A Semantic Web Architecture for Context Recommendation System in E-learning Applications

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Abstract. The widespread use of e-learning applications has put emphasis on the importance of having applications more personalized and adaptable to every learner needs. The one size fits all is no more working. Every learner should be delivered the right learning material that suits its learning context at the right time. The challenge is to incorporate the recommendation system in e-learning platforms in order to offer to learners a successful learning experience. In response to this challenge, in this paper, we propose a semantic web architecture of a context recommendation system in e-learning by means of which the learners will be offered learning content based on their profiles, activities and social interactions. The proposed architecture is a re-engineering of classical web architecture of current e-learning platforms. It's based on semantic web technologies. It comprises an ontology that guarantees a shareable and reusable modeling of the learning context and OWL Rules filtering that will be used as a recommendation technique.

Keywords: Semantic web · E-learning · OWL ontology
Recommendation system · Context-aware · SWRL

1 Introduction

Nowadays, e-learning platforms are widely used in education for both universities and companies. Because learners are given the opportunity to access electronic learning courses through the network. This access allows developing learners' skills, while making the process of learning independent of time and place. However, the continuous development of e-learning platforms has led to a huge amount of learning materials available on the network. It is time-consuming for learners to find the learning materials that they really need. "The one size fits all" is no more working. The challenge is to deliver to the learners the right learning materials at the right time.

To lead a successful learning experience, the learning materials should be recommended for the learners in coherence with their learning context. The contextual information such as; prior knowledge, activity history, interests, social interactions; should be taken into account in order to deliver to learners the learning materials suitable to what they really want [6]. This new learning pattern is specified as context-aware [7].

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Context-aware applications should be developed with suitable context modelling and reasoning techniques. Therefore, ontology could be the suitable model to represent the context since this latter is considered as specific domain of knowledge. Complex context knowledge provided with formal semantics could be represented by ontology-based models. This representation allows to share and integrate context information [8].

Most of current e-learning platforms are based on a layered architecture which encapsulates the three levels of abstraction: data, application and presentation. In this paper, we propose a re-engineering of this architecture to integrate a semantic layer that holds an ontology and rule based approach for semantic recommendation. We aim to use the ontology as a domain knowledge for gathering the learning context information and OWL Rules filtering will be used as recommendation technique. The remainder of the paper is structured as follows. Section 2 summarizes the state of the art on semantic recommendation systems. Section 3 describes the proposed semantic architecture for context-aware applications. Finally, Sect. 4 concludes and shows some future lines of work.

2 Related Works

There have been many researches about personalized learning using semantic web technologies, mainly ontologies [9, 12]. Several ontologies-based approaches for context-aware e-learning platforms were proposed. Authors of [6] propose to make recommendation to realize context-awareness in learning content provisioning by exploiting knowledge about the learner (user context), knowledge about the content, and knowledge about the learning domain. For this purpose, they designed three ontologies with a focus on learner's prior knowledge and his learning goal in the recommendation process. But the social learner interactions are not taken into consideration.

The work presented in [10] proposes to recommend learning content based on the expert learning object knowledge base and personal learning progress where sequencing rules were used to connect learning objects. The rules were created from the knowledge base and competency gap. However, all the focus is on the learning content; the authors do not study the learner profile and its social interactions that are important contextual information.

[11] Proposed a framework to observe personalization in e-learning system based on ontology. They created user ontology, domain ontology and observation ontology. They also used reasoning mechanism over distributed Resource Description Framework (RDF) annotation. The query rule language used in this system is Triple. However, OWL has more powerful expressive capability than RDF.

[12] proposed a semantic recommender system for e-learning. It comprises ontology and web ontology language (OWL) rules. The proposed system is consisted of two subsystems; Semantic Based System and Rule Based System. In this work, the authors do not explain how they built the ontology and which Rule language they work with.

Our work differs from these researches by proposing a re-engineering of the layered architecture of current e-learning platform by integrating a semantic layer that will hold

the semantic recommender system. Our proposed semantic recommender consists of two subsystems that are: E-learning Ontology Subsystem and the Semantic Rules Subsystem.

3 Semantic Web Architecture

Most of the current e-learning platforms are based on a layered architecture which encapsulates the three levels of abstraction: data, application and presentation. The first layer is concerned with the storage of the data. The second handles the requests of the user interface by querying the storage media, after performing the various treatments and returning the results to the third layer this last layer then manages their display. These solutions are not sufficiently aware of the learner context. The context-awareness is highly recommended to deliver to the learner the learning material relevant to the current situation of the learner. To achieve this, we adopt the ontological approach to define a model to represent and manage context information. In this work, we want to perform a re-engineering of this architecture, with a view to incorporate the technology of the Semantic Web. To this end, we are proposing to insert a Semantic Layer between the layer of data and that of the application. Figure 1 resumed schematically this architecture.

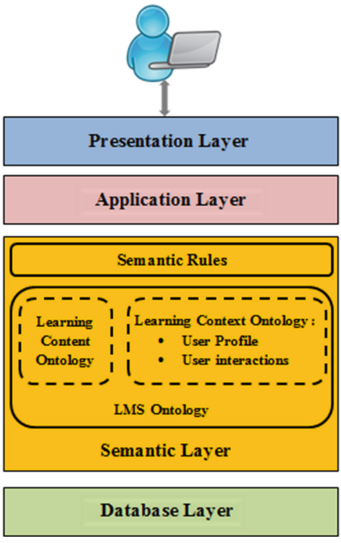

Fig. 1. Semantic web architecture for recommendation system in e-learning

In the following, we focus on the semantic Layer of our proposed architecture. It's organized in two main parts:

- E-learning Ontology
- Semantic Rules

3.1 E-learning Ontology

Our approach considerably relies on semantic modeling of the learner's context and environment. For this purpose, we make use of ontologies and Semantic Web technologies. The e-learning ontology is the ontology of the whole Learning Management System. Since we are working on current e-learning platforms that are already running and designed with UML diagrams and in order to limit the amount of effort required to build such a consistent ontology, we propose to build this ontology by adopting the approach UML-To-OWL proposed in our previous work [1]. Then the resulted OWL ontology will have some changes to be able to model the learner context. In order to keep the modeling task manageable, we divide this ontology into two sub-ontologies that are: Learning Content Ontology and Learning Context Ontology.

Learning Content Ontology: A learning content is an instantiation of Learning Objects-abbreviated LO. The LO are a digital small size components of a learning course which can be reused several times in different learning contexts. However, these Learning Objects are often designed and developed by different organizations and authors which make the learning content semantically heterogeneous. This heterogeneity affects its reusability. So it is essential to think of a shared modeling of LO in order to make them easily accessible, usable, reusable and semantically interoperable.

Different standards have been defined to help the development of learning systems and the representation of their joined LOs. Making use of these standards, not only guarantees the interoperability, but also the quality of the system [3]. Among these standards, we can cite LOM, SCORM and the IMS-LD. LOM is interested in learning content description, SCORM in content, structure, and the IMS-LD in learning scenario. In our work, we are interested in LOM standard. LOM (Learning Object Metadata) is a standard developed by IEEE consortium. It defines the structure of an instance of metadata for a LO. It is composed of a set of 80 elements divided in 9 categories performing each a different function [2]. To capture the semantics of LOs, we present this standard in an ontological way (Fig. 2).

Learning Context Ontology: The context of learning is a crucial aspect in e-learning. Therefore, it is important to determine according to the learner current context what are the relevant learning materials to deliver, how, and at what time. All the learning process must be adapted to context changes. To take into account the context in an e-learning system, it is necessary to find a way to represent it. This representation must provide a coherent model to store and process the context information in order to respond to the environment changes. At the semantic level, we define context information using a Learning Context Ontology that includes two interrelated sub-ontologies: Learner-Social ontology and Learner Activity ontology. This ontology will represent and store every learning context's information.

Figure 3 shows the Learner Social Ontology that is built from FOAF ontology. FOAF Ontology is an ontology that is built on the Resource Description Framework RDF2. It's conceived to represent people's personal information and their social relationships among a social network. People are represented as nodes and relationships by edges [5].

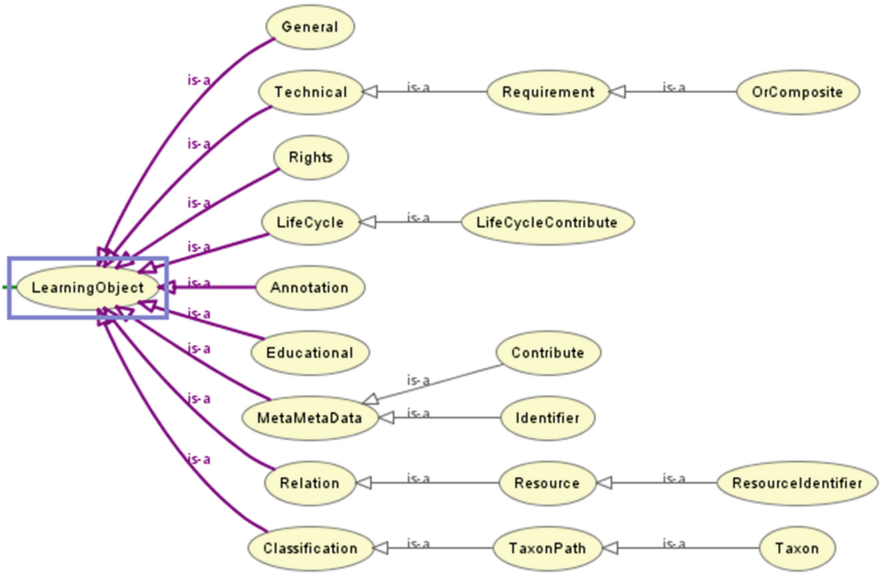

Fig. 2. Learning content ontology designed with Protégé according to LOM standard

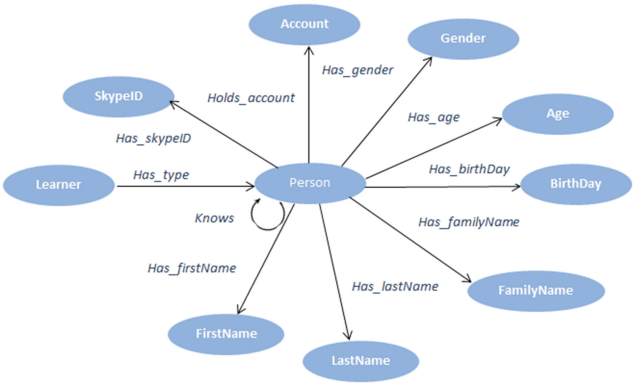

Fig. 3. Learner-social ontology

This ontology is widely used, [4] claims that the class foaf:Person has nearly one million instances spread over about 45,000 web documents. So it's relevant to reuse it to represent the context information about the learner profile and its social interactions.

Figure 4 shows the Learner Activity Ontology. This ontology represents and stores the different information about the learner's pedagogical interest and behavior. It shows in which topic the learner is interested, in which courses is enrolled and what are the specific activities he did.

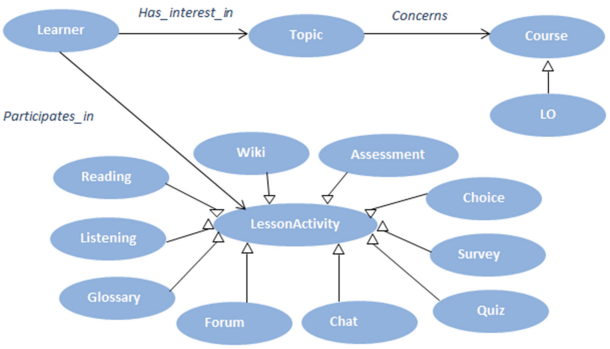

Fig. 4. Learner Activity Ontology

3.2 Semantic Rules

To take into account the context in an e-learning system, it is necessary to find a way to represent the context in the latter. This representation should provide a coherent model to store and process the context information in order to react to the environment changes. The e-learning ontology is the context model. After building this ontology, it's time now to apply techniques of refinement and adaptation of the LOs on it to deliver to the learner the learning object relevant to its context. A method to filter the LOs is to apply a set of business rules, indicating what LO to use in what context. These filtering rules will be used as our recommendation technique. They synthesize the domain knowledge and business constraints that must be met by the system. Business rules are translated into SWRL (Semantic Web Rule Language).

SWRL (Semantic Web Rule Language) is a language for Semantic Web rules, combining the OWL - DL and OWL-Lite with the unary/binary sub-language of RuleML (Rule Markup Language). The structure of SWRL rules consists of an antecedent and a consequent. A rule means «if the antecedent conditions are maintained, then the consequent conditions must also be applied».

If Antecedent Then Consequent Antecedent (Body) → Consequent (Head)
Example of a SWRL Rule:
If a Learner x knows (FOAF Object Property) another Learner y who is interested in a Topic T, then the learner x may also be interested in the same Topic T. So in this case, it's relevant to recommend to the Learner x the topic T. This recommendation rule is expressed with SWRL language as:
Learner (?x) Λ Knows(?x, ?y) Λ has_interest_in_topic(?y, ?T) → has_interest_in_topic(?x, ?T).

4 Conclusion and Future Works

Context-aware applications play an important role in education, especially e-learning. Context recommendation systems give the opportunity to learners to lead a successful

learning experience by getting the right learning materials that suit their needs at the right time. Semantic web technologies make these systems more performant and relevant. In this paper, we have proposed our semantic web architecture for current e-learning platforms. This ontology and rule based architecture is proposed to make use of ontology as a domain knowledge for gathering the learning context information and OWL Rules filtering as a recommendation technique.

For future work, we will extend our semantic architecture that will offer a context recommendation system for mobile learning.

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