Semantic Web Services for e-Learning: Engineering and Technology Domain

Krupali Shah and Jayant Gadge

Abstract—**E–learning has gained its importance over the traditional classroom learning techniques in past few decades. It is required to have a system which adds to the learning needs of the learner for better understanding. Thus the resources which are used to store the information on the web have to be organized and stored in a way that their retrieval would be meaningful as compared to just a key word search. To accomplish this goal, semantics are used to store the resources. This paper demonstrates how semantic metadata can be stored and retrieved to provide better results to the learner along with personalized learning.**

Index Terms—**E-learning, semantic web.**

I. Introduction

E-learning is being increasingly viewed as an important activity in the field of distance education. Web-based courses offer obvious advantages for learners by making access to educational resources very fast, just-in-time and at any time or place. With such a huge amount of information available on almost every topic on the Internet, the problem arises when one tries to search for some specific topic. Browsing such a huge amount of content consumes a lot of time and efforts. It has a drawback for retrieving intended information, as it (usually) follows a keyword search pattern. These tools are based on a simple scan of a text document to find a key word or root stem of a key word.

To remove this disadvantage of the current web standards, the notion of adding meaning to the web (e-learning repository in this study) is considered. Thus adding Semantics (meaning) to the e-learning would add up to the advantages of distance learning as the results then obtained have with the meaning of the learner's topic of concern. With the increasing and rapidly growing field of learning on Web; personalized services offered with e–learning has also gained its importance, thus making the web more understandable and personalized. When a combination of Semantic Web based personalized learning is taken, lot of improved services can be offered compared to traditional systems.

The notion of Semantic web personalized services on the whole e–learning repository makes the system not only reliable, scalable and computer processable but also computer interpretable. Thus the whole idea is to create a Web of machine-understandable and interoperable services that intelligent agents can discover, execute, and compose automatically.

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In this paper, a systematic approach towards the development of semantic web services for e–learning domain of engineering and technology is presented. This gives the traditional e-learning repository, semantic and powerful mechanism for organizing such material.

II. Literature Review

In the era of information sharing and fast growth in technology evolution, learning has moved from the traditional one to one learning to web based interactive learning systems. The availability of information has grown so wide that any kind of information in any format is available in just few clicks. But still the user (learner) has to invest a lot of time to find relevant information from a vast pool. Thus to make the learner's task easier and speed up the learning process, a new improved system is needed.

A. Semantic Web

The Semantic Web is based on a vision of Tim Berners-Lee, the inventor of the WWW (World Wide Web). The great success of the current WWW leads to a new challenge: A huge amount of data is interpretable by humans only; machine support is limited. Berners-Lee suggests enriching the Web by machine-processable information. For instance, today's search engines are already quite powerful, but still too often return irrelevant lists of hits. Machine processable information can point the search engine to the relevant pages and can thus improve both precision and recall [1].

The process of building the Semantic Web is currently an area of high activity. Its structure has to be defined, and this structure then has to be filled with metadata. In order to make this task feasible, one should start with the simpler tasks first. The following steps show the direction where the Semantic Web is heading [1]:

1) Providing a common syntax for machine understandable statements.
2) Establishing common vocabularies.
3) Agreeing on a logical language.
4) Using the language for exchanging proofs.

B. Ontology

Ontologies applied to the Web are creating the Semantic Web. Ontologies provide the necessary armature around which knowledge bases should be built, and set grounds for developing reusable Web-contents and Web services. Ontologies facilitate knowledge sharing and reuse [2].

An ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins [3].

Only considering Ontologies to standardize and provide interpretations for Web content, are not enough to build the Semantic Web. To make Web content machine-understandable, Web pages and documents themselves must contain semantics, i.e. annotations which use the terminology that one or more ontologies define and contain pointers to the network of ontologies.

Semantics are contained within the page published on the Web, and is saved as part of the file representing the document/page. Services also must be properly designed to have semantics, to make them computer-interpretable. They must contain mapping mechanisms which would act as pointers to the corresponding ontologies.

Adding Semantics to a Web page or service might state that it is a member of a class, has some property, relationship between them, and can have different references. Typically, semantics are specified using an XML based high-level ontology-representation language syntax.

C. Personalization

When dealing with web services provided for an individual, customer feedback and customer needs are one of the important criteria. Thus personalization plays an important role in the e – learning systems in order to give the learner the required services according to their interests.

Web pages are personalized based on the characteristics like interests, social category, context etc of an individual [4].

D. Intelligent and Personalization Services in E-Learning using Ontology and Semantic Web

Some of the systems as mentioned in [5], Sylvain Dehors, Acacia and Mainline in [6] have developed an e-learning platform QBLS (Question Based Learning System) which supports lab sessions based on knowledge engineering and Semantic Web. It reuses learning resources available on the web and pedagogical ontologies to create a convenient learning system for assignment sessions. It is also used on actual curricula at the EPU engineering school of Sophia Antipolis, but it only considers the user's personalization characteristics. Cisco as in [7] has developed a system of reusable learning objects; each learning object can mix and match a specific explanation of the curriculum and activities. J. Jovanovi, D Gaševiü, and V Devedžiü in [8] have developed TANGRAM (an integrated learning environment for the domain of Intelligent Information Systems) which uses an ontology-based approach for automatic decomposition of learning objects into reusable content units, and dynamic reassembly of such units into personalized learning contents. P. Gomes, Bruno Antunes, Luís Rodrigues, Arnaldo Santos, Jacinto Barbeira, and Rafael Carvalho in [9] have a project named PERSONA. It is developed in collaboration between PT Inovação and the Artificial Intelligence Lab of Coimbra University, they present an approach to E - Learning personalization based on ontology, by which a student model is constructed for enabling the personalization system to guide the student's learning process.

III. Design Consideration

The goal of developing Semantic Services for E-Learning is to make the user's task easier and help him learn according to his area of interest. The system will make the structure of the E - Learning repository in a domain standardized way which can then be used to model the system. Many different styles have been proposed for the development of Semantic web Services which uses standards already developed by many organizations for E-Learning.

Domain standardization can be performed by developing ontologies to model learner's profile and the E-Learning repository. These ontologies are then used to write metadata for describing the resources which can then be referred to extracting most relevant and accurate information from the problem specific domain. System architecture for the system can be given in Fig.1.

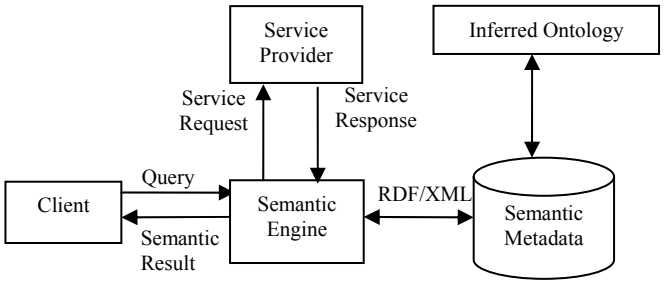

Fig. 1. System architecture

As evident from the Fig. 1, when a client queries through web client or a browser, it is in turn given to the semantic engine. This request is then analyzed for client side processing after which it is forwarded to the service provider in the form of service request. The response is given back by the processing server to give the suitable service to the semantic engine. Here the role of semantic engine is as a mediator for analyzing the meaning from query given by the client. This meaning is stored as semantic metadata repository. This repository is created, updated and maintained from the ontology developed for the considered domain, for the purpose of standardization.

The important stages of the design are ontology development, Personalization and Semantic Service modeling. The proposed system will deal with basically two types of ontologies: learner's ontology and e-learning system ontology. Learner's ontology basically shows how the different learners are classified based on their learning level, their learning method and the learner's behavior. E-Learning system ontology basically deals with how the whole e-learning domain is divided and incorporated into the whole system.

The next part will be dealing with the personalization of the web pages based on the learner's requirements. When the learner interacts with the system for the first time, he will have to register by giving his learning level and area of interest. According to these criteria, the learner's profile is created. Thereafter, the learner's behavior is tracked and according to his history and preferences he interacts with the system. The steps for system design can be depicted from Fig. 2.

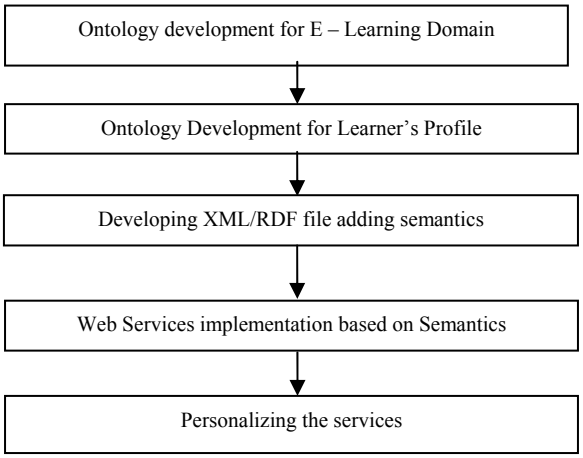

Fig. 2. System design flowchart

IV. Implementation

The domain of e-learning considered in this project is restricted to Engineering and Technology field. Ontology is used to model the repository in an organized standard pattern. Thus ontology is developed for Engineering and Technology that includes classes such as Basic, Computer Science, Computer Software, Computer Language, Operating System, Database, C/C++, and Java. Some of the web based services offered are user registration, online course, interactive tutorial, user history maintenance. These services are accompanied with certain assessment services like exercises and quizzes which are used to allow the user to progress through the system.

By following the design steps discussed in section III, implementation of the system is carried out as follows, section A gives detailed steps of developing ontology for the system, section B gives details of developing XML (Extensible Markup Language) files for personalization and section C deals with developing RDF (Resource Definition Framework) for the domain.

A. Developing Ontologies

The major steps in creating ontology are listed below. The e-learning ontology design is taken as an example and each step is elaborated.

Step 1: Determine the domain and scope of the ontology.

Considering the e-learning ontology for the proposed system the scope of the ontology is limited to the Engineering and Technology that includes classes such as Basic, Computer Science, Computer Software, Computer Language, Operating System, Database, C/C++, and Java.

Step 2: Consider reusing existing ontologies

None of the existing ontology would be useful to be reused directly for the E - Learning domain which has been considered. Thus a whole new set of ontology have to be developed

Step 3: Enumerate important terms in the ontology

The important terms in the domain would be, learner, learning level, subject learnt, pre requisite, level of mastery.

Step 4: Define the classes and the class hierarchy

Step 5: Define the properties of classes

Once we have defined some of the classes, we must describe the internal structure of concepts. This is depicted in Fig. 3, Fig.4 and Fig.5.

Step 6: Define the facets of the slots

Slots can have different facets describing the value type, allowed values, the number of the values (cardinality), and other features of the values the slot can take.

Step 7: Create instances

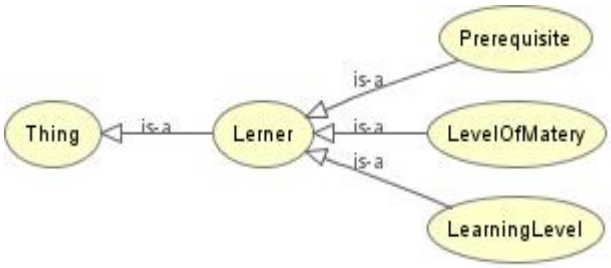

Fig. 3. Learner ontology

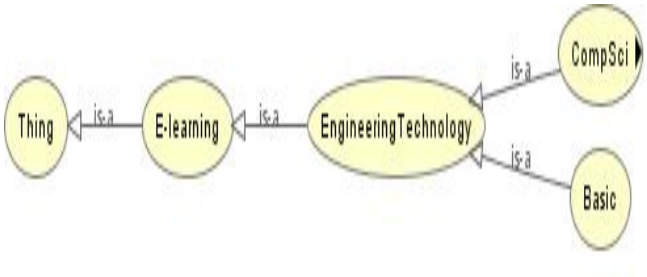

Fig. 4. E-Learning ontology showing E-Learning class

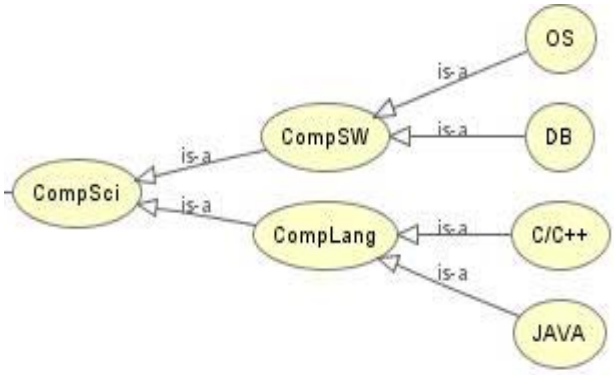

Fig. 5. E-Learning ontology showing engineering technology class

B. Developing XML Files

Each user registers with the system, an XML file is generated for individual user. This file is then used to provide personalized service to the user. Along with the personalization file and the history about the user's session is being stored in another XML file at run time as the user navigates through the tutorial pages.

Upon the next login, the user is given few links inferred from the previous session. Thus a link to the most relevant page is stored for reference for the user in the next session.

These XML files are created and parsed by using parser API available like DOM (Document Object Model) and SAX (Simple API for XML) using Java. Example of each is shown in the Fig. 6 and Fig.7 respectively.

```
<?xml version="1.0"?>
   <UserDetails>
   <UserName>
      kk
      <LearningLevel>1</LearningLevel>
      <Personalization>Yes</Personalization>
      <Personalization_Details/>
      <EmailAddress>kk@jj.com</EmailAddress>
   </UserName>
</UserDetails>
```

Fig. 6. Personalization XML instance

```
<UserDetails>
   <User>
   <UserName>kk</UserName>
   <History>
      <Detail Date="Mon Apr 18 10:09:22 IST 2011"
      URI="/WebApplication2/loginServlet"/>
      <Detail Date="Mon Apr 18 10:09:22 IST 2011"
      URI="/WebApplication2/loginServlet"/>
      <Detail Date="Mon Apr 18 10:09:22 IST 2011"
      URI="/WebApplication2/recentHistory"/>
   </History>
   </User>
</UserDetails>
```

Fig. 7. User history XML instance

C. Developing RDF Schema

Defining RDF is another important part in order to link the semantics, as they define the vocabulary of an RDF model. It provides a mechanism to define domain-specific properties and classes of resources to which those properties can be applied, using a set of basic modeling primitives. Basically RDF is XML file with detailed specification or metadata for a particular resource. The RDF files generated by the domain ontology are shown in Fig.8.

```
<rdf:RDF
xml:base="http://www.semanticweb.org/ontologies/2010/8/E-learn-le
rner.owl">
<owl:Ontology
rdf:about="http://www.semanticweb.org/ontologies/2010/8/E-learn-le
rner.owl"/>
<owl:Class
rdf:about="http://www.semanticweb.org/ontologies/2010/8/E-learn-le
rner.owl#LearningLevel"/>
<owl:Class
rdf:about="http://www.semanticweb.org/ontologies/2010/8/E-learn-le
rner.owl#LearningLevel">
```

Fig. 8. RDF model for learner ontology

The user will interact with the system via a browser which will act as a semantic engine and accept a query. Then this query is scrutinized by inferring to the ontology and the metadata provided by the semantics will provide the services from the server. These services will be based on the user customized preferences and behavior.

The proposed system registers the user for his first visit, stores his profile information and records his search criteria and preferences. Then for the subsequent visits inferring the earlier visits the results are given according to the user's clicks. The learner's ontology is created for storing his preferences and history information. Ontology is also developed for the courses offered by the E - Learning domain. The domain is basically restricted to the computer engineering field. Web based services are offered to the user for better personalized learning.

On the ontology tier the Semantic web based RDF/OWL schema will be written which will facilitate adding of Semantics to the resources of the related topics. This will be accomplished by defining a markup using XML encoding. The semantic web services then can be personalized depending upon number of parameters like user's interest; user's learning level and user's search history etc.

V. Results and Discussion

The system is developed on JAVA platform. The tutorial pages have been built by using HTML for the front end and technologies like JSP (Java Server Pages), Servlets, Java Beans etc are used for various processing.

MySql is used as a database server in collaboration with Tomcat 5.5. The whole system is run on Netbeans 5.5 IDE, which has an inbuilt Tomcat application server.

The E–Learning domain has been standardized by designing ontology for that domain. These Ontologies are made by using open source software Protégé 4.1.

Proposed system offers various Semantic Web services, such as registration, personalization, notifications and ontology mapped tutorial pages. The pages designed can be shown in the Fig.9.

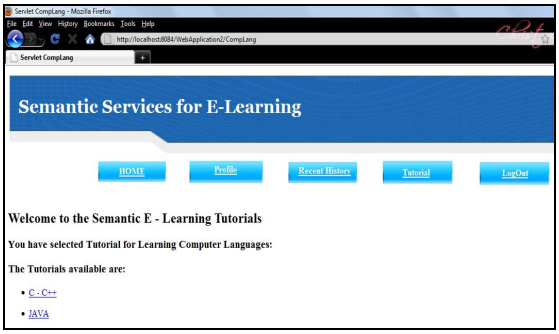

Fig. 9. Computer language tutorial page

The developed ontology is mapped to provide relevant tutorial pages to the user depending upon the user's learning level and level of mastery. Using this mapping semantic web services are provided to each user who visits the tutorial pages, acquiring knowledge in the process and thus mastery level for the user is increased as he progresses from one tutorial to the next.

According to the ontology design for Engineering and Technology domain of E–Learning the user has to traverse the tutorial in the following pathway:

5) Basic
6) Computer Software
   - Operating System
   - Databases
7) Computer Languages
   - C – C++
   - Java

Once the user logs into the system for the first time, he is given a list of available tutorials on the site. Then from the subsequent logins his history and personalized details are

provided. This is done by referring to the user's history XML file which stores last visited and most relevant links for navigation.

User's access to the tutorial pages is restricted till the user gains the corresponding mastery level to view that resource. The user's mastery level is updated when the user takes quiz page corresponding to that resource and satisfies the minimum criteria for that resource. The current version of the system considers static quiz which can then be updated and mapped with semantics, by using QBLS [6], as future work.

VI. Conclusion and Future Work

The work done so far presents a meaningful retrieval of resources based on the user's level of mastery and the defined system ontology: Learner's profile modeling ontology and e–learning domain modeling ontology. The pre – requisites for each tutorial web page is checked before it is presented to the user.

The mapping from ontology to system resource is crucial as it adds metadata about the resources. Thus while adding some new resource is not only easy but also with semantics which also are machine process able.

Thus ontology based semantic web based systems gives better results when compared with relational database systems.

The current version of the system can be extended to a larger scale by increasing the E – Learning ontology which will automatically be reflected to the user interface of the system, as the system takes the resources from the specified ontology. Also various types of resources can be added to the system for better personalization provided to the user.

The future work of the system would include implementing better personalized services which provide recommendations by considering user's history. The domain ontology can then be extended to include new tutorials with user interactive tools. The future work would also include developing better ways to update the user's mastery level and let the user progress through the system in an incremental way.

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