THE SEMANTIC WEB TECHNOLOGIES AND THEIR INTEGRATION WITHIN E-LEARNING SYSTEMS: AN OVERVIEW

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Abstract

The semantic web creates an environment in which content can be well defined in order to make it more accessible to computer software agents. This feature can be exploited in the e-learning systems for building learning ontologies, semantic annotations of learning materials and also for content adaptation based on specific parameters. Using web semantic technologies can provide system interoperability and reusability of content by integrating existing adaptive technologies with the ideas of the semantic web for content representation. This paper presents the current state of the art in the research area of the semantic web technologies and their integration within the e-learning systems. It also shows examples on how e-learning systems can be empowered by using semantics, common problematic, implementation methods and semantic presence in today's most popular learning management systems.

Keywords: Semantic web, ontology, e-learning, adaptation.

1 INTRODUCTION

Technology has always played an important part in the educational process. At the beginning of the 20th century Radio was used for as a tool for distance education and later also television. Today, Internet and computers are leading technology for enhancing learning. The first online web based educational systems emerged after the year 1996 with the expansion of the World Wide Web, since they started to benefit from the rapid development of web technologies. The majority of today's e-learning systems are web based with purpose for both blended and online learning, and focused on either individual student or collaboration. Basic functionalities of such system are curriculum management, courseware authoring, student registration and administration, reporting and events management.

Traditional educational systems are based on closed corpus learning materials which are predefined by tutors or domain experts. Such systems cannot provide content from external sources. The World Wide Web provides an open corpus environment where knowledge is relatively easily accessible. This huge amount of data leads to the problem of its exploration, as it has to be machine processable in order to link it with educational systems. One of the possible solutions to this problematic is the semantic web movement that provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries [1]. It provides the possibility of building learning ontologies and semantic annotation of learning materials.

Apart from open corpus syndrome, during the last century, and especially in the last few decades with the development of computer technology there is a need for more personalized approach in education. There are many different reasons for content adaptation such as different level of prior knowledge and skills among individuals, sociocultural and demographic differences, different abilities or disabilities and student's affective state such as frustration, motivation, confidence etc. [2] Some of the researchers are trying to surpass by implementing semantic web technologies in adaptation process.

This paper shows few examples on how e-learning systems can be empowered by using semantics, presents some of the implementation methods and points out common problematic. It also inquires semantic presence in today's most popular learning management systems. The second chapter brings general definitions of semantic web technology. The third chapter presents some of the semantic web technology implementation examples in order to achieve more individualized educational approach and generally shows different methods of ontology implementation in learning system. The fourth chapter discusses system interoperability with help of semantic web technology and, finally chapter five concludes this paper.
2 SEMANTIC WEB [3], [4]

The World Wide Web has evolved greatly over the last decade. At the beginning, the web consisted of mostly static HTML pages which had almost no dynamic interactivity. Over time scripting languages were developed with purpose of generating dynamic web pages, consequently increasing the interactivity and overall quality of the web. This led to the second generation of the web called Web 2.0. Despite the power of the Web 2.0, it is limited by the fact that it is designed for interaction among people and not machines. Web 3.0 aims for a web which can enable machines to process and understand information contained on it and interact with each other. The semantic web is a collaborative movement led by the World Wide Web Consortium (W3C) which should accomplish this task. The semantic web is a vision of information that can be interpreted by machines, so machines can perform the work involved in finding and, combining information on the web. Tim Barnes Lee coined the term semantic web. He is considered the creator of the web and as the director of the W3C is one of the leading people responsible for the evolution of the new semantic web. In practice, the semantic web should be able to solve tasks such as making travel arrangements quickly. Users should be able to input the desired location and time of travels, and a virtual agent should be able to give them the optimal travel plans by fetching information from relevant web sites. That can only be possible if information is interpreted by all relevant machines equally. Fast growth of the World Wide Web causes many problems with the semantic web. With more data and multimedia content available it is much more difficult to find, sort and present relevant data. Its' practical feasibility was brought into question, but proponents argue that applications in industry, biology and human sciences research have already proven the validity of the original concept.

Ontologies are the basis of the semantic web. The most common definition is: “Ontology is a formal specification of a shared conceptualization”. Ontologies try to describe entities and how they can be connected and grouped into hierarchies. The semantic web had created the need for an improved ontology language, because previous languages such as RDF and RDF schema were flawed. Various research groups joined together to form a joint initiative called DAML+OIL which developed the new Web Ontology Language (OWL). Every ontology language must have well defined syntax, well defined semantics, efficient reasoning support and enough expressive strength for entity description and OWL fulfills all of those demands. There are three different OWL languages defined: OWL full, OWL DL and OWL lite. OWL full is entirely compatible with RDF and RDF schema and they can be combined. In order to accomplish computer efficiency OWL DL was designed by restricting certain OWL full constructors and their use. The flaw of OWL DL is its' incompatibility with RDF. Further OWL restriction led to the creation of OWL lite which is the easiest to implement and understand. The semantic web hierarchy model is presented on "Fig. 1".

![Semantic web hierarchy model](image.png)

Fig. 1 Semantic web hierarchy model.
3 EXAMPLES OF SEMANTICS IN EDUCATIONAL SYSTEMS

There are many different implementations of semantic web technologies in educational systems. Observing the learning environment as a closed system this technology can be used for purpose of testing students' knowledge, various types of collaboration, user modeling which is an important part in adaptation process, social network analysis over learning resources and interactions among users.

Some proposals of systematic way to facilitate the development process when building intelligent educational applications do exist. Barros et al. [5] focus on problematic of building intelligent applications, in particular intelligent tutoring systems, based on semantic web services and proposes a systematic way to facilitate the development process by providing a set of guiding steps for system developers with the use of Grinv middleware for discovery, composition and automatic invocation of semantic web services. They propose a 7 step process that is composed of: 1) domain specification through ontologies with purpose to specify the concepts and relations in the system, 2) defining services responsible for system functionalities by building semantic annotations, 3) service development, 4) defining the types of repository the system uses to store the services, 5) implementation of mechanisms responsible for service discovery and automatic service composition with goal to provide functionality required by users, 6) development of invocation mechanisms in order to invoke required services, and 7) integration of defined and developed technologies.

Semantic web technology can be seen in user modeling approaches, for example Barla, Tvarozek and Bielikova [6] describe user modeling approach based on automated acquisition of user behavior and its transformation into an ontological user model.

Gladun et al. [7] use the semantic web and multi-agent system technologies with the purpose of testing student knowledge. In their approach students need to build their own respective domain ontology which is then compared to a reference one in order to show mistakenly understood parts of the domain knowledge. In their work they show how web semantics can be used in the e-learning environment for evaluation of domain that had to be learned. Similar appliance of ontologies can be found in other research papers, as in work [8] presented by Falquet, Nerima and Ziswiler where students make their own coarse hyperbooks which are then compared and discussed.

Huang and Yang [9] show usage of ontology and semantic tagging mechanism in semantic bliky system called blikiBook to support different types of knowledge and adaptive learning. By using semantic description, the system provides users with possibility to arrange their learning goals and paths which can, afterwards, also be revised collaboratively.

Semantic support in collaborative learning can also be observed in various research papers. For example, in their work [10], Vega-Gorgojo et al. present system Ontoolsearch that searches for appropriate tools, annotated with the Ontoolcole, for different situations in collaborative environment in order to help tutors.

Appliance of semantic web technology can be observed in peer assessment which is a collaborative method in which students engage in other students' work by giving them feedback with previously defined criteria. Belcadhi and Garlatti [11] describe the design of peer assessment ontology dedicated to inquiry based learning courses and demonstrate how semantic web technologies enable assessment process with objective to guarantee selection, contextualization and rendering of unstructured content across tools as need for peer assessment delivery. In inquiry based learning environment, peer assessment helps to develop the acquisition of self-directed learning skills as students participate in the assessment experience. In their work they present assessment scenario built upon ontologies that permit to acquire automatically semantic metadata and to guarantee seamless access to information across tools for enabling effective collaboration and assessment.

Isotani et al. [12] have developed a tool called CHOCOLATO that helps teachers in planning collaborative scenarios with goal to prevent off-task behavior and encourage students in learning. In order to achieve this task the system uses semantic web technologies and ontology in order to represent knowledge about various pedagogies and practices in collaborative learning.

In their research [13] Cuéllar, Delgado and Pegalajar match the relational database structure of LMS with ontology in order to do social network analysis over learning resources, teachers, learners and their interactions. In social sciences, a social network represents the group of people and their interactions which can be analyzed with social network analysis methods. Furthermore, authors suggest that if semantic would be added to entities and relations, the systems could share information.
They propose domain ontology based in FOAF (Friend of a friend project) [14] to represent actors and social relations within e-learning system. OntoLMS, the software they have build, allows users to select properties and actors for social network analysis and to suggest the social network that best represents the user interest. They also propose an extension of FOAF called foafLMS to support hierarchical organization of actors and relations in the system in order to make social network analysis at different levels depending on classes and relations.

4 LEARNING OBJECTS AND LEARNING OBJECT REPOSITORIES

Learning Objects offer a new conceptualization of the learning process. According to IEEE the definition of a Learning Object is: “any entity, digital or non-digital, that may be used for learning, education or training”. They provide smaller, reusable units of learning. Every Learning Object must have three basic components: content, learning activities and elements of context. Additionally, a Learning Object should contain metadata which is defined as the attributes required to fully describing a Learning Object. Description of objects is more effective if metadata contains their semantic meaning in addition to their syntactic description. Metadata is also used for identifying Learning Objects in search engines, learning management systems or content management systems.

Learning Objects are main units of educational content and they must have these key features: reusability, accessibility, interoperability, portability and durability. Using Learning Objects in e-learning systems has many advantages. Same learning resources can be used in different contexts which brings flexibility. It is easy to administer learning resources using metadata. It enables adaptation and personalization by allowing the user to use all learning resources related to his or her interests. It is important that Learning Objects are compatible with different platforms in order to attain interoperability. [15], [16]

Learning Object metadata standard approved by IEEE groups data elements which describe a Learning Object into following categories [16]:

- **General** – groups the general information that describes the Learning Object as a whole.
- **Lifecycle** – groups information about the history and the current state of the Learning Object.
- **Meta-Metadata** – groups information about the metadata instance of the Learning Object.
- **Technical** – groups information about the technical requirements and technical characteristics of the Learning Object.
- **Educational** – groups information about the educational and pedagogic characteristics of the Learning Object.
- **Rights** – groups information about the intellectual property rights and conditions of use for the Learning Object.
- **Relation** – groups information about features that define the relationship between the Learning Object and other related Learning Objects.
- **Annotation** – groups information about the comments on the educational use of the Learning Object.
- **Classification** – describes the Learning Object in relation to a particular classification system.

LOM standard is very useful but there are some issues involved with it:

- Complete lessons are indexed in the same way as a unique exercise or an image.
- Metadata definition and meaning of terms is not completely solved.
- The unit of indexation is a file which represents a technical unit, but not an educational one.
- Some ambiguities in the model make its usage difficult.

To help solve some of these problems LOM standard uses application profiles. Also LOM indexation is completed with content representation based on theme ontology. In addition to the IEEE Learning Object metadata standard (LOM) there are other proposed standards such as Dublin core, IMS and SCORM. [17]

Using metadata as recommended by e-learning standards is not sufficient to solve the problems of object reusability and accessibility. Indeed, these problems will be solved only if a common meaning for metadata values is used by the system and the actors. The main reason for creating Learning
Object metadata standard was to make it possible to share Learning Objects between various repositories and learning systems. For standardization of Learning Object content we use ontologies. In education it is impossible to define a single ontology for all areas of knowledge so it is necessary to define local ontologies. However, the problem remains to consolidate local ontologies that have been developed separately for fields with overlapping domains. [15]

Learning repositories enable educators to share, manage and use educational resources. A more narrow definition requires that repositories implement a metadata standard. They store Learning Objects and the metadata that describes them. If we want to use Learning Objects for sharing learning information between different learning systems or repositories those objects should follow the same standards.

Different learning management systems have different degrees of support for Learning Objects and learning repositories. Moodle [18] has a module called Shared Resource which has been developing for the last five years. It provides Moodle with a full-featured central resource repository handling full indexing with LOM-based metadata schemas. This plug-in is currently still in beta. ANGEL’s Learning Object Repository is fully integrated, standards-based and included in ANGEL. It enables storage, tagging, searching, sharing, linking, reuse and management of Learning Objects in a highly scalable, efficient manner. Blackboard [19] has started beta testing xPlor, a new cloud-based Learning Object Repository. It supports multiple learning management systems. XpLor aims to make it easier for educators to manage and share rich content regardless of what system they are using or their institutional affiliation. Desire2Learn’s Learning Object Repository [20] enables storage, tagging, searching, sharing, linking, reuse and management of Learning Objects. Standards-based content packaging allows Learning Objects to be easily moved in and out of learning management systems while maintaining the integrity of the object. In addition, Desire2Learn’s Learning Repository allows for external repositories to be linked in, providing a single interface for searching organizational content along with external sources.

Although the main purpose of Learning Objects is reusability and interoperability, there are still lots of barriers for resource sharing among educational institutions and their learning management systems and repositories. Educational institutions usually have small Learning Object Repositories with open access, but they are not effectively used by others due to isolation and multiple standards. There is currently no easy way for institutions to provide open access to their Learning Object Repositories. There is also a problem with the copyright laws and required permission from content creators. [21]

5 CONCLUSIONS

E-learning systems need to provide educational resources that are dynamic, easily findable and adaptive to the user. The semantic web and ontologies are a great way to empower e-learning systems. Using ontologies enables users to search accurately for topics that interest them. It is impossible to organize and share Learning Objects effectively without creating ontologies that describe them. Sharing Learning Objects among Learning Object Repositories is important because it leads to their improvement and more available learning material for students. That way content changes dynamically through user input. Content is determined by the individual user’s needs and it allows direct access to knowledge in whatever sequence makes sense to the user. There is a current trend in educational institutions to produce learning objects and make them freely available through open web repositories. It is next to impossible to create a unique ontology for all areas of knowledge which leads to attempts of creating smaller ontologies separately. That causes a problem of their integration which needs to be solved. Most popular e-learning systems have at least some degree of support for resource sharing, but there is still a lot of room for improvement.

REFERENCES


