Transforming Learning Through Semantic e-Learning Experience

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Abstract

Semantic e-learning aspires to transform e-learning experience towards more productive and innovative learning organizations, since these emerging technologies allow defining a meaning (semantics) of learning materials, making it possible to fill the gap between human and machine understanding. The focus of this paper lies on a conceptual level, presenting the needs of semantic web technologies and discussion on fundamental component underlies to model semantic e-learning system namely metadata, ontologies, RDF and OWL. Finally, it highlights the significance of semantic e-learning implementation in transforming learning to another level of learning experience.

Keywords: *semantic web technologies, e-learning, ontologies*

Introduction and background

E-learning (electronic learning) stands for all forms of Web-based learning and uses computers and network technologies to create, store, deliver, manage and support online learning courses to anyone, anytime and anywhere (Cao & Zhang, 2006) . In Open University's context e-learning takes essentially as a place to support learner's tutorial electronically besides having face-face tutorial in a physical classroom. It is a complement tool between online and physical environment in distance learning activities. Virtual Learning Environment platform is brought for an integrated environment for users that includes learners, tutors, subject matter experts and administrators to work together. Through this environment, it was possible to integrate a series of services and tools to support learning activities such as forum, chat, lecture notes, i-lecture, i-radio as well as administration activities such as registry, finance, exam, library and etc. As the e-learning industry begins to mature, we are seeing the extension of e-learning currently into using a series of tools from the internet generation called web 2.0. However the current enhancement is still remain a challenge to produce an active user who is able to get involve constantly in producing quality content, despite variety of tools available for ease of communication.

To this direction semantic web technologies has emerged to change the focus of e-learning systems from task-based approaches to knowledge-intensive ones (Eseryel & Klein, 2006). These technologies capable

to add meaning to information, stored in such way that it can be searched and processed, provide the mechanisms for semantic knowledge representation, exchange, sharing, reuse and collaboration of e-learning applications (Anderson & Whitelock, 2004). Semantic technologies can enhance the advanced learning experience by using the expressive power of metadata to describe learning content, people, and services, and then matching these intelligently (Tiropanis, Davis, Millard, & Weal, 2009).

Semantic e-learning can be defined as "e-learning based on the Semantic technologies that can easily provide learning materials in a common format and therefore enhance personalized learning" (Cao & Zhang, 2006) . Semantic e-learning uses the power and flexibility of semantic technologies in order to facilitate large-scale collaboration of e-learning activities and develop tools, standards and environments that support content management, knowledge navigation and experienced-oriented environments. Semantic e-learning can render support to learners, assisting them to successfully organize and manage their learning. For example, the system can track learner assessment results, interactions with a virtual experiment as well as provide feedback and links to suitable learning material (Millard, Tao, Doody, & Woukeu, 2006).

This paper aims to present the idea of transforming learning through semantic e-learning experience. Firstly, we define semantic e-learning, explore the need of this semantic web technologies emerged. Secondly, fundamental component of semantic web technologies are defined, that can be incorporated in semantic e-learning application. Finally the paper highlights the significance of semantic e-learning implementation in transforming learning to another level of learning experience.

Background

"The Semantic Web is not a separate web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation" (Berners-Lee, Hendler, & Lassila, 2001). But why would the current web need any extension or fixing? The current web is the web of documents and semantic web is a web of data. Whereas a document might be a page with lots of text in it, the data itself isn't structured in a way that can be interpreted by a computer. Even though this paragraph can be understood by human reader, it cannot be interpreted by a computer because the words in this paragraph are not associated with any particular software syntax or structure. In other words, information on the Web is designed only for human consumption. Humans can read web pages and understand them, but their inherent meaning is not shown in a way that allows their interpretation by computers.

One way to enable machine-to-machine exchange and automated processing is to provide the information in such a way that computers can understand it. This is by structured data which must follow some prescribed syntax and structure because it's used by software algorithms for data processing. Software algorithms must receive data in the structure and type that they expect; otherwise, an exception occurs. What we are dealing with now is a knowledge gap: what the machine understands and able to work with is much more limited than human knowledge. Machines are lacking both knowledge and skills in interpreting content of all kinds (text, images, and video).

Dealing with the knowledge gap, is the objective of the semantic web by making the processing of web information through computers possible. The idea of the Semantic Web is to apply advanced knowledge technologies in order to fill the knowledge gap between human and machine. This means providing

knowledge in the forms that computers can readily process and reason with it. Figure 1 illustrated undergoing evolution of the web and different approaches are being sought for solutions to adding semantics to web resources (Cardoso & Sheth, 2006). On the left side of the Figure 1, a diagram representation of the normal web is given. Resources are linked together forming the web. There is no distinction between resources or the links that connect resources. To give meaning to resources and links, new standards and languages are being investigated and developed. The rules and descriptive information made available by these languages allow the type of resources on the web and the relationships between resources to be characterized individually and precisely, as illustrated on the right side of Figure 1.

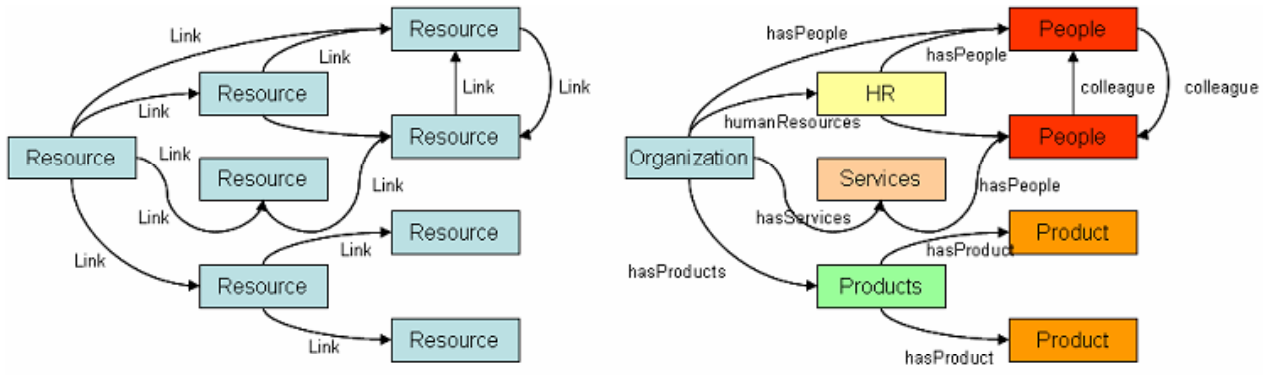


Figure 1: Evolution of the web (Cardoso & Sheth, 2006)

Semantic web technologies

There are a lot of technologies in semantic web area that define and enable knowledge representation, structure, reasoning to implement semantic e-learning. However, in the following section, we only define the fundamental component that underlies in this area namely metadata, ontologies, RDF and OWL that can be incorporated in designing semantic e-learning application.

Metadata

Metadata is data about data and can be used to describe information about a resource. A resource can be a thing such as a Web page, a document, a person, a song, an image, or a file. Examples of metadata that can be associated with a file include its title, subject, author, and size. A number of organizations are involved in producing metadata specifically for learning technologies known as educational metadata. Educational metadata record extends the scope of regular metadata. It adds further fields to the metadata so that it describes information that has particular educational relevance (Recker & Wiley, 2001). Metadata has been widely used to structurally describe learning resources so that they can be better reused.

In designing semantic e-learning, this first part of metadata process need to be gathered by a process of interviewing learning domain experts and examining teaching and learning materials to create common vocabulary and identify key concepts and its relations.

Ontologies

Metadata is a starting point to describe content in the semantic web area. Recent development have focused on the use of ontologies for richer semantic of metadata. Scerri, Abela, and Montebello (2005) defined semantic metadata as "…the process of attaching semantic descriptions to Web resources by linking them to a number of classes and properties defined in Ontologies". Ontologies are knowledge representation frameworks that describe an area of knowledge by defining the common concepts of that domain and the concepts' properties and relationships (Daconta, Obrst, & Smith, 2009; Gruber, 1993; Wilson, 2004). Ontologies can be seen as an improvement over metadata as they formally define not only keywords (as concepts) but also relationships, constraints, rules among them. Simple example of subject/teacher modeling to show how basic ontology is constructed such as below:

Semantic web → is a → name

Michael → is a → name

Semantic web →is taught by → Michael

Ontologies enable us to make the second shift, from information to knowledge and support knowledge reusability across domains. Example of standardization of ontologies in e-learning domain include Simple Knowledge Organization Systems (SKOS) express the knowledge structure suitable to represent the taxonomies of subject ontology; Semantically-interlinked online Communities (SIOC) express communities, discussion channels and threads suitable to represent structure of forum ontology; Friend of a Friend (FOAF) express on people and what they do suitable to represent learners ontology; and Dublin Core (DC) express documents and resources suitable to support the subject ontology. Figure 2. below show the level of semantic the ontology holding in:

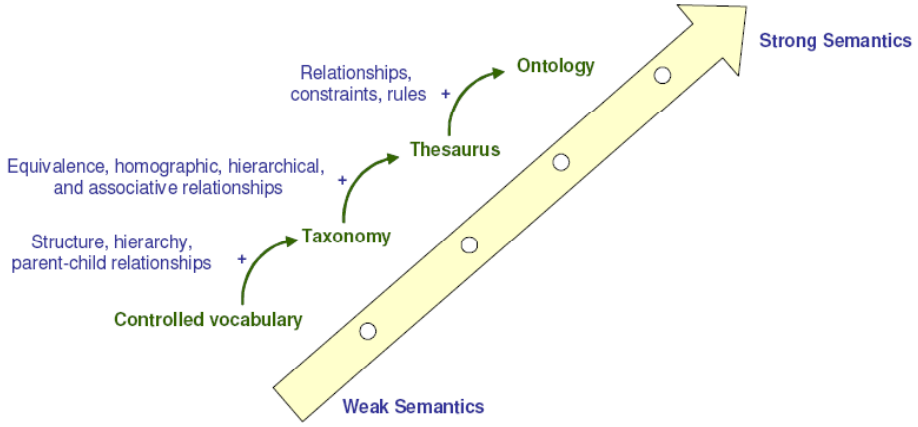
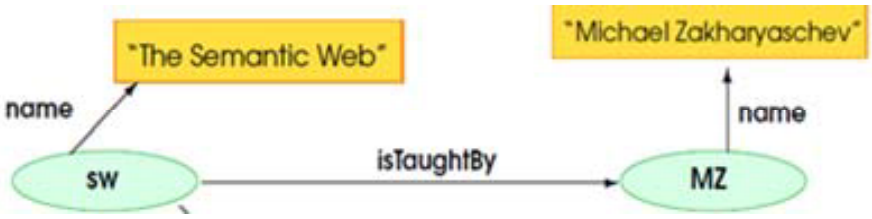


Figure 2: Levels of semantics

The next part of designing semantic e-learning, where key concepts and relations identified are formalized into ontologies. Current research has shown the important role that ontologies can play in the e-learning domain. They can be used for realizing sophisticated e-learning scenarios and improving resources' management, for automatic generation of hypertext structures from distributed metadata, for organizing learning material according to different needs of tutors and learners, for more accurate searching, etc. (Brase & Nejdl, 2004). This ontology development stages is led by knowledge engineer or known as ontologist as well as domain expert for content reference. The knowledge engineer will use an authoring tool to focus on modeling without worrying about the underlying language and syntax. The knowledge modeling works can be saved in RDF or OWL format.

RDF and OWL

There are a lot of languages can represent for semantic web but the most often chosen to represent will be RDF and OWL. RDF stands for Resource Description Framework a general purpose language for representing Web information in a minimally constraining, extensible, but meaningful way. The structure of data in RDF is in the form of triples : subject (what the data is about), predicate (attribute of the subject), object (actual value). Figure 3 below presented the idea of RDF statement



Subject : "SW" , Predicate: isTaughtBy, Object: "MZ"

Figure 3: RDF graph and triples

OWL stands for *Web Ontology Language also* a knowledge representation language for the Semantic Web. The difference between RDF is it provides additional vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes. As designing the semantic e-learning, the ontologies created and languages used itself is not visible for end users of a system, but rather it is an intermediate artifact intended for knowledge engineer only.

Significance of semantic e-learning

This section explore the affordances of semantic web technologies in realizing the needs of e-learning education. Increased semantics offer learners a more effective view of their learning and enables new learning opportunities (Ronchetti & Saini, 2004; Sampson, Lytras, Wagner, & Diaz, 2004). There are a number of ways in which semantic e-learning could enrich a better learning process:

- *Structure*: As Laurillard (2002) indicates, one central component of learning is coming to see structure. This is becoming more important as the learning resource grows unless the learners can find a way to successfully navigate through and filter out irrelevancy. Structure means of seeing something (a theory, or concept) as a whole which includes the relations which link these to other ideas and theories and stated interdependencies. This rich information explicitly able to provide learners to see the larger picture of certain concept and how it being related to other concepts. This integration of parts is the needs for learners to conceptualize the subject matter and produce better navigation, interpretation and orientation of the content provided.

- *Personalized learning*: Adaptation to individual learner characteristics is highly desirable since no two learners have the same learning pre-requisites, skills, aptitudes or motivations. However such adaptation can only be done realistically when the adaptation is wholly or at least partially automated. Otherwise it becomes too much work for the learners and tutors. "E-learning based on the semantic technologies can easily provide learning materials in a common format and therefore enhance personalized learning" (Cao & Zhang, 2006).

- *Reuse from collective knowledge repository*: All exchanges of information between learners are stored in the discussion transcripts. These transcripts can be used by learners for reflection purposes or they can serve as data for research (Meyer, 2004). This technology supports the reuse and adaptation of content through support for the construction, distribution, and retrieval of digitized content that is formatted and formally described (Eggins & Slade, 2005). This give maximum benefit for learners to choose variety of answers through this collective knowledge that can make sense in helping them to understand the subject. In addition learners can access or learn from the content at any time of the day without need to wait for tutor response which makes learning process ubiquitous.

- *Learning vocabulary and ontology*: In the learning domain building vocabulary can be translates to a process of interviewing learning domain experts and examining teaching and learning materials to create a common vocabulary and identify key concepts. This learning vocabulary can be enhances semantically based on some educational metadata standard and formalized using ontology-authoring tools, such as Protégé , TopBraid, OntoEdit and other related tools. From here active learners could annotate information themselves based on ontology developed such as examples, questions, ideas or further explanation to enhance the existing learning vocabulary.

- *Search engines*: Knowledge can be accessed in any order the learner wishes, according to their interests and needs. This can be done by performing semantic search for searching suitable learning content. This technology can improve search results by adding concepts that relate to the search query. This searching will save time by entering what the user do know about the topic they're researching. Then let the semantic search uncover related concepts and terms. It is expected, instead of looking for keywords, user might browse for ideas or data concepts; the search engines could help distinguish the meaning behind the words entered. Ultimately, more results with greater levels of accuracy presented.

The wealth information available in the e-learning resources can be harnessed using semantic web technologies by incorporating pedagogical theories and processes. This can provide a complete paradigm shift towards more active and quality learning environment. Ultimately, the learners will benefit from these through extended availability.

Conclusion

The focus of this paper lies on a conceptual level, namely in presenting the basis why this emerging technology being introduced. What are the components needed for modeling semantic e-learning application. Finally, the value it can offer to enrich and reuse e-learning resources to another level of learning experience.

Semantic web is needed to deal with the knowledge gap between human and machine. This is only possible through technologies that underlie in the semantic web which include metadata, ontologies, RDF and OWL. The enhancement by offering semantic e-learning is critical to improve learning process in the aspect of learning structure, learning personalization, reuse from collective knowledge, standard learning vocabulary through ontology development and improved search engines.

We believe in e-learning education where access to information is central, which crucially depends on the representation, creation and organization of knowledge can be realized through implementation of semantic e-learning as efficient learning in more productive and innovative learning organizations. This manifests itself not only immediate advantages to manage teaching and learning successfully, as well as achieving the goals of resource sharing, collaboration and automation.

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