RECENT ADVANCES IN INFORMATION TECHNOLOGY: ROLE OF SEMANTIC WEB TECHNOLGY IN E-LEARNING ENVIRONMENT

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ABSTRACT

e-Learning is the use of technology to enable people to learn anytime and anywhere. It is fast, relevant; dynamically changing and can include training, the delivery of just-in-time information and guidance from experts. The semantic web technology enables information in machine-processable form to coexist and complement the current web with better enabling computers and people to work in co-operation. The use of semantic web solves some of the basic problems in education such as to increase flexible and lifelong learning and decrease teachers' workload. This paper focuses on two application areas – a) software agents that support teachers in performing their tasks in flexible online educational settings, and b) software agents that interpret the structure of distributed, self-organized, self-directed learning networks for lifelong learning. The resulting information can be used by the learners to perform their task in this environment more efficiently. These tasks require a semantic representation of educational entities, specifically the structure of the teaching-learning process, in order to allow for automatic processing. The mechanisms responsible for the efficiency of learners and teachers are principles of self-organization and software agents. Both of which are based on semantic web principles that provide support and regulative feedback for both learners and teachers.

Keywords: e-learning, software agents, self-organization, semantic web, distributed learning

Introduction:

Semantic web is a tool with realistic educational application. It is going to change future learning and teaching. In this paper, the possible directions of this future change will be discussed.

The basic idea of the semantic web is relatively straightforward: to create a layer on the existing web that enables advanced automatic processing of the web content so that data can be shared and processed by both humans and software (Tim Berners-Lee & Fischetti, 1999;T. Berners-Lee, Hendler, & Lassila, 2001, SW, 2003). Current web pages are structured with (X)HTML tags that provides information about the surface structure of a web page. These tags reveal that every page has a head (e.g. with a title, metadata) and a body with some structured content. The content is structured grammatically in headings, paragraphs, tables, images etcetera. Although some people advocate that this is only a presentation oriented structuring of data, this is only partly true. In essence it provides a semantic structure for the concept of a generic 'page'. A web browser can interpret and process these pages, along with some style sheets, automatically. However, this is only true to the extent that the information is provided in a structured, machine-interpretable way.

For example, a paragraph can be interpreted as a sequence of lines that addresses a common topic. Nothing more, and nothing less. The tagging is generic, does not tell anything about what content has been structured (a poem, a story, a catalogue, a course), and it does not reflect the typical patterns found in different types of documents. This lack of semantic detail is of little consequence if the text is meant for human interpretation only. However, this also implies that the possibilities for automatic processing and manipulation of the web page are restricted to tasks like the ordering and presentation of the paragraph.

It would be nice if computers were able to 'understand' web pages so that they can help users to better search for relevant information, make inferences and calculations from the information and combine information in new ways to support knowledge-based tasks such as authoring, planning, navigation, cultural exchange and research. This is the ambitious goal of the semantic web, but it comes at a cost: it requires that more explicit, domain specific meaning ('semantics') be provided by the authors in order to allow for machine-interpretation.

In this article I will explore the use of semantic web technologies in the context of teaching and learning. The usefulness of any technology in any field is dependent on its capacity to address real problems and address practical needs in that field (Mitcham, 1994). Thus, I will make a short inventory of the core technologies in the semantic web, explore some of the current problems and needs in the field of education and will discuss areas where the semantic web technologies can be used to address some of these issues. This exercise cannot be done exhaustively. One way of looking in the crystal ball for future significant developments is to look at current research and technological development (RTD) projects that are working towards the solution of long standing educational problems. So, I will focus on some of our RTD work related to the semantic web, specifically our work on the semantic modelling of educational content and processes, and our work in the realization of self-organized distributed learning networks for lifelong learning. This work is focussed on post-secondary distributed education using Internet technologies.

Problems and needs in Education:

One way of looking at problems and needs is by looking at current trends. Howell, Williams, & Lindsay (2003) analysed 32 trends and Merrill (2003) identified current trends in instructional design. Summarized and regrouped on several eLearning domain dimensions (Koper, 2003) we can identify the trends in Table 1.

Dimension	Problems/Needs
I. Changes in Societal Demands	Current higher education infrastructure cannot accommodate the growing college-aged population and life-long learning enrollments, making more distance education programs necessary. Knowledge and information are growing exponentially and Lifelong learning is becoming a competitive necessity. Education is becoming more seamless between high school, college, and further studies
II. Changes in Learning Teaching process	Instruction is becoming more learner-centred, non-linear, and self-directed. There is an increasing need for new learning and teaching strategies that a) is grounded in new instructional design research and b) exploit the capabilities of technology Learning is most effective when learners are engaged in solving real-world problems; learning environments need to be designed to support this problem-centred approach. Students demand more flexibility; are shopping for courses that meet their schedules and circumstances Higher-education learner profiles, including online, information-age, and adult learners, are changing

	Academic emphasis is shifting from course-completion to competency The need for faculty development, support, and training is growing Instructors of distance courses can feel isolated
III. Changes in Organization of Educational Institutions	There is a shift in organizational structure toward decentralization Higher education outsourcing and partnerships are increasing Retention rates and length of time taken to completion concern administrators, faculty members, students and tax payers The distinction between distance and local education is disappearing Faculty members demand reduced workload and increased compensation for distance courses Traditional faculty roles are shifting or unbundling

Table 1. Summary of problems and needs in education

Stated in more general terms, the longer-term aim of educational change is to (a) increase the effectiveness of education, (b) to increase the flexibility and accessibility of education, (c) increase the attractiveness of education and (d) to decrease the workload for staff (or more in general: to decrease the institutional costs). The relevance of the semantic web for education depends on how much it contributes in the accomplishment of this aim.

My personal expectation is that the semantic web will be of help in two general areas, both related to the fact that it allows for more and better automatic processing of web information:

Staff can be helped to perform some of their tasks in flexible, online educational settings more efficiently and less isolated, this includes online course development tasks, learner support tasks, assessment tasks and course management and administration tasks (e.g. setting-up new instances of courses).

Persons in different roles (learners, tutors, content providers) can be helped to perform tasks more effectively and efficiently in large, distributed, problem-based, multi-actor, multi-resource learning spaces that are set-up to establish, learner-centred, non-linear, self-directed lifelong learning opportunities.

The first expectation is directed at helping staff members to perform their tasks more efficient. This has an effect on the quality of learning. A common finding is that renewal of education (increase flexibility, use of eLearning, learner-centric approaches) leads in most situations to an increase in staff workload. This is one of the (many) reasons why teachers, schools and universities are resistant to change. When the workload of teachers is decreased, more time is available for more and higher quality support activities. It is expected that this will provide a stimulus to implement more fundamental and necessary innovations in the teaching-learning process.

Self-organized Learning Networks for Lifelong Learning

LD is able to represent any learning design model. However, most users in eLearning and distance learning interpret this in terms of modelling courses based on some underlying assumptions. These assumptions are:

A curriculum consisting of one or more courses that is explicitly designed by teachers, institutes and/or other parties in society. The course is developed by a teacher and/or other expert developers. The developed course is put into practice by enrolling students and assigning teachers/tutors. A student takes a course and the support is provided by the teacher/tutor. Assessment is a responsibility of the teacher or a (super-) institutional entity. However, given the current need for lifelong learning scenarios, the demand for more flexible, self-directed informal and formal learning opportunities and the need for more efficient teaching scenarios, this model is quite restricted and labour intensive. In lifelong learning the roles are not so fixed as implied above: students can be (co-) producers of course materials, can perform assessments (e.g. in peer and self assessment), and can support other students, just like teachers and experts can both teach and learn at the same time in a certain field of expertise. We want to examine a form of education delivery that goes beyond course and curriculum centric models, and envisions a learner-centred and learner-controlled model of lifelong learning where learners have the same possibilities to act that teachers and other staff members have in regular, less learner-centred educational approaches, but without increasing the workload for learners and staff members. Mechanisms responsible for this efficiency are principles of self-organization and software agents, based on semantic web principles that provide support and feedback for persons in performing their learning and support tasks in the learning and teaching process.

Self-organization allows the creation of an efficient system with a minimum of planning and control overhead while maintaining maximum flexibility to adapt to learners' needs thereby reducing the current overhead costs in maintenance, planning, control and quality issues. The essence of self-organisation is stated Heylighen and Gershenson (2003) who wrote:

"A self-organizing system not only regulates or adapts its behaviour, it creates its own organization. In that respect it differs fundamentally from our present systems, which are created by their designer. We define organization as structure with function. Structure means that the components of a system are arranged in a particular order. It requires both connections, that integrate the parts into a whole, and separations that differentiate subsystems, so as to avoid interference. Function means that this structure fulfils a purpose."

It is expected that the application of self-organization principles will help empower learners to move beyond passive consumption of e-learning content towards active production (Fischer & Ostwald, 2002). This shift of control aims to help relieve the burden on providers to predict needs, costs, expected use and income, and tilts the balance of responsibility for learning processes towards the learners themselves (see Tattersall et al, 2003).

It is recognised that, in putting the learner centre-stage, care must be taken that the shifting of control does not lead to an overburdening or abandonment of learners. Instead, support and guidance must be given to learners in taking up their new responsibilities. Here lies the opportunity for educational providers -- to create the best conditions for self-organizing learning networks to flourish. Part of these conditions will be the provision of software agents that provide support in area's like navigation through the network.

Figure 1 provides a high-level use case of a learning network (A UML use case specifies the different functions that different actors can perform in a learning network).

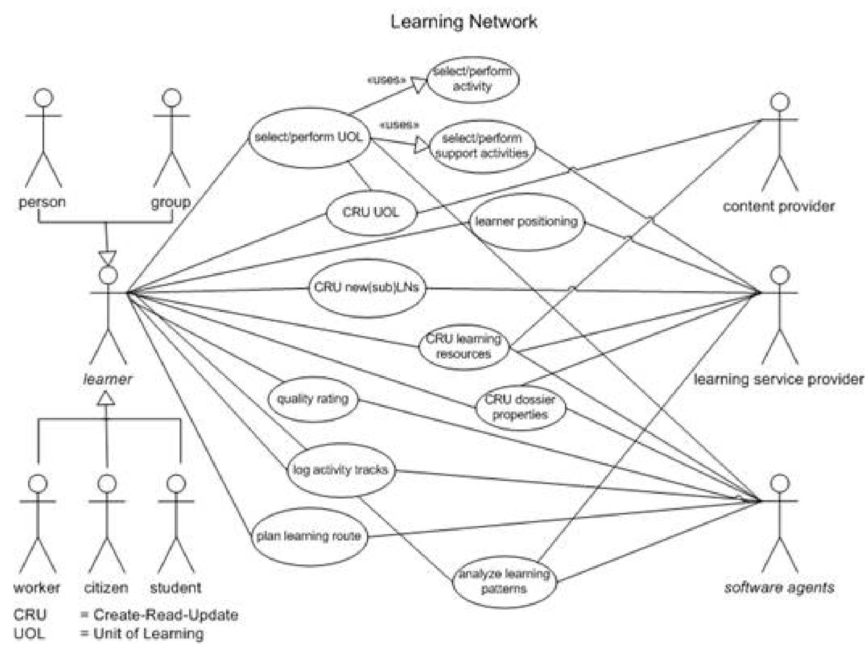

Figure 1: a general use case for learning networks

The use case diagram (figure 1.) specifies several actors in a learning network: learners, providers and autonomous software agents. A learner can be an individual person or a group of persons. A further specialization of learners can be given in terms of workers, citizen and students (in regular educational institutes). Different kinds of providers may be distinguished, such as content providers responsible for the provision of learning content (e.g. experts, publishers, libraries) and learning service providers can be distinguished, responsible for tutoring, mentoring, assessment and other learning support functions (e.g. schools, universities, training institutes). Software agents can perform a variety of activities in collaboration with the human actors: sometimes they take over some human activity but in most cases they will support the humans in performing their activities.

The figure specifies several use cases, i.e. the activities performed by the actors, represented with oval boxes. A learning network is defined in a certain knowledge or application domain (e.g. psychological diagnosis or eLearning) and consists of a heterogeneous community of humans with a variety of backgrounds and offerings in this field. You can enter the network to learn something new, to increase your level of competence in a certain area or to offer something for others to learn or use. The core concept of the learning network is that it consists of a collection of nodes, each representing a unit of learning (UOL nodes). Every node contains some study tasks, knowledge resources, collaborative services and learning support facilities organized around some learning objective and some prerequisites. Learners can create their own UOL nodes, can use nodes created by others, can collaborate with others to create nodes and can evaluate and rate the quality of UOL nodes. Providers of high-quality materials and courses can do the same. Someone who wants to learn something (a learner) can search for his or her own learning path (a sequence of nodes), explore node after node or can use a predefined route defined by someone else. This route can be analysed on the basis of previous successful path of others or can be pre-planned by e.g. an educational institution. Some UOL nodes can serve as assessment nodes, resulting in a certificate or diploma that reflects the acquired competencies in the learning network. In a learning network, the user will find several software agents that can support him by performing certain tasks, like the creation of new UOL nodes, selection of adequate learning path, etcetera.

A key notion in the learning network is that it supports learners performing all types of use cases including the ones that traditionally are only available for content and learning service providers. There are no central control actors; the control is expected to emerge under favourable conditions (local feedback, pattern detection) and in a democratic way. This is another way of saying that a person can take all the other roles in a learning network.

A similar argument holds true for quality control: there is no central quality control foreseen in learning networks. It is expected that the network will uphold a variety of different qualities, but that the feedback mechanisms (like ratings and paths) will assure that on the average a satisfactory quality level will be maintained. Thus factors like development costs, frequency of use, incentives, price, and satisfaction may be dynamically balanced. Again this is expected to be an emergent behaviour that will only occur at a certain scale of interactions within the network.

Conclusion:

In this article I explored the use of semantic web technology in the educational field. The core ambition of the semantic web is to allow software agents to interpret the meaning of web content, in order to support users in performing their tasks. In order to be able to interpret the meaning of learning objects and services, several semantic modelling and coding techniques are available, like UML, XML schemas, RDF (-Schema), Topic Maps, OWL Web Ontology Language and techniques like Latent Semantic Analysis.

I started the exploration of use of the semantic web in education by looking at some of the basic problems and needs in education that could be addressed by semantic web technology, at least in principle. Two areas of interest were identified: a) software agents that interpret the semantic structure of units of learning to decrease teacher workload and b) software agents that interpret the structure of distributed, self-organized, self-directed learning networks for lifelong learning to help persons to perform their tasks in this context. Examples of these tasks are: finding appropriate units of learning, creating and adapting units of learning, creating and adapting learning resources, navigating through the network (creating effective, efficient and sensible learning routes), access the current position in the network and provide help with support tasks (e.g. providing feedback on performance; organizing and replying email).

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