Chapter 5
An Adaptive System for Retrieval and Composition of Learning Objects

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ABSTRACT
This paper proposes a new approach to automatic retrieval and composition of Learning Objects (LOs) in an Adaptive Educational Hypermedia System (AEHS) using multidimensional learner characteristics to enhance learning effectiveness. The approach focuses on adaptive techniques in four components of AEHS: Learning Paths, LO Retrieval, LO Sequencing, and Examination Difficulty Levels. This approach has been designed to enable the adaptation of rules to become generic. Hence, the application to various domains is possible. The approach dynamically selects, sequences, and composes LOs into an individual learning package based on the use of domain ontology, learner profiles, and LO metadata. The Sharable Content Object Reference Model is employed to represent LO metadata and learning packages in order to support LO sharing. The IMS Learner Information Package Specification is used to represent learner profiles. A preliminary evaluation of the developed system indicates the system’s effectiveness in terms of learners’ satisfaction.

INTRODUCTION
Recent trends in adaptive e-Learning have led to the development of the Adaptive Educational Hypermedia System (AEHS) (Karampiperis, 2005). Adaptive navigation and presentation techniques are employed to provide personalization of courses. AEHS creates a model of goals, preferences, learning styles and knowledge of each learner and utilizes this model throughout the interaction with individual learners in order to adapt learning content to meet the individual learner’s needs. Moreover, AEHSs adaptability can provide a better learning process for learners. Although AEHS yields various benefits, there are still several problems:

DOI: 10.4018/978-1-4666-2470-2.ch005
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• Many AEHSs focus only on a limited number of learner characteristics in which learning styles are restrictedly supported. Therefore, a newly developed AEHS should allow or encourage the consideration and utilization of multidimensional learner characteristics for more effective adaptation.
• Many AEHSs employ inflexible representation schemes to model domain knowledge. This leads to difficulties in modifying, exchanging, or reusing knowledge for different domains.
• Most AEHSs are unable to automatically compose the learning materials for personalized course packages in a real-time manner. Therefore, learners cannot own portable course packages.

This paper proposes an approach to automatic retrieval and composition of Learning Objects (LOs) for AEHS for individual learners and different knowledge domains. The approach supports multidimensional learner characteristics and adopts ontologies and well-known standards for the representation of information required for retrieval and composition. Ontology, generally defined as a representation of a shared conceptualization of a particular domain, allows LOs that are in the same domain but created by different authors to share common terms. As a consequence, related LOs can be readily retrieved and composed. This ontology as well as learner and adaptation models are expressed via an Extensible Markup Language (XML) platform. Based on this approach, a prototype system has been developed with the following capabilities to solve some key problems of AEHS:

• Support of many learner characteristics and general domain models.
• Adaptive selection of appropriate learning courses based on the prior and background knowledge of learners.

• Adaptive selection of LOs in a chosen course based on learning styles.
• Adaptive sequencing of the LOs in a chosen course based on learning styles.
• Automatic composition of LOs into a personalized Sharable Content Object Reference Model (SCORM) (ADL, 2004) package in real time.

The rest of this paper is organized as follows: in the next section, we present related studies from the literature. After that, we describe the system architecture of this approach. Then, details of how the prototype system is implemented follow. Next, the system evaluation is presented in detail; and finally, conclusions are drawn in the last section.

RELATED STUDIES

There are a number of related studies which we reviewed such as architecture, learner models, domain models, knowledge and LO sharing, and SCORM supporting current AEHSs.

A sophisticated architecture of AEHS fully consists of 5 complementary models in three categories: i) the domain model which specifies what subject is to be adapted, ii) the learner and content models which indicate what parameters can be adapted, and iii) the instructional and adaptation models which express rules and the pedagogical approach the learning process should be based on, as well as the forms of adaptation to be performed. Karampiperis and Sampson (2005) identify the current state of the art of adaptive hypermedia systems such as AHA!, OntoAIMS, the Personal Reader, WINDS, ACCT which are based on the AEHS architecture model. This model builds upon the Dexter model, a common model for hypertext-based systems that was designed for general purpose adaptive web applications (Vincenza, 2007).

With regard to the learner model, Brusilovsky (1996) classify different aspects of learner char-
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