CONTRIBUTI SCIENTIFICI

PERSONALIZZAZIONE DI COURSEWARE SCORM NEL SEMANTIC WEB

SCORM COURSEWARE ADAPTATION ON THE SEMANTIC WEB

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SOMMARIO/ *ABSTRACT*

Questo lavoro affronta il problema di selezionare e comporre risorse di elarning nel Semantic Web. Il punto di partenza e` costituito dal framework SCORM, utilizzato per la rappresentazione di learning object. Viene avanzata una proposta per arricchire la rappresentazione con informazione di tipo semantico, riguardante le competenze che consente l'uso di tecniche di ragionamento automatico, ottenendo in questo modo forme di adattativita` derivate dall'area di ricerca sugli adaptive educational hypermedia. La descrizione delle strategie di insegnamento basata sulle competenze piuttosto che su risorse specifiche apre la via a scenari di Semantic Web in cui le risorse di learning sono distribuite sulla rete ed i sistemi di ragionamento possono automaticamente selezionarle e comporle a seconda delle esigenze degli utenti. I vantaggi sono un aumento del riutilizzo delle risorse e una maggiore apertura dei sistemi.

In this work the problem of selecting and composing learning resources in the Semantic Web is considered. The starting point is the SCORM framework, used for learning object representation. A proposal is done for enriching the representation with semantic information about competences, that enables the use of automated reasoning techniques, thus achieving forms of adaptation taken from the fields of adaptive educational hypermedia. The description of learning strategies based on competences, rather than on specific resources, opens the way to Semantic Web scenarios where learning resources are distributed over the network and reasoning systems can automatically select and compose them according to the user's needs. The advantages are an increase of reuse of the resources and a greater openness.

Keywords: Semantic Web, e-learning, automated reasoning.

1. Introduction

The Semantic Web [6] is concerned with adding a semantic level to resources that are accessible over the internet in order to enable sophisticated forms of use and reuse. Resources are not all of a same kind; the most classical type of resource is the HTML document; recently, the attention has been posed also on software that can be invoked over the internet, leading to the definition of web services. Different proposals have been made for adding a semantic layer to the description of these resources, producing languages such as DAML+OIL and OWL for documents, OWL-S for web services. Especially with the development of peer-2-peer e-learning architectures [11], also *learning objects* can be considered as resources that are accessible over the internet, a view that is supported by some authors who report similarities between them and web services [2].
In the literature, there already exist various proposals for standardizing the description of learning objects, for instance to make them cross-platform (cross-LMS, learning management system). One of the most interesting is SCORM, especially in its new version 1.3 [12], which allows the description of a learning "activity" by including rules that govern the presentation of the learning items, by which the activity is composed, in an XML-based format.
It would be interesting to arrive to an integrated representation that, on a hand, takes into account the proposals of the standardization committees that work on learning object representation, while on the other it also takes into account the Semantic Web approach. In this way, it would be possible to apply the reasoning techniques that have been (and are being) developed in the Semantic Web area [1] to the problem of automatically selecting (over the internet) and composing learning objects, by adapting to the user's learning goals and characteristics. In particular, we will show how techniques, that we have already applied to curriculum

sequencing, can naturally be applied to this aim, given a proper extension of SCORM representations.

2. Relevant issues from adaptive educational hypermedia

In the last few years the field of adaptive hypermedia, applied to educational issues, attracted greater and greater attention [7]. Considerable advancements have been yield in the area, with the development of a great number of Web-based systems, like ELM-Art [13], the KBS hyperbook system [10], TANGOW [8], and many others, based on different, adaptive and intelligent technologies, with the common goal of using knowledge about the *domain*, about the *student* and about the *learning strategies* in order to support flexible, personalized learning and tutoring.

Among the technologies used in Web-based education for supporting adaptation and guidance, *curriculum sequencing*, where an "optimal reading sequence" through a hyper-space of learning objects is to be found, is one of the most popular [13, 10, 4]. Different methods have been proposed on how to determine which reading (or study) path to select or to generate in order to support in the best possible way the learner navigation through the hyper-space. However, one important characteristic which emerges as crucial in many approaches [2] is the possibility to keep separate the *knowledge entities* (i.e. the abstract competences related to the learning objects) and the *information entities* (that is the actual learning objects). Given such separation, it is possible to define at the *knowledge level*, a set of learning dependencies, that is the dependencies among knowledge entities (or competences). The set of all the possible competences and of their relations defines an *ontology*. We can, then, associate to each learning object a set of competences that describe it. In this framework, it is possible to add to the system an adaptation component, that uses such an ontology, together with a representation of the user *learning goal* and of the user knowledge, for performing the sequencing task, producing sequences that fit the user requirements and characteristics, based on the available learning objects.

Working at the level of competences is closer to human intuition and makes the reuse of the learning objects easier because the same learning object will be automatically taken into account by the adaptation component whenever a competence that is supplied by it is necessary during the sequencing process. Moreover, it enables the application of *goal-directed reasoning processes*, as it is done by the WLog system [4]. In this system the learning objects are represented as actions each having a set of preconditions (competences that are necessary for using the learning object) and a set of effects (the supplied competences). Competences are connected by causal relationships and define an ontology. A group of agents, called *reasoners*, uses such descriptions, the user learning goal (expressed as well in terms of competences) and the ontology for performing the sequencing task. This is done by refining curriculum schemas, described only on the basis of the ontology, and decoupled from the actual learning objects. Thus, adaptation is based on the *reasoning capabilities* of the *rational agents*, that are implemented in the logic language DyLOG [5]. The reasoning techniques that are used by the agents are taken from the field of "reasoning about actions" and are *planning*, *temporal projection*, and *temporal explanation*; basically, they allow to reason about the dynamics of the learning objects outcomes and preconditions and to generate sequences of learning objects for achieving the learning goal.

3. The SCORM framework

In SCORM 1.3 terminology the learning units are called SCO, and their structure plus the rules that govern the learning activity are defined in the so-called "manifest" of the SCO. Broadly speaking we can say that each manifest can be interpreted as a learning strategy, since it describes both the structure into which the learning material is assembled and the way in which it is presented.

The language by which rules are written basically exploits three operators: sequencing, if-then branching, and presentation of a set of learning items that the user can freely explore. These operators allow the description of a learning object as a tree in which inner nodes (items) represent sub-activities. The tree leaves are the single units (assets) of which the learning object is made (e.g. a set of HTML pages). The decision by which the next item to show is taken by the Learning Management System (LMS), based on the rules contained in the manifest and on features that depend on the user behavior (e.g. the user has read the previous item, the user has not answered a question correctly). The nice point is the intrinsic modularity of this representation: learning objects can be composed, they can be reused in many compositions, and reuse can occur at any level, so composed learning objects can be reused as well as a whole.

Each SCO can be annotated by adding a description in terms of IEEE LOM (Learning Object Metadata). More specifically, a complete LOM description [12] consists of attributes, divided in nine categories (general, life cycle, meta-metadata, technical, educational, rights, relation, classification, and annotation). In [11] it is shown how fifteen of such attributes are sufficient to describe most of the learning resources. Such attributes include the possibility of describing the *contents* of a learning object in terms of keywords taken from an *ontology* of interest. Therefore, in principle, a SCORM description includes a description at the level of knowledge entities (we will come back to this point); therefore, in principle, it would be possible to apply reasoning techniques, of the kind described shortly above: it would possible to dynamically assemble the learning objects to be used in a course, on the basis of the learning goals, to verify if a learning object satisfies a given learning goal, or to adapt a general learning strategy to a user's needs.

4. Reasoning about SCOs for adapting the courseware

SCORM learning objects show some degree of flexibility in the sense that the presentation is adapted to the user behavior, as briefly described in the previous section. However, the kind of adaptation that is implemented is very simple and it is based exclusively on the navigation behavior of the user. An item is shown if the user has already visited one or more other items or if he has given the wrong answer to a question associated to such an item. A more ambitious goal would be to embed in the SCORM environment the possibility of composing on the fly the learning objects, exploiting some of the dynamic adaptation techniques mentioned in the previous section. We could, for instance, add to the LMS an intelligent component that after acquiring the user's learning goal, composes an ad hoc courseware based on a set of available learning objects, properly enriched with a high-level semantic information, according to the approach of the advanced adaptive educational systems described in Section 2.

More precisely, our idea is to introduce at the level of the learning objects, some metadata that describe both their *pre-requisites* and *effects*, as done in the curriculum sequencing application. This allows to express *learning strategies* at the competence level rather than at the level of the specific resources, as instead done by the SCORM manifests. Notice that the separation of these two levels is important in order to achieve flexibility, reuse and adaptation. By applying the forms of reasoning supported by the DyLOG language, it is, then, possible to generate a plan, built on the available learning objects, that represents the structure of the courseware, adapted to the user's learning goal and knowledge. Intuitively, a plan is an instance of the general learning strategy, that can be translated into a SCORM manifest and, then, presented to the user.

Regarding annotation, LOM allows the annotation of the learning objects by means of an ontology of interest (see for instance [11]), by using the attribute *classification*. A LOM classification consists of a set of ontology elements (or *taxons*), with an associated role (the *purpose*). In particular, it is possible to define as roles *pre-requisites* and the *educational objectives*. By exploiting this feature, the interpretation of a SCO as an action is possible in a quite straightforward way.

The description of learning objects and learning strategies based on competences, opens the way to Semantic Web scenarios where learning resources are distributed over the network and reasoning systems can automatically select and compose them according to the user's needs. The advantages are an increase of the ease of reuse of the resources and a greater openness.

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REFERENCES

[1] S. Abdennadher, J. Alves Alferes, G. Antoniou, U. Assmann, R. Backofen, C. Baroglio, P. A. Bonatti, F. Bry, W. Drabent, N. Eisinger, N. E. Fuchs, T. Geisler, N. Henze, J. Maluszynski, M. Marchiori, A. Martelli, S. Carro Martinez, H. Jurgen Ohlbach, S. Schaffert, M. Schroeder, K. U. Schulz, U. Schwertel, and G. Wagner. Automated reasoning on the web. Communications of Applied Logic, 2004. To appear.

[2] L. Aroyo, S. Pokraev, and R. Brussee. Preparing SCORM for the semantic web. In Proc. of the Int. Conf. on Ontologies, Databases and Applications of Semantics (ODBASE03), Catania, Italy, 2003.

[3] M. Baldoni, C. Baroglio, N. Henze, and V. Patti. Setting up a framework for comparing adaptive educational hypermedia: First steps and application on curriculum sequencing. In Proc. of ABIS-Workshop 2002: Personalization for the mobile World, Workshop on Adaptivity and User Modeling in Interative Software Systems, pages 43-50, Hannover, Germany, October 2002.

[4] M. Baldoni, C. Baroglio, and V. Patti. Web-based adaptive tutoring: an approach based on logic agents and reasoning about actions. Artificial Intelligence Review, 2004.

[5] M. Baldoni, L. Giordano, A. Martelli, and V. Patti. Programming Rational Agents in a Modal Action Logic. Annals of Mathematics and Artificial Intelligence, Special issue on Logic-Based Agent Implementation, 41(2-4), 2004.

[6] T. Berners-Lee, J. Hendler, and O. Lassila. The Semantic Web. Scientific American, 2001.

[7] P. Brusilovsky. Adaptive hypermedia. User Modeling and User-Adapted Interaction, 11:87-110, 2001.

[8] R. M. Carro, E. Pulido, and P.~Rodriguez. Dynamic generation of adaptive internet-based courses. Journal of Network and Computer Applications, 22:249-257, 1999.

[9] Learning Technology Standards Committee. Draft Standard for Learning Object Metadata, IEEE 1484.12.1-2002, 2002.

[10] N. Henze and W. Nejdl. Adaptation in open corpus hypermedia. IJAIED Special Issue on Adaptive and Intelligent Web-Based Systems, 12:325-350, 2001.

[11] W. Nejdl P. Dolog, R. Gavriloaie and J. Brase. Integrating adaptive hypermedia techniques and open rdf-based environments. In Proc. of The 12th Int. World Wide Web Conference, Budapest, Hungary, 2003.

[12] ADL Technical Team. SCORM XML controlling document - SCORM CAM version 1.3 navigation XML XSD version 1.0, 2004. http://www.adlnet.org/.

[13] G. Weber and P. Brusilovsky. ELM-ART: An Adaptive Versatile System for Web-based Instruction. IJAIED Special Issue on Adaptive and Intelligent Web-Based Systems, 12(4):351--384, 2001.

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