Abstract

The major industrial firms and academic and research institutions have started to think seriously about use and applications of semantic web technology in which information in machine-processable form can coexist and complement the current web with better enabling computers and people to work in co-operation. The semantic web technology has the potentiality to be applied in different areas. eLearning is one of the domains which may benefit from this new web technology. This paper focuses on potential uses of semantic web technology in eLearning and advantages of using ontology to describe learning materials. Also a conceptual architecture of semantic eLearning portal is presented with some related work.
1. Introduction

Today’s technology enhanced learning landscape is characterized by a high and growing number of heterogeneous educational service providers. For a user with a particular educational need, a typical scenario involves the user visiting one or several online educational centers, browsing their offers, collecting information about the courses (study programs, requirements, needed tools, prices, etc.), selecting the most appropriate course for his/her needs and preferences and, finally, registering it. This manual browsing is too time consuming and, typically, a user will visit just a very few online centers before making a decision. Therefore, learning processes need to be fast and just-in-time. Speed requires not only a suitable content of the learning material (highly specified, not too general), but also a powerful mechanism for organizing such material. Also, learning must be a customized on-line service, initiated by user profiles and business demands. In addition, it must be integrated into day-to-day work patterns and needs to represent a clear competitive edge for the business. Learning needs to be relevant to the (semantic) context of the business (1).

The new generation of the web, the so-called Semantic Web, appears as a promising technology for implementing eLearning. The Semantic Web constitutes an environment in which human and machine agents will communicate on a semantic basis (2). One of its primary characteristics, viz. shared understanding based on the ontology backbone. Ontology enables the organization of learning materials around small pieces of semantically annotated (enriched) learning objects (3).

2. Objectives

This paper will highlight the effective use of Semantic Web technology for realizing sophisticated learning scenarios. First we will see the potential uses of Semantic Web technology in eLearning and give overview of layers of the Semantic Web architecture. We will see the advantages of using ontology to describe the learning materials. Also, a conceptual architecture of Semantic eLearning portal is presented along with some related work.
3. Characteristics of E-learning

Our traditional learning process could be characterized as centralized authority (content is selected by educator), strong push delivery (teacher push knowledge to students), lack of personalization (content must fulfill the needs of many) and the static/linear learning process (unchanged content). But learning process should be - fast, just-in-time (cheap) and relevant (problem-dependent), which is possible with the distributed, student-oriented, personalized, non-linear/dynamic learning process – what is possible in e-learning.

Important characteristics of e-learning are (4):

- **Pull**- student determines agenda
- **Interactive**- responds to problem at hand
- **Non-linear**- allow direct access to knowledge in whatever sequence make sense to the situation at hand
- **Systematic**- learning occurs as in integrated activity
- **Continuous**- learning runs in the parallel loops and never stops
- **Distributed**- content comes from the interaction of the participants and the educators
- **Personalized**- content is determined by the individual user’s needs and aims to satisfy the needs of every user
- **Dynamic**- content changes constantly through user input, experiences, new practices, business rules and heuristics

The origin of e-learning is computer-based-training (CBT), which was an attempt to automate education, replace a paid instructor and develop self-paced learning. The objective of e-learning is not only recorded education (as in CBT), but also education without barriers of time and distance, and customized to users’ and business needs.
4. Semantic Portals

The heterogeneity, distributed nature of web led to the need for web portals, web sites providing access to collections of interesting URLs and “dumb” (i.e. keyword-based) search for information. Similarly, a semantic portal can be seen as an entry point to knowledge resources that may be distributed across several locations. However, differently from “dumb” web portals, semantic portals are “smarter” and carry out intelligent reasoning behind the scenes. They offer semantic services including semantics-based browsing, semantic search and smart question answering. Semantic browsing locates metadata and assembles point-and-click interfaces from a combination of relevant information (5). Semantic search enhances current search engines with semantics, it goes beyond superficial keyword matching by adding semantic information, thus allowing easy removal of non-relevant information from the result set. Smart question answering is the technique of providing precise answers to a specific question. For instance, given a question such as “Which country had the highest inflation rate in 2004?”, the system would directly reply to the question with the name of the country, as opposed to the approach of current search engines (such as Google). All these services would be built on top of functionality such as machine access to semantic information.

We can think of a scenario where educational services can be mediated on student behalf. The advantage of having a semantic portal is that students need not look for courses distributed across many locations (unlike current solutions). Moreover, semantic services perform inferences in the background (taking into account student preferences) as opposed to having users manually searching the traditional way.

From a pedagogical perspective, semantic portals are an “enabling technology” allowing students to determine the learning agenda and be in control of their own learning. In particular, they allow students to perform semantic querying for learning materials (linked to shared ontologies) and construct their own courses, based on their own preferences, needs and prior
knowledge. By allowing direct access to knowledge in whatever sequence students require them, just-in-time learning (4) occurs. At the other end of the spectrum, tutors are freed from the (now student-run) task of organising the delivery of learning materials but must produce materials that stand on their own. This includes properly describing content and contexts in which each learning material can be successfully deployed. One possibility is metadata, i.e. tags about data that allow describing, indexing and searching for data (6).

Semantic portals technology is built in a layered manner, i.e. it is processed in steps, each step built on top of another. The pragmatic justification of it is that it is easier to achieve consensus on small steps, whereas it is much harder to get everyone on board if too much is attempted.

XML (8) allows users to add arbitrary structure to their document by creating tags to annotate a web page or text section. Although the meaning of XML tags is intuitively clear, tag names by themselves do not provide semantics. XML is not appropriate for propagating semantics through the

Layered Approach to Semantic Web (7)
semantic web, but is used as a “transport mechanism”. It is particularly suitable for sending documents across the web. RDF (Resource Description Framework) (9) and RDFS (10) provide a basic framework for expressing metadata on the web, while current developments in web-based knowledge representation, such as DAML+OIL (11) and OWL (12), build on RDF to provide more sophisticated knowledge representation support. Logic layer which enables intelligent reasoning with meaningful data.

5. Semantic Web and E-learning

E-learning is an area which can benefit from Semantic Web technologies. The Semantic Web technology has enabled by a set of suitable agents, which seems to be powerful enough to satisfy the e-learning requirements – fast, just-in-time and relevant learning. The possible uses of Semantic Web technology for e-learning are (4):

- **Pull**: Knowledge items (learning materials) are distributed on the web, but they are linked to commonly agreed ontologie(s). This enables construction of a user-specific course, by semantic querying for topics of interest.
- **Interactive**: Software agents on the Semantic Web may use commonly agreed service language, which enables co-ordination between agents and proactive delivery of learning materials in the context of actual problems. The vision is that each user has his own personalised agent that communicates with other agents.
- **Non-linear**: User can describe situation at hand (goal of learning, previous knowledge,...) and perform semantic querying for the suitable learning material. The user profile is also accounted for. Access to knowledge can be expanded by semantically defined navigation.
- **Symmetric**: The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in an organisation, including learning activities.
Semantic Web Based eLearning

- **Continuous:** Active delivery of information (based on personalised agents) creates a dynamic learning environment.
- **Distributed:** The Semantic Web will be as decentralised as possible. This enables an effective co-operative content management.
- **Personalized:** A user (using personalised agent) searches for learning material customised for her/his needs. The ontology is the link between user needs and characteristics of the learning material.
- **Dynamic:** The Semantic Web enables the use of knowledge provided in various forms, by semantical annotation of content. Distributed nature of the Semantic Web enables continuous improvement of learning materials.

6. Ontologies for E-learning

In an e-learning environment the situation can easily arise that different authors use different terminologies, in which case the combination of learning materials becomes difficult. The retrieval problem is additionally compounded by the fact that typically instructors and learners have very different backgrounds and levels of knowledge. Therefore, some mechanism for establishing a shared-understanding is needed. Ontologies are a powerful mechanism for achieving this task.

The role of ontology is to formally describe shared meaning of used vocabulary (set of symbols). An ontology contains the set of possible mapping between symbols and their meanings. But shared-understanding problem in e-learning occurs on several ontological levels, which describe several aspects of document usage. When a student searches for learning materials, the most important things are (7):

- what the learning material is about (i.e. content);
- in which form this topic is presented (i.e. context); and
- while learning material does not appear in isolation, another dimension (i.e. structure) is needed to encompass a set of learning materials in a learning course.
Therefore, there are three ontology levels: content, context (pedagogy), and structure.

A content ontology describes the basic concepts of the domain in which learning takes place (e.g., history or computer science). It includes also the relations between these concepts, and some basic properties. For example, the study of Classical Athens is part of the history of Ancient Greece, which in turn is part of Ancient History. The ontology should include the relation “is part of” and the fact that it is a transitive property of an element. In this way, an automated learning support agent can infer that knowledge on Classical Athens can be found under Ancient History. The content ontology can also use relations to capture synonyms (‘creator’ and ‘writer’), abbreviations ‘World Wide Web’ and ‘WWW’), and so on.

Contextual (pedagogical) issues can be addressed in a pedagogy ontology. Learning material can be presented in the various learning contexts, like, as lecture, tutorial, example, figure, walk-through, exercise, solution, and so on. It helps in context-relevant searching for learning material as per user needs. For example, if you are searching for detailed explanation of a topic, obviously you would like have material which has given more examples.

Finally, a structure ontology is used to define the logical structure of the learning materials. E-learning is often self-paced environment, so training needs to be broken down into small bits of information, which can be tailored to meet individual needs and skill gaps. But these chunks of knowledge should be well connected to create the whole course. So, greater attention should be given to design the structure of e-learning materials. Typical knowledge of this kind includes hierarchical and navigational relations like previous, next, hasPart, isPartOf, requires, and isBasedOn. Relationships between these relations can also be defined; for example, hasPart and isPartOf are inverse relations. It is natural to develop e-learning systems on the Web; thus a Web ontology language should be used.
7. Guidelines for Building-up Ontology

As users are the main part of our ontology based e-learning system, the first stage of the development process involves the capture and documentation of the most basic functional requirements from readers’ viewpoint. The steps involved are (13):

- Identification of the aim and the scope of the ontology
- Reuse existing vocabularies
- Enumerating the most important terms in the ontology
- Defining the classes and their hierarchy
- Defining the properties of the classes
- Defining the features of the properties
- Creating instances

In this way, the development of the ontology is an iterative process, centered on the architecture and driven by use cases, where each stage refines the previous one. As the use cases mature and are refined and specified in more detail, more of the ontology terms are discovered. This, in turn, can lead to new use cases. Therefore, both the ontology and the use cases mature together.


Fig. 1 shows a conceptual Semantic e-learning architecture which provides high-level services to people looking for appropriate online courses.
Fig. 1 Conceptual Semantic eLearning Portal Architecture
**Knowledge Base:** This is the basic and core element of the architecture. It is a repository where ontologies, metadata, inference rules, educational resources and course descriptions, user profiles are stored. The metadata may be placed within the document itself or in some external metadata repository (e.g. an RDF repository) (14). Here the metadata are stored externally in the knowledge base. The advantages of external storage are: (i) it is easier to scan a separate meta-description stored in a database and it takes less space to store it, and (ii) the point of view may vary according to different authors who reuse the same learning material. It means that it is possible to have different descriptions of the learning material according to the different contexts (13).

**Search Engine:** It provides an API with methods for querying the knowledge base. RDQL (RDF Data Query Language) can be used as an ontology query language.

**Inference Engine:** It answers queries and is responsible for inferring new facts by an intelligent combination of facts already have in the knowledge base.

**Services:** Different services are offered, like, personalized searches, notification service, course annotation, etc.

**Access Interface:** It provides an integrated interface through which readers as well as authors/ administrators of academic institutions can access, upload or modify the data with particular authority.

**9. Initiatives**

There are very few initiatives to build e-learning process using Semantic Web technology. One approach is Ontology-based Intelligent Authoring Tool, which has used four ontologies (domain, teaching strategies, learner model and interface ontology) for construction of learner model and teaching strategy model (15).
A Collaborative Courseware Generating System which focuses on facilitating the courseware generating process taking advantage of recent Internet protocols and industry standards. Adopted a collaboration-friendly Internet protocol, WebDAV to support collaborative courseware authoring, XML to represent meta-data of course contents, and JSP for describing course structure but without explicit ontology support(16).

10. Conclusion

The Semantic Web is the emerging technology aiming at web-based information and services that would be understandable and reusable by both humans and machines. One of its primary component is ontology, generally defined as a representation of a shared conceptualization of a particular domain. It is anticipated that semantic web technologies will influence the next generation of e-learning systems and applications.

In this paper, discussed an e-learning scenario that exploits ontologies in three ways,

- content i.e. for describing the semantics of the learning material;
- context i.e. for defining in which form this topic is presented; and
- structure i.e. to define the logical structure of the learning material.

Also presented conceptual architecture of semantic e-learning portal which provides a common interface for learners, intermediators, authors/administrators of academic institutions for accessing learning materials.
11. References


