FOAPA: A Fuzzy Ontology E-Education Adaptive Portal Architecture for E-Learner

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ABSTRACT

Teachers usually have a personal understanding of what "good teaching" means from their experience and domain knowledge background in education, lots of them create learning resources(LRs) and put on the web for learners or students to study. In fact, most of student can not find the suitable LR (e.g. learning materials, or learning assets, or learning packages) from webs. In this paper, we based on ontology and fuzzy technology to propose an architecture for adaptive and re-usability in personalized web-based E-Education Portal, help learners fetch the LR from ontology LR repositories according by the learner characteristics/attribute (e.g. domain knowledge background and Kolb's [11] Learning Style), and we also interested in exploiting the semantic relationships that characterize theses LRs, so we redefine two "relation" attributes from Dublin Core [3] metadata schema call "Pre_Relation" and "Succ_Relation" for enhance LR relations in order to recommend the relative LRs for learner further reference.

1. INTRODUCTIONS

In the classic teacher-centered situation, the course is built from the content defined by the teacher or author, and most teachers or educators agree that, in the design and development of educational material, attention must be focused on learner characteristics and requirements, defined in terms of contents and of learning style[1][2]. Teachers usually have a personal understanding of what "good teaching" means from their experience and domain knowledge background in education, and they create learning resources put on the web for learners to study. In fact, most of student can not find the suitable learning resource from web, because each LRs has different attribute (e.g. resource level, resource type), each Individual learner also have different characteristics(e.g. learning style, domain knowledge background), and well-known search engine (e.g. Google, Yahoo) search by keyword not involve the semantic and personalize characteristic, actually, the front-end users require efficient, effective and adaptive access to LRs in personalize way, according to their individual attribute, requirements, domain knowledge background, and so on. So, how to help learner easy to find the adaptive LRs according their own characteristics is need, In past decade, several metadata schemas have been proposed to describe LRs, such as Dublin Core [3], Learning Object Metadata (LOM) [4], Shareable Content Object Reference Model (SCORM) [5], RDF[12], RDF/S[13], DAML+OIL[14] and OWL[10], use these metadata schema can make a good description and definition about LR's attribute, but exploits the semantic relationships of LRs in order to support conceptual navigation and retrieval of LRs through specific views of Dublin Core metadata schema(e.g. "relation" relationships) or RDF/S metadata schema(e.g. "prerequisite", "part-of", "see-also" relationships) is not enough, because they supplies one-direction relationships, we think that relationships of LR not only one-direction relationship, bi-direction relationships is much make sense (e.g. Figure 1), so we define two "relation" attributes metadata call "Pre_Relation" and "Succ_Relation" and incorporate fuzzy logic into ontology to handle LRs relation issue.

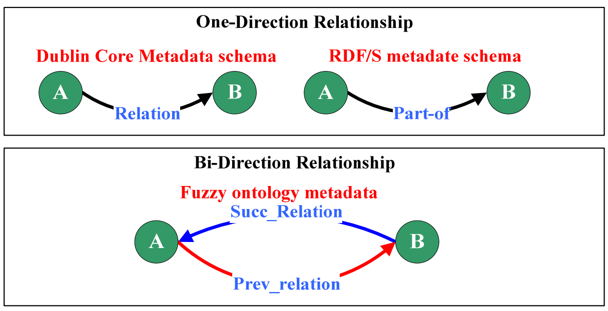

Figure 1. One-direction or Bi-direction relationship

Figure 2 shows that if the learner("Daniel") want to get the most adaptively LR from LR repository(e.g. local host or remote host file system), which LR is the best choice? To figure out the issue, we must consider threes core factors, there are learners' attribute, author's attribute and LR's attribute. Each learner has different learning style [1], [2], [11] (e.g. diverging, converging, assimilating, accommodating), and domain knowledge background (e.g. beginner, intermediate, expert), each author has his own domain knowledge background (e.g. SQL expert or SQL user) and each LR has its own format (e.g. MS Word, PowerPoint, Adobe PDF, HTML, XHTML, audio/video, hypermedia, etc.) and LR level (e.g. easy, advance, export). Subsequently, we must propose a methodology to match the learners' requirement, in the case, to decide which LR ("SQL introduction" or "Basic SQL" or "Advance SQL") is the most adaptive LR to learner("Daniel"), that's a big question mark. The remainder of this paper is organized as follows: Section 2 introduces the fuzzy ontology LR and Kolb's learning style model. Section 4 outlines the architecture for our Portal, while Section 5 compares out Portal infrastructure with related work. Finally, Section 6 concludes our paper and discusses future research directions.

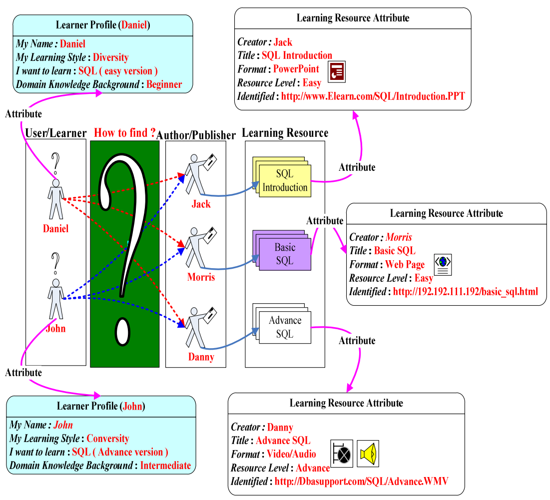

Figure 2. Which one is the most adaptive LRs for the learner?

2. FUZZY ONTOLOGY LRS AND KOLB'S LEARNING STYLE MODEL

2.1 Ontology

Ontology is a conceptualization of a domain into a human understandable, but machine-readable format consisting of entities, attribute, relationships and axioms [6]. Ontology use classes to represent concepts. Ontology also supports taxonomy and non-taxonomy relation between classes. Figure 3 shows the Berners-Lee's Architecture which being put forward by Tim Berners-Lee of the W3C consortium, Berners-Lee presented his version of the semantic web as being machine processable [15].

Ontologies have been widely applied in many fields that including knowledge engineering, knowledge representation, database design, information retrieval and extraction, and knowledge management, library science [3], ontology-enhanced search (e.g. http://www.e-Cyc.com/, Swoop-ontology portal search engine) and e-commerce (e.g. Amazon.com, Yahoo Shopping etc.), and configuration. In this paper, we will be restricting our sense of ontologies to LR's attribute description and FOAPA architecture description.

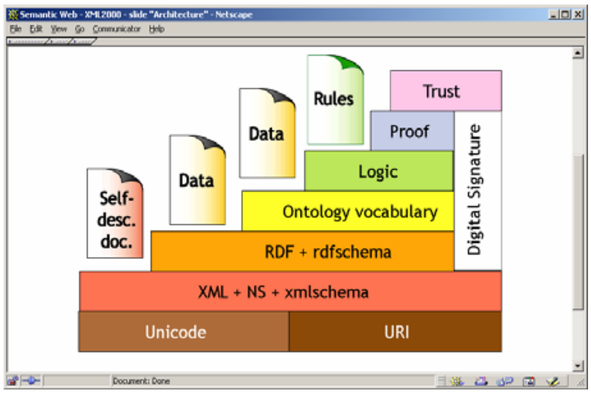

Figure 3. Berners-Lee's Architecture

2.2 Fuzzy Ontology

Zadeh originally introduced fuzzy logic in 1965 [16], in the context of set theory. We use the concept of "membership" as an attribute of an item within an ontology. The membership value can be assigned via author preference assigned through the Portal or automatically as describe in future.

The fuzzy ontology is based on modification Dublin Core metadata schema of an existing crisp ontology. Figure 4 shows the LR's (e.g. Oracle OCA courseware) relative attribute in a crisp ontology and Figure 5 shows LR's attribute in a fuzzy ontology. A fuzzy ontology membership value can therefore be used to identify the most likely location in the ontology of a particular item. Assigning the membership values of each term in each location is based on the membership function shown in figure 6. In fact, a author may create lots of LRs with different level, for example, "SQL introduction" for easy level, "SQL Programming" for intermediate level, "Advance SQL application" for advance level, "Expert in SQL" for expert or professional level etc. Note that each term identified within a LR may have its membership value updated when the LR is registered in portal by author.

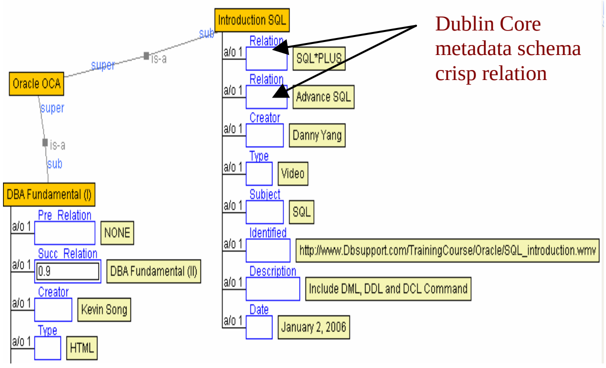

Figure 4. A crisp ontology for ORACLE OCA

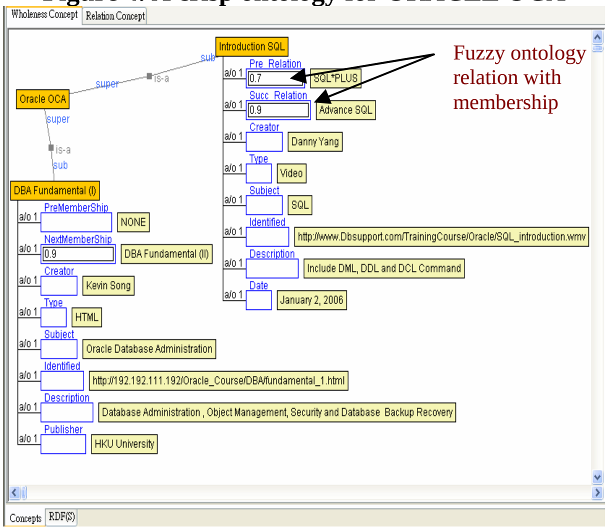

Figure 5. A fuzzy ontology for ORACLE OCA with membership values

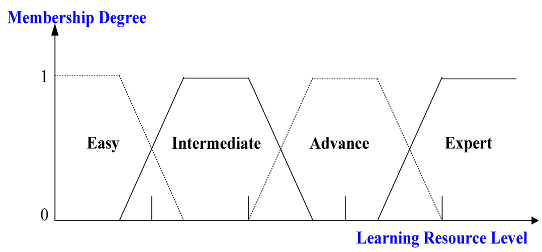

Figure 6. Membership function for fuzzy ontology

One of the important features of FOAPA is its ability to exploit the available relationships defined among the LR in order to implement conceptual navigation and retrieval. LR's relation always play a key point for learner to decide which LR is the next one, and which LR is the prerequisite one. We interested in exploiting the semantic relationships that characterize theses LRs, so we redefine two "relation" attributes from Dublin Core [10] metadata schema call "Pre_Relation" and "Succ_Relation" for enhance LR relations in order to recommend the relative LRs for learner further reference.. The method uses the membership function shown in figure 7. The degree of relatedness to the LR is recorded such as "Weakly Related", "Moderatedly Related" and "Strongly Related", default will note "NONE", meaning "No related". In this way, learner can easily lay out learning paths. We believe that the semantic bi-direction relationships of LRs play a crucial role especially in adaptive peer-to-peer learning environment.

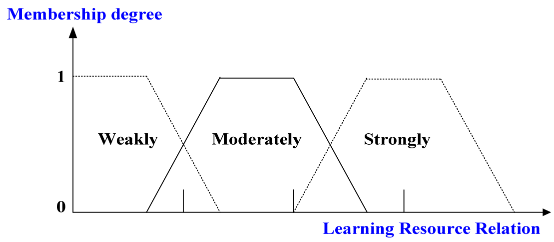

Figure 7. Membership function for Fuzzy ontology LR related

2.3 Kolb's learning style model

David Kolb published his learning styles model in 1984. The model gave rise to related terms such as Kolb's experiential learning theory (ELT), and Kolb's learning styles inventory (LSI). Kolb's learning theory sets out four distinct learning styles (or preferences), which are based on a four-stage learning cycle. (which might also be interpreted as a 'training cycle'). In this respect Kolb's model is particularly elegant, since it offers both a way to understand individual people's different learning styles, and also an explanation of a cycle of experiential learning that applies to us all.

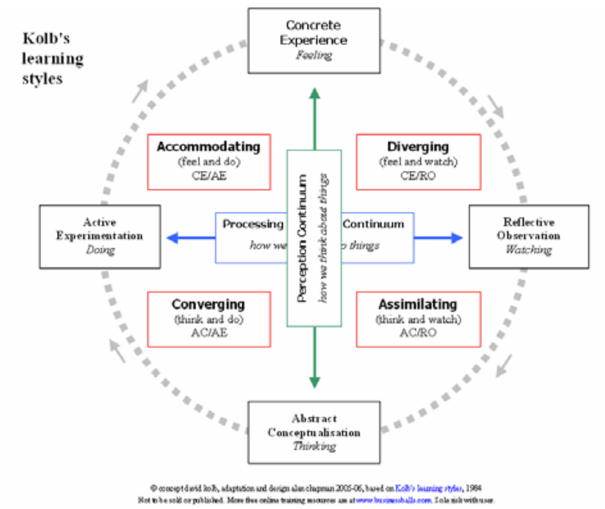

Figure 8. Kolb's learning styles

Kolb's model therefore works on two levels - a four-stage cycle: *1: Concrete Experience (CE), 2: Reflective Observation (RO), 3: Abstract Conceptualization (AC), 4: Active Experimentation (AE)*, and a four-type definition of learning styles, (each representing the combination of two preferred styles, rather like a two-by-two matrix of the four-stage cycle styles, as illustrated below), for which Kolb used the terms: Diverging (CE/RO), Assimilating (AC/RO), Converging (AC/AE) , Accommodating (CE/AE). As Figure 8 shows, Kolb explains that different people naturally prefer a certain single different learning style. Various factors influence a person's preferred style, These learning styles are the combination of two lines of axis (continuums) each formed between what Kolb calls 'dialectally related modes' of 'grasping experience' (doing or watching), and 'transforming experience' (feeling or thinking). The combination of these two choices produces a preferred learning style. See the matrix below.

Table 1. Learning style matrix

	doing (Active Experimentation - AE)	watching (Reflective Observation - RO)
feeling (Concrete Experience - CE)	*accommodating (CE/AE)*	*diverging (CE/RO)*
thinking (Abstract Conceptualization - AC)	*converging (AC/AE)*	*assimilating (AC/RO)*

Here are brief descriptions of the four Kolb learning styles: *Diverging (feeling and watching - CE/RO)* - These people are able to look at things from different perspectives. They are sensitive. They prefer to watch rather than do, tending to gather information and use imagination to solve problems. *Assimilating (watching and thinking - AC/RO)* - The Assimilating learning preference is for a concise, logical approach. Ideas and concepts are more important than people. These people require good clear explanation rather than practical opportunity. *Converging (doing and thinking - AC/AE)* - People with a Converging learning style can solve problems and will use their learning to find solutions to practical issues. *Accommodating (doing and feeling - CE/AE)* -People with an Accommodating learning style will tend to rely on others for information than carry out their own analysis.

Our portal aiming to support a mechanism to matching of learner and learning resources styles according to the Kolb's learning styles model. For example, if learner with Accommodating learning style, he will prefer prefer to work in teams to complete tasks. They set targets and actively work in the field trying different ways to achieve an objective, so if there are two LRs named "Practical SQL" and "SQL Theory", "Practical SQL" will be the adaptive choice for the learner who with the Accommodating learning style.

3. FOAPA: FUZZY ONTOLOGY ADAPTIVE E-EDUCATION PORTAL ARCHITECTURE

The FOAPA (shown in Figure 9) includes lots of modules for tailored to learners' objectives, domain knowledge background, learning style and needs; Figure 10 shows FOAPA prototype. The modules of the FOAPA are described below.

Login/Questionnaire: Upon entering the Portal for the first time, each learner/authors is prompted a short questionnaire, for determining his or her characteristics. This profile is automatically updated, taking into account the learner interactions with the Portal.

Learner: The learner needs to be able to authenticate themselves via login module, as well as define, edit and save their profile for adaptive personalized services. Then, learner need to search into *LRs Fuzzy Ontology Database* through *Ontology Search Agent*, and retrieve LR according to their specific requirement, learning style and domain knowledge background.

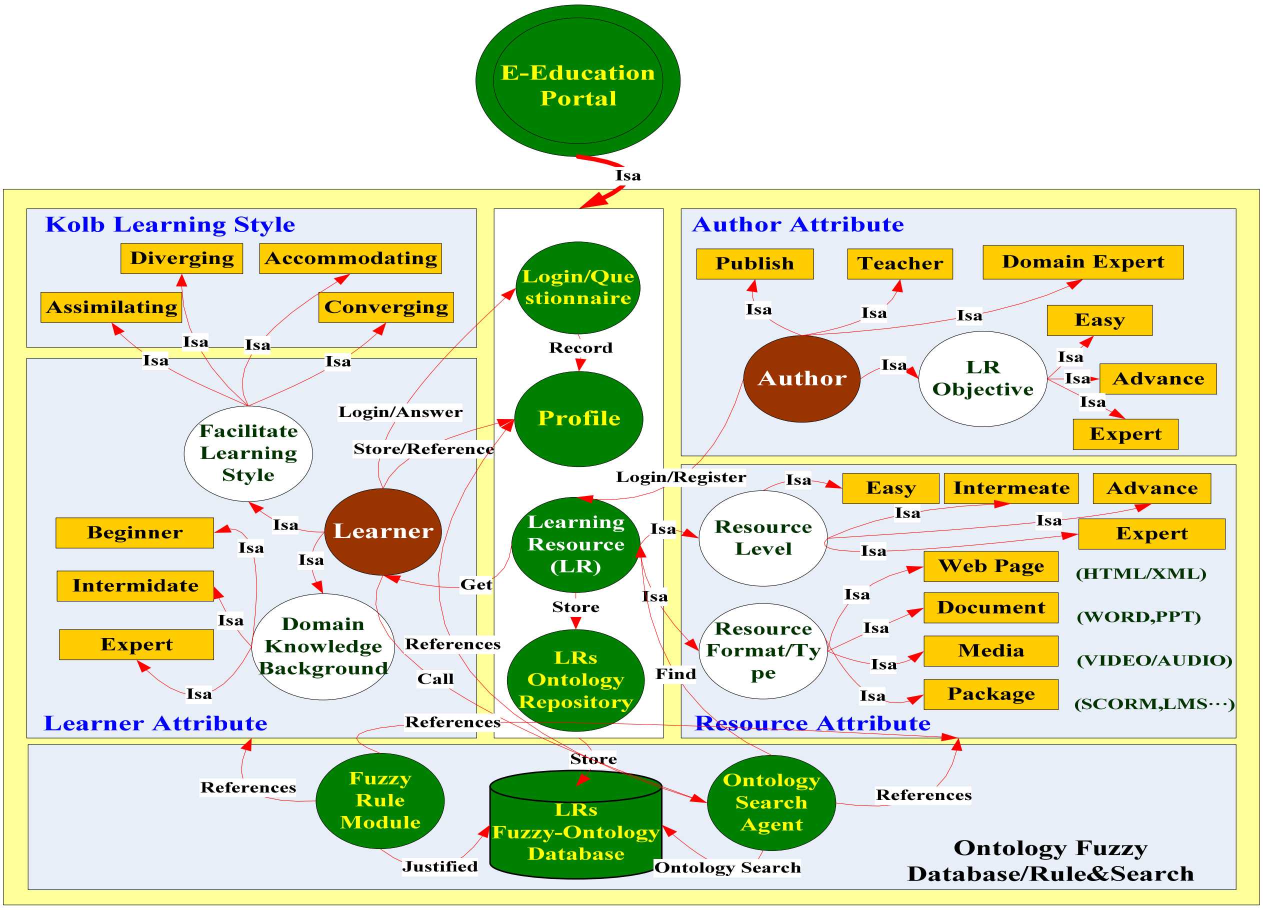

Figure 9. Fuzzy Ontology Adaptive Portal Architecture

Author: The author need to be able to publish or upload their LRs in a commonly accessible format, so that it can be effectively, efficiently and adaptively searched and retrieved in the different contexts of use described in LR attribute, different LR are described in metadata which are related to each resource and presented according to different learner profile, thus meeting the requirements for learner, adaptive personalized learning.

Ontology Search Agent: The Ontology Search Agent is responsible for compiling the query result from the LRs Fuzzy-Ontology Database, ranking them according to user preferences and weight, as supplied by the Fuzzy Rule Module. In particular, the expressiveness of the declarative RDF/S Query Language (RQL) [19] is crucial for specifying on demand personalized views in order to navigate and update LRs using the Portal RDF/S schemas.

Fuzzy Rule Module: The Fuzzy Rule Module is responsible for define criteria for search ranking, LR level which is indicated by a weight – a number between 0 and 100, and assign by the author, such as: 1) if LR's level = Easy then weight=between 0 and 30, 2) If LR's level=Intermediate then weight=between 31 and 60, 3) if LR's level =Advance then weight between 61 and 85, 4) if LR's level =Expert then weight between 86 and100) - assigned to that LR, or the weight associated with a term comprising a query.

LRs ontology repository: Store the ontology file (e.g. RDF) for the LRs.

LRs Fuzzy-Ontology Database: We create table schema for store the LR's attribute and its fuzzy ontology relationship weight in order to management the LR and retrieved by search agent. The ontology Search Agent through RQL returns the search result item, and then uses it as the parameter for LRs Fuzzy-Ontology Database advance search to get the final result.

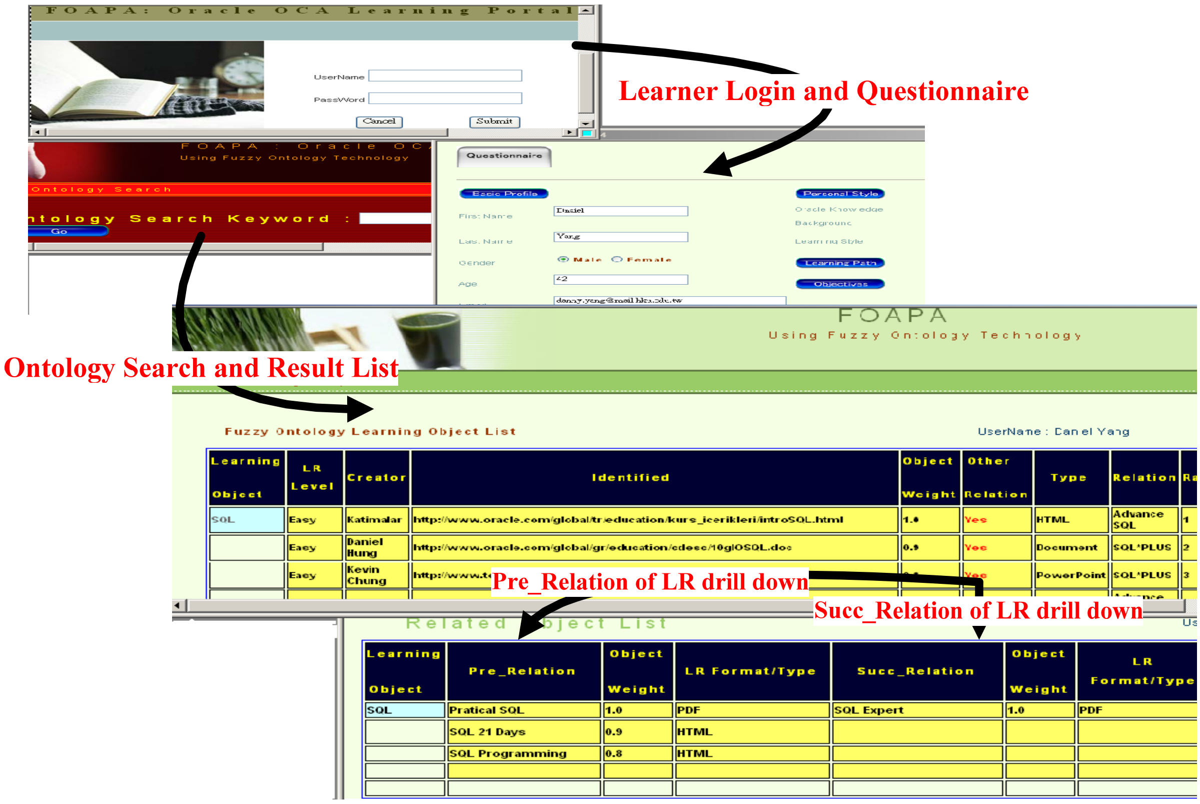

Figure 10. FOAPA Prototype

4. RELATED WORK

Online E-Education Adaptive Portal is significantly different both commercial and open source e-learning Portals, it aim to supply an environment for learner can adaptive to get LR according their attribute, it can be also compared to Semantic Web brokerage systems aiming to support large-scale knowledge sharing. For example, ontology-based Portals, like OntoWeb [9] and OntoPortal [17], can also be considered as related to our work although their access and visualization interface are too generic to be directly used in e-learning environments. Furthermore, Edutella [1] provides a peer-to-peer infrastructure for the connecting peers supporting different types of repositories, and metadata schemas. Unlike out Portal infrastructure, these system are lacking personalization facilities for LR attribute. Work on adaptive hypermedia can finally considered as relevant, but most of this work is based upon the generation of learning paths by restricting for instance the available hyperlinks between individual LRs according to an appropriate use model [7], [8]. A notable effort is the AdaptWeb Project [18] aiming to provide adaptive educational content, personalized according to different courses' and learners' profile. The AdaptWeb Project mainly focuses on adaptive user profiles, by monitoring users' browsing and retrieval activities inside the Portal. Compared to our approach capturing learners' domain knowledge background to matches the LR attributes, access to LRs during a specific search session, in the above system learners' preferences are usually an accumulation of their past interactions. This is not a suitable approach for Online E-Education Adaptive Portal enabling to learn more and new LRs in different learning style and learning level.

[1] http://edutella.jxta.org

5. CONCLUSION AND FUTURE WORK

In this paper we have presented the architecture and implementation using semantic web and fuzzy technologies of an Online E-Education Adaptive Portal, FOAPA. Our Portal infrastructure exploits the bi-direction semantic relationships established among LRs based on fuzzy ontology technology. We would like to enhance the FOAPA with grid technology in future. Additionally, we are currently integrating our portal infrastructure with adequate tools facilitating course management tasks like project and assignment submissions, examination schedule, online test and forums.

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