Knowledge representation in Semantic Web and Development of Academic Ontology using Web Ontology Language& SWRL

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Abstract: The current Web is an enormous and increasing source of information and services. These information and services need to be shared not only by people but by applications. The Semantic Web is an evolving extension of the current World Wide Web (WWW) in which web content can be expressed in a format that can be read, understood and used by software agents, so software agents can easily find, share and integrate information more easily. In the stack of Semantic Web Layered Architecture, Ontology is one kind of data model which represents a set of concepts/classes within a domain of interest and the relationship between those concepts. Ontology plays an important role in information exchange and sharing by extending syntactic interoperability of the current Web to semantic interoperability of Semantic Web. Ontology offers a common understanding of a domain that can be communicated among the people as well as heterogeneous and distributed systems.

On the World Wide Web, RuleML is a markup language which is used for sharing and publishing rule. Its emphasis is on rule interoperability between industry standards. Semantic Web Rule Language (SWRL) is proposed to be the rule language of the Semantic Web. All rules in SWRL are expressed in triplet like OWL concepts. Both Ontology and development of Ontology using SWRL are central to the semantic web, and their combined use will enable the restriction of the ontology in adaptable and extensible manner.

This paper focuses on the utilization of combining both Ontology and SWRL structure towards system integration for Academic Institute. In this paper, I have demonstrated how to define rules in Academic Domain using SWRL and partially implemented Academic Ontology where I have used Web Ontology Language (OWL) to model the domain and SWRL to model the rules for the development of Academic Ontology. Here, I have used SWRL to specify rules for Academic Ontology, so on behalf of human being machines can automatically deduce new rule which is helpful for generating knowledge from existing one.

Keywords: Ontology, RuleML, Semantic Web, OWL, SWRL.

1.INTRODUCTION TO SEMANTIC WEB
The current Web is an enormous and increasing source of information and services. These information and services need to be shared not only by people but by applications. The Semantic Web is an evolving extension of the current World Wide Web (WWW) in which web content can be expressed in a format that can be read, understood and used by software agents, so software agents can easily find, share and integrate information more easily.[1]

The Semantic Web is a Web of data (instead of documents). For example, I can see, on-line, my AXIX Bank statement (document), my PNB Bank statement, my credit card transaction, My Demat Account transactions, etc. thru respective websites. But can I see my financial position at once? No, because my data is managed by different application and they are not linked. The vision of the Semantic Web is to extend principles of the Web from (linking) documents to (linking) data. Data should be accessed using the general Web architecture, e.g., URIs; data should be related to one another just as documents (or portions of documents) are related. This also means creation of a common framework that allows data to be shared and reused across application, enterprise, and community boundaries, to be processed automatically by tools as well as manually, including revealing possible new (ad-hoc) relationships among pieces of data.

Tim Berners-Lee has created semantic web layer cake model which illustrates the hierarchy of languages which can be used for the implementation of Semantic Web. It shows how technologies that are standardized for Semantic Web are organized to make the Semantic Web possible. It also shows how Semantic Web is an extension (not replacement) of classical hypertext Web.[2]

2.INTRODUCTION TO ONTOLOGY
According to Tom Gruber, Ontology is "the specification of conceptualizations, used to help programs and humans share knowledge." Ontology is an agreed vocabulary in any domain which gives a set of well-defined constructs to form meaningful higher level knowledge for specifying meaning of terminology systems in a definite and well-defined meaning. Ontology has a set of well-defined
constructs which can be influenced to figure out knowledge in any domain. [3] Most important feature of Ontology is its machine interoperability due to formal and real-world semantics. Because of this important property of Ontology, it is possible to reuse and share the Ontologies not among humans but among machines also. [4] Another important key feature of Ontology is that it can support reasoning. For example, using Ontology we can state that if Y is a father of X and Z is a father of Y then we can infer that Z is a grandfather of X or if A is a friend of B then we can infer that B is a friend of A. Due to this reasoning capability of Ontology, it is more effective and powerful than data storage before. Using this reasoning capability of Ontology, we can make a number of applications more capable of handling complex and disparate information. This capability can be used to make Semantic Web Vision true.

3. WHAT ARE RULES ON THE SEMANTIC WEB?
Semantic Web Rule Language (SWRL) is the rule language for Semantic Web which combines Ontologies (OWL-DL) and rules (RuleML). A rule language is required for several reasons[5]:
- First, the existing rule sets can be reused.
- Second, expressivity can be easily added to OWL.
- Third it is easier to read, write rules with a rule language.

4. INTRODUCTION TO RULEML
RuleML is a markup language for publishing and sharing rule bases on World Wide Web. RuleML based on a hierarchy of rule sublanguages such as XML, RDF and OWL [6]. Ontology which is consisting of rules and facts in any domain that can be refined and transcribed by RuleML.

As given in “RuleML Tutorial” by Harold Boley, Benjamin Grosos, Said Tabet, the Datalog (constructor-function-free) sublanguage of Horn logic is the foundation for the kernel of RuleML. Datalog is the language in the intersection of SQL and Prolog. It can thus be considered as the subset of logic programming needed for representing the information of null-value-free relational databases, including (recursive) views. That is, in Datalog we can define facts corresponding to explicit rows of relational tables and rules corresponding to tables defined implicitly by views. RuleML-Datalog, being a markup language, can conveniently represent relational information where all of the columns are natural-language phrases [6].

5. DEVELOPMENT OF ACADEMIC ONTOLOGY
The Domain Ontology for this paper is the Academic Ontology. Figure-1 shows concepts and the relationships existing within its domain. In Academic Ontology, I have defined main three concepts namely, University, Department and Faculty; and three object properties namely isAffiliatedTo, isAssignedTo and isAssociatedTo. I have also defined some of the data type properties for each class.

With the help of OWL, one can also define the relationship between the classes. Following are the some of the statements in OWL, which expressed the relationships between classes of Academic Ontology.

Similarly, we can define datatype properties of each and every classes using OWL. Following are some of the examples of datatype properties declared in Academic Ontology.

Figure – 1: Pictorial Representation of Ontology in Academic Domain
6. PARTIAL IMPLEMENTATION OF ACADEMIC ONTOLOGY USING SWRL IN PROTEGE

As explained earlier, RuleML is designed to be an XML-based interchange language for rules on the web. The Semantic Web Rule Language (SWRL) is OWL-specific and it could be mapped to an equivalent RuleML representation. The SWRL based on a combination of OWL DL and OWL Lite sublanguages of OWL with the Unary/Binary DatalogRuleML. SWRL permits users to write rules that can be expressed in terms of OWL concepts to provide more powerful deductive reasoning than OWL. Because of this additional functionality, I have used SWRL rule language for specifying rules in Academic domain.

SWRL is used to specify rules in Ontology, for e.g. if Faculty isAssignedTo Department and Department isAffiliatedTo University then Ontology can deduce that the Faculty isAssociatedTo particular University. Following is the syntax for writing above rule in SWRL:

\[
\text{academic:isAssignedTo( } \text{academic:X, academic:Y) }
\text{ ∧ academic:isAffiliatedTo( } \text{academic:Y, academic:Z) }
\rightarrow \text{academic:isAssociatedTo( } \text{academic:X, academic:Z)}
\]

Following is the code for writing above rule in SWRL:

```xml
<swrl:Imprdf:ID="Rule-1">
  <swrl:body>
    <AtomList>
      <first>
        <IndividualPropertyAtom>
          <argument1 rdf:ID="X"/>
          <argument2 rdf:ID="Y"/>
        </IndividualPropertyAtom>
      </first>
      <rest>
        <IndividualPropertyAtom>
          <argument1 rdf:resource="#isAssignedTo"/>
          <argument2 rdf:resource="#Y"/>
        </IndividualPropertyAtom>
      </rest>
    </AtomList>
  </swrl:body>
  <head>
    <AtomList>
      <first>
        <IndividualPropertyAtom>
          <propertyPredicate rdf:resource="#isAssociatedTo"/>
          <argument1 rdf:resource="#X"/>
          <argument2 rdf:resource="#Z"/>
        </IndividualPropertyAtom>
      </first>
    </AtomList>
  </head>
</swrl:Imp>
```

Following figure – 2 shows screen shot of partially implemented Academic Ontology in Protégé 3.4.2 using OWL and SWRL Editor. The SWRL Editor is an extension to Protégé-OWL which can be used to write SWRL rules, editing if existing rules and you can easily read and write SWRL rules. You can directly open SWRL Rule Tab in Protégé editor.

Once you create Academic Ontology in Protégé, you can fire any query using SPARQL. In this Academic Ontology, if someone is interested in finding list of faculty members affiliated to a particular university along with the faculty designation then following is the code for SPARQL query:

```sparql
SELECT ?FacultyName ?FacultyDesignation ?UniversityName
WHERE {
  ?x academic:FacultyName ?FacultyName.
  ?x academic:FacultyDesg ?FacultyDesignation.
  ?y academic:UniName ?UniversityName.
  ?x academic:isAssociatedTo ?y
}
```

Here SPARQL automatically applies SWRL Rules which are defined in Academic Ontology.
7. CONCLUSION

OWL has expressive power but a SWRL rule can provide more concise and understandable formulations than OWL, which may instead require a set of not-obviously-related axioms distributed throughout ontology to make equivalent statements. SWRL adds additional expressive power. As discussed by Ian MacLarty, LudovicLangevine, Michel VandenBossche and Peter Ross, SWRL supports true separation of business and IT knowledge. It also maintains tight and natural integration with modeling language (OWL). It is easy to extend with domain-specific built-ins. Description logic which is a powerful logic and supports greater reasoning capabilities which work behind SWRL, so combination of OWL and SWRL will allow in a near future the development of powerful knowledge management and semantic web applications.

References


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Dr. Priya R. Swaminarayan presently working as Professor & Head in MCA Department at Institute of Science and Technology for Advanced Studies and Research (ISTAR). She has completed her Ph.D. in Computer Science. She has earned more than 15 years of professional experience. She has published more than 20 Research papers in National and International Journals.