E-Learning and Semantic Technologies

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INTRODUCTION

Traditional teaching and learning methods have had to adapt to keep up with Information and Communication Technologies (ICTs) in modern society. *E-learning* stands for all forms of Web-based learning and uses computer and computer networks to create, store, deliver, manage and support online learning courses to anyone, anytime and anywhere. It provides a configurable infrastructure that can integrate learning materials, tools, and services into a single solution to create and deliver training or educational materials quickly, effectively, and economically.

Recently, emerging *Semantic Web technologies* have changed the focus of e-learning systems from task-based approaches to knowledge-intensive ones. The Semantic Web is a W3C initiative and according to Berners-Lee et al. (2001) comprises *"an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation"*. The capability of the Semantic Web to add meaning to information, stored in such way that it can be searched and processed, as well as recent advances in Semantic Web-based technologies provide the mechanisms for semantic knowledge representation, exchange and collaboration of e-learning applications (Anderson & Whitelock, 2004).

Semantic e-learning is the *"e-learning based on the Semantic Web technologies that can easily provide learning materials in a common format and therefore enhance personalised learning"* (Cao & Zhang, 2006). In this context, e-learning systems have the potential to develop descriptions of their processes, as well as rules in order to create content-based and logic-driven information and knowledge value.

The aim of this article is to define Semantic e-learning, review the literature and all these foundations upon which it is envisioned and demonstrate its close relation with development of Semantic Web technologies. Moreover, we present the directions that support the vision of Semantic e-learning, illustrate the future trends and discuss the open issues in the field.

BACKGROUND

In the majority of past e-learning systems the courses and the educational materials were not dynamic enough, provided a rather restricted feature set or presented complicated structuring and consequently could not respond effectively to the needs and competencies of the learners, resulting in poor experiences. An answer to this problem that comprises also the current challenge for Web-based learning systems is their enhancement by the integration of adaptive features that allow for the delivery of personalized learning (Brusilovsky, 2001). These advanced e-learning applications provide high quality content, efficient structuring, and full support for the varied tasks of all the user profiles participating in a typical distance learning scenario. Specifically, depending on the knowledge background of the learner, his strengths and weaknesses, as well as the preferred learning style and the progress made so far, the system decides what and in which way the content should be presented next. Possible parameters are different learning paths through the content, different ways of presentation of the same content (e.g. with or without audio) or offering a different set of functions which the user interface of the learning system provides to reduce complexity.

To achieve this, methods and techniques from various scientific domains and application areas are used. The most well-known are Data Mining, Web Mining, Knowledge Discovery, User Modelling, User Profiling, Artificial Intelligence and Agent Technologies, etc. Especially, Web Mining is defined as the use of Data Mining techniques for discovering and extracting information from web documents and services and is distinguished as Web Content, Structure or Usage Mining depending on which part of the Web is mined

(Kosala & Blockeel, 2000). In the majority of cases, e-learning applications base personalization on Web Usage Mining, which undertakes the task of gathering and extracting all data required for constructing and maintaining learners' profiles based on the behaviour of each user as recorded in server logs (Markellou et al., 2004).

The combination of Web Mining and Semantic Web has created a new and fast-emerging research area that of Semantic Web Mining. The idea behind using the Semantic Web for generating personalized Web experiences is to improve Web Mining by exploiting the new semantic structures. Semantic e-learning, use the power and flexibility of Semantic Web technologies in order to facilitate large-scale collaboration of e-learning activities and develop tools, standards and environments that support content management, knowledge navigation, experienced-oriented environments, etc.

In the following sections, we focus on those technologies that define and enable knowledge representation, structure and reasoning, offer exchange mechanisms to allow collaboration and sharing and provide organizations the means to implement Semantic e-learning.

XML

Extensible Markup Language, shortened XML (Bray et al., 2004), consists of a set of rules for defining and representing information as *XML documents* where information structures are indicated by explicit markup. The markup vocabulary and the structures specified for a particular domain create an *XML application*, a formal language for representing information of the domain. The use of XML has extended towards data interchange between software applications. In e-learning, likewise in other domains, the use of XML can be divided into two major categories: the format for data interchange and the format for information assets. The information assets can be further divided into documents and metadata.

URIS

A Uniform Resource Identifier (URI) which *"is a compact string of characters for identifying an abstract or physical resource"* can be used to designate a particular Web resource i.e. *"anything that has identity"* (Berners-Lee et al., 1998). Further, a URI does not have to map to a real Web address. URIs that refer to objects accessed with existing protocols are known as Uniform Resource Locators (URLs). So, URIs provide a general identification mechanism, as opposed to URLs which are bound to the *location* of a resource.

RDF AND RDFS

Resource Description Framework (RDF) is a general-purpose language for representing information in the Web (Brickley & Guha, 2000). It was developed by the W3C and provides a common specification framework to express document metadata in a standardized form that computers can readily process. RDF commonly uses XML for its syntax and URIs to specify entities, concepts, properties, and relations. The basic unit of data in RDF is a *triple*, which consists of i) the *subject* (what the data is about), ii) the *property* (an attribute of the subject) and iii) the *actual value*. RDF Schema (RDFS) is a language for defining RDF vocabularies, which specifies how to handle and label the elements. Generally, the role of a schema as a representational model in the context of Web information is to mediate and adjudicate between human and machine semantics.

Web Services

Web service is a software system designed to support interoperable machine-to-machine interaction over a network (Booth et al., 2004). It is identified by a URL, whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML-based messages conveyed by Internet protocols. The Web service model consists of three entities, the service provider, the service registry and the service consumer (Dustdar & Schreiner, 2005). Other models, such as a peer-to-peer structure, also exist.

Ontologies

Ontologies comprise the backbone of the Semantic Web and offer a way of representing the semantics

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