Position Paper - W3C Workshop on Semantic Web in Energy Industries;

Part I: Oil & Gas

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Towards an Ontology Driven EOR Decision Support System

Introduction

Since April of 2007 we have been working in collaboration with Schlumberger to explore the application of ontologies to oil and gas and in particular in the domain of Enhanced Oil Recovery (EOR). EOR is defined as oil recovery by injection of fluids not normally present in the reservoir, It excludes pressure maintenance and waterflooding and is not necessarily the same as tertiary recovery.

Why Enhanced Oil Recovery?

With the increase in the price of oil to the $100 range and the fact that 65% of the oil remains in place after secondary recovery, EOR has become an increasingly important aspect of the hydrocarbon production.

The University of Texas at Austin is the recognized world leader in research on EOR with Drs. Larry W. Lake and Gary A. Pope supervising more than 20 graduate students working in this area. In particular, the Chemical EOR Joint Industry Project has more than 20 sponsoring companies from all over the world. The University of Texas EOR laboratories are unequaled in both academia and industry. Research projects being pursued include:

- Development of New Surfactants and Polymers for EOR
- Modeling Chemical EOR
- Chemical EOR Experiments to Change Wettability
- Modeling the Effect of Pressure on Microemulsion Phase Behavior ,
- Scaling Groups for Screening of SP/ASP Flooding
- Understanding the Mechanisms in Low Salinity Waterflooding and Polymerflooding
- pH Sensitive Polymers for Novel Conformance and Mobility Control Applications
- Novel EOR Foams.

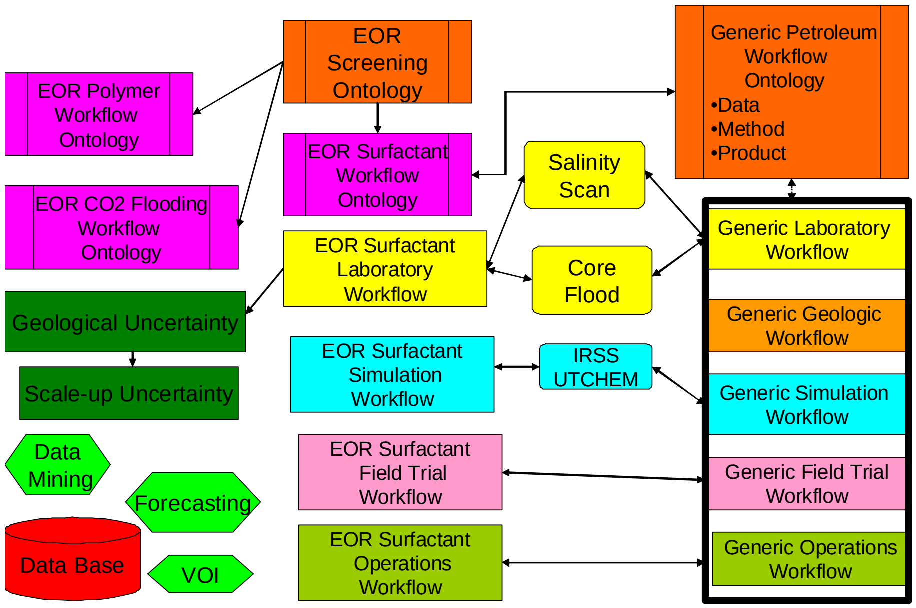
Why a Decision Support System?

Looking at the decisions that must be made in selecting and executing a plan for EOR for a particular reservoir, it becomes clear that the current process is ad-hoc and would benefit significantly from a decision-support system. In addition, with the scarcity of trained engineers in the oil and gas industry, a decision-support system would enhance the decision-making ability of many decision-makers and significantly leverage the scarce workforce trained in EOR.

Why Ontology-Driven?

Ontology provides an organizing mechanism such that knowledge is managed to be accessible to software agents as well as humans. It also helps bridge the gap among disciplines and maximizes reusability. In addition, it provides the basis for automatic inferences.

The Vision



A Vision for an Ontology-Based EOR Intelligent Decision Support System

The idea is to capture all the workflows dealing with different aspects of EOR, create workflow-driven ontologies, and combine them together into a comprehensive decision-support system that will be able to answer questions such as:

- What EOR Methods should be considered for this reservoir?
- How do we calculate the oil recovery vs. time when this EOR Project is implemented?
- What is the total porosity/permeability of the reservoir and what is their uncertainty?
- If chemical flooding, what chemicals should be considered as candidates for surfactants, co-surfactants, alkali, polymers, co-solvents for this particular chemical flooding project?
- What is a rough estimate of the net present value (NPV) of this EOR Project?
- How much uncertainty is associated with the prediction of performance in the field?
- Given that chemicals are available and the NPV is acceptable, what is the chemical EOR formulation that we should simulate?
- How do we calculate the value of doing more lab work before going into production with this EOR method?
- Should we do a pilot test in the field?
- How do we decide whether to skip a step in the process to accelerate production?

Tools Used

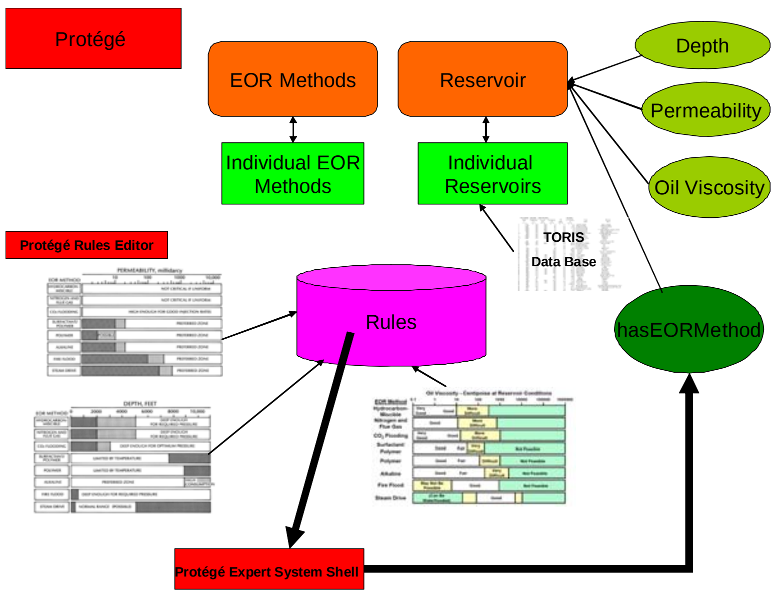
We are using the Stanford developed and maintained Protégé-OWL to build all ontologies. We believe it provides a very flexible environment for ontology development with many plug-ins and APIs for extensibility.

Pilot Ontologies

We have developed several pilot ontologies to investigate the feasibility of building the decision support system. A short summary of each ontology follows:

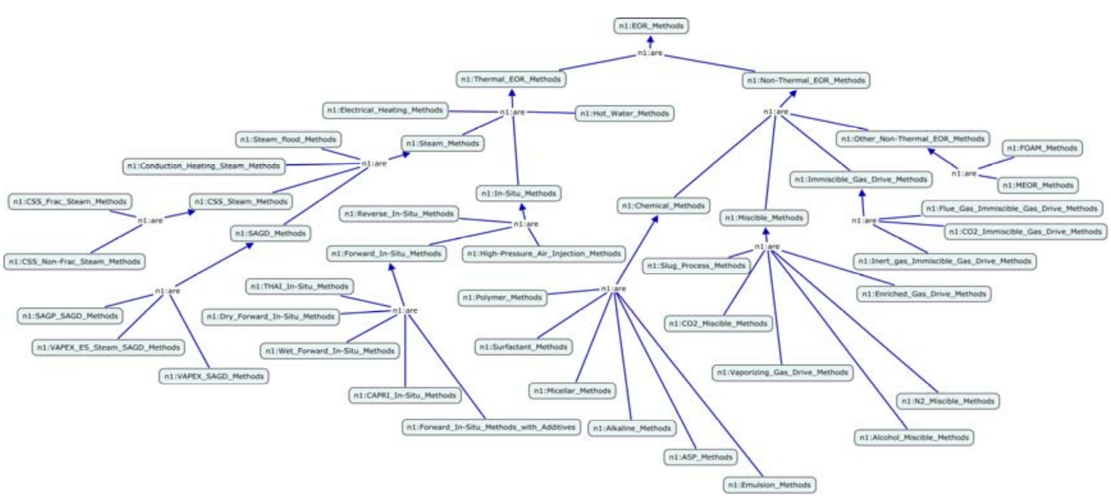
1. EOR Screening Ontology

This ontology was developed using Protégé-OWL in conjunction with the SWRL (Semantic Web Rule Language) plug-in. It iresembles an expert system that determines what EOR methods potentially apply to a given reservoir based on reservoir permeability, depth and oil viscosity. Reservoir properties from the TORIS data base were used to populate the data base. A schematic of the system follows:



2. EOR Ontology

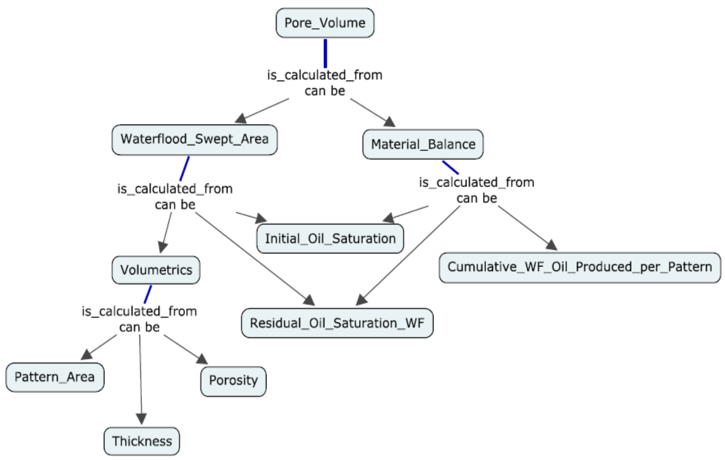
We have developed the beginnings of a comprehensive ontology for EOR Methods. A partial concept map illustrating the class structure follows:



3. Simplified Recovery Calculation Ontology

We have developed an ontology that illustrates the estimation of future recovery from a reservoir. It uses only one property : the “is calculated from”. The following partial concept map is an illustration of the structure of the ontology:

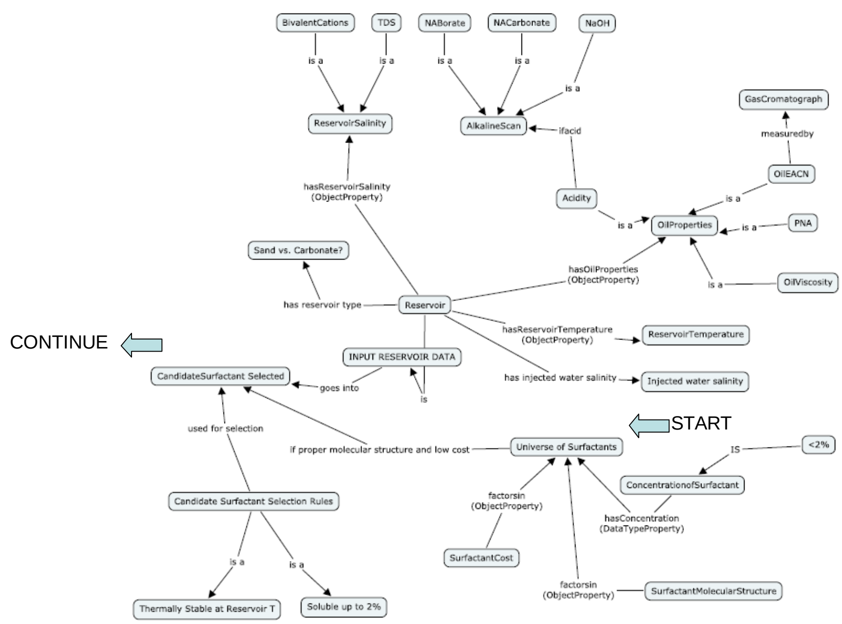
A



4. Surfactant Selection Lab Workflow Ontology

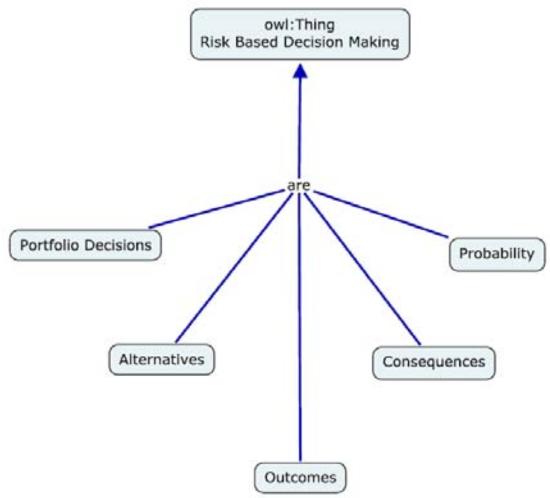
We have captured a simplified workflow for the laboratory work necessary for selection of surfactants for a surfactant flood. We intend to create a “workflow-driven” ontology of this process. Following is a partial concept map that illustrates the process:

1 of 3



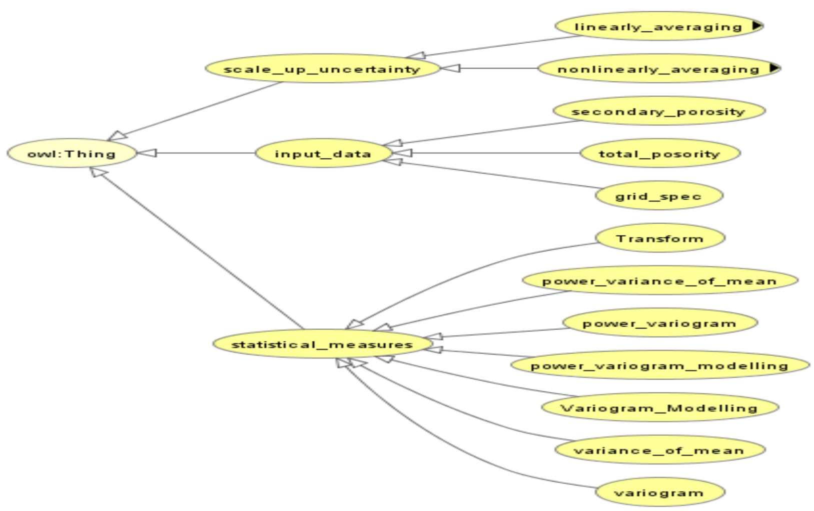
5. Risk Management Ontology

Any decision-support system dealing with Oil and Gas Exploration and Production, including EOR, must deal with uncertainty. We have developed an ontology to capture processes of Risk-Based Decision Making. This decision ontology synthesizes the other ontologies and guides their development to provide the tools and information that are most useful for making EOR decisions. A partial concept map is presented below:



6. Scale-Up Uncertainty Ontology

We have developed an ontology of methods to deal with geologic uncertainty during scale-up from laboratory to the field. The following is a schematic showing the class structure:



Future Work

We intend to develop ontologies for all aspects of EOR, using interfaces to Protégé to develop a decision-support system that includes a user-friendly front-end for queries.