Chapter XIII
From Learning Objects to Adaptive Content Services for E-Learning

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ABSTRACT

This chapter argues that a new generation of powerful e-learning systems could start on the crossroads of two emerging fields: courseware reuse and adaptive educational systems. We argue for a new distributed architecture for e-learning systems based on the idea of adaptive reusable content services. This chapter discusses problems that have to be solved on the way to the new organization of e-learning and reviews existing approaches and tools that are paving the way to next-generation e-learning systems. It also presents two pioneer systems—APeLS and KnowledgeTree that have attempted to develop a new service-based architecture for adaptive e-learning.

INTRODUCTION

Adaptive Web-based educational systems and standard-based courseware reuse systems constitute two significant streams of research and development in the field of e-learning. *Courseware reuse* systems have emerged as a reaction to the standard practice of "hardwiring" high-quality

educational materials within course content. This practice made it impossible to reuse educational material and resulted in the wasted efforts of the educational community as a whole to the need to re-develop the same material again and again. The early answer to this problem was a database of educational resources and a courseware-reuse approach to authoring new courses (Olimpo, Persico, Sarti, & Tavella, 1990). The courseware reuse ideas have found a fertile ground in Web-enhanced education. Some early large projects in the field of Web-based education like ARIADNE (Forte, Forte, & Duval, 1996) and MTS (Graf & Schnaider, 1997), funded by the European Community, were centered on such a courseware reuse approach. ARIADNE provides a very good example of a courseware reuse architecture. It includes multiple *pools* (repositories) of educational material indexed with metadata and an open set of tools to produce, index, and reuse this material. Other well-known European projects driven by the same motivation are PROMETEUS (http://www.prometeus.org/) and GESTALT (Wade & Doherty, 2000). In the USA the reusability approach has been promoted by EOE Foundation (http://www.eoe.org/) and GEM Consortium (http://www.geminfo.org/).

Adaptive Web-based educational systems (Brusilovsky & Peylo, 2003) emerged as an alternative to the traditional "one size fits all" approach in the development of educational courseware. These systems build a model of the goals, preferences and knowledge of each individual student, and use this model throughout the interaction with the student in order to adapt to the needs of that student. The first pioneer adaptive Web-based educational systems were developed in 1995-1996 (Brusilovsky, Schwarz, & Weber, 1996a, 1996b; De Bra, 1996; Nakabayashi et al., 1995; Okazaki, Watanabe, & Kondo, 1996). Since that time, a number of systems have been created all around the world. The majority of adaptive Web-based educational systems are based on technologies developed in the areas of adaptive hypermedia (AH) (Brusilovsky, 1996) and intelligent tutoring systems (ITS) (Polson & Richardson, 1988).

The methods and tools developed by both researchers of courseware reuse systems and adaptive Web-based educational systems can contribute to creating better Web-enhanced courses. We believe that a way to the future starts on the crossroads of courseware reuse and adaptive educational systems. This chapter attempts to bridge the gap between the information retrieval abilities of modern educational material repositories and the just-in-time delivery and personalization power of ITS and AH technologies. We start with a brief analysis of these approaches comparing their strong and weak points (illustrated later in Table 1).

The courseware reuse frameworks such as ARIADNE allow a course author to search for the relevant learning objects in repositories of educational material and "paste" them into their courses (Figure 1). This approach reduces course development time and improves the quality of courses by making high-quality educational material available for the learning community. At the same time, current implementations of this approach have at least two serious problems.

Firstly, courses developed with this reusability approach suffer from "one size fits all" problem. When identifying relevant material and organizing it within a course section, teachers have to think about the class in general. The students in any class have different interests, knowledge, backgrounds, and learning styles. Some material carefully selected by the teacher can be useless for some students and only distract them. Some material that is important for particular students might not even be selected. An organization of material that benefits one category of learners may create obstacles for other categories. This problem is becoming especially important in Web-based education where the variety of learners taking the same course is constantly increasing.

Secondly, modern reusability frameworks implicitly assume that a learning object is a moveable