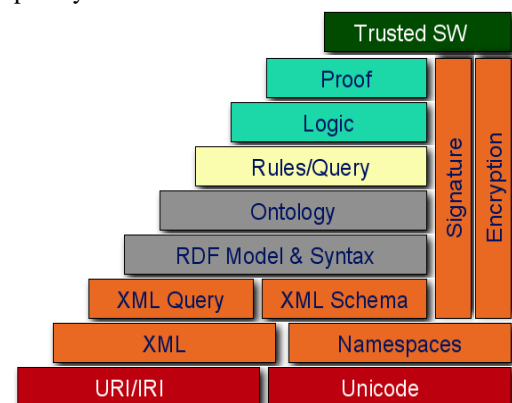

Figure 1: Semantic Web Stack (W3C)

Data/information can be represented as knowledge in semantic web using Resource Description Framework (RDF) and a set Ontology.

A. RDF

Resource Description Framework (RDF) is a general method for modeling the information. The RDF paradigm is based upon the idea of making statements about resources. RDF mainly describes innate objects and the relationships between them. This means that it will be extremely easy to reuse RDF information for various mobile devices. The basic unit of data representation in RDF is a statement or

triple, which is of the form subject-predicate-object. A set of related statements form an RDF graph. Although the graph based RDF paradigm can be encoded in different ways, the most common and important way of encoding it is as a XML document, using a well defined convention. Resource Description Framework Schemas (RDFS) define the meaning of the concepts used in an RDF document just like XML schema acts for XML documents. The following table gives the RDF format

B. Ontology

In Petroleum industry data integration is a complex problem due to the large volumes of data/information stored in different formats (RDBMS, XML, OO etc...) with different semantics. Ontology provides the solution for this complex problem by efficiently integrating the data/information stored in different formats of databases and provides effective mechanisms for knowledge management. Ontology is a shared representation or a data model of a set of concepts in a domain and the relationships between them [4]. Ontology can also be defined as semantic similarity of terms of taxonomies [3]. Ontologies are represented by Ontology languages. Semantic web technologies have provided richer set of primitives better than RDF and RDFS by adding constructs for more expressiveness through OWL. Web Ontology Language (OWL) builds on the RDF standards and improves its expressiveness while making sure that the computational complexity of the language is reasonable.

The following table provides the comparative outlook for the XML/XMLS and Semantic web technologies (RDF/RDFS and OWL) for data modeling and representation.

Table 1: Comparative outlook of Semantic Web and XML

Feature	Category	XML/XMLS	RDF/RDFS	OWL
Classes and class hierarchies	Data modeling	Partial support	Supports	Supports
Properties and Property Hierarchies	Data modeling	Not supports	Supports	Supports
Functional properties (Primary keys), Transitive Properties, inverse properties etc.	Data modeling	Not supports	Not supports	Supports
Class definition as constraints (E.g. ClosedWell is a Well that has status=closed)	Data modeling	Not supports	Not supports	Supports
Ability to infer new information based on existing information	Reasoning	Not supports	Supports	Supports
Standard representation based on open standards	Representation	Supports	Supports	Supports
Ability to represent and query instance data	Instance data	Supports	Supports	Supports

III. VARIOUS SEMANTIC WEB APPLICATIONS IN PETROLEUM INDUSTRY

Presently, a large number of research projects are working on designing the Semantic Web applications for Oil, Gas and Energy industries. These projects are mainly focusing on data interchange, Knowledge management and designing the domain ontology etc... The following are the various semantic web applications for Petroleum industry.

A. Data Interchange:

Feigenbaum et. al developed a semantic web application for data interchange in oil industry [5].

B. AKSIO:

Active Knowledge System for Integrated Operations (AKSIO) [6] is a knowledge management project which uses RDF, OWL and SPARQL for semantic annotation of experiences and supports contextual ontology driven retrieval of content.

C. IIP :

Integration Information Platform (IIP) [7] aims to ease the integration of data and processes across phases and disciplines by providing a comprehensive unambiguous and well accepted terminology standard that lends itself to machine-processable, interpretation and reasoning.

D. Smart WellOnto Project:

This project has developed a preliminary version of an ontology for smart wells, which is expected to be used to build a knowledge base system for optimization of the oil/gas reservoir [8].

E. IAM Project:

This project has designed domain ontology for field entities in a reservoir [9].

F. GEON Project:

This project is developed for Geoscientists'; this project integrates the different formats of data represented by the various disciplines like Petrology, Geophysics, and Hydrology etc.

IV. CONCLUSION

In this paper we have explained the various concepts of Semantic web and its significance in Petroleum industry. We are in the process of developing the Semantic web application for Petroleum industry; we will explain our work in next paper.

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