Digital Libraries of Learner-Adapted Courseware

Anthony Savidis¹
Margherita Antona¹
George Kartakis¹
Constantine Stephanidis¹, ²

¹ Institute of Computer Science
Foundation for Research and Technology - Hellas (FORTH)
GR-70013, Heraklion, Crete, Greece
cs@ics.forth.gr
² Department of Computer Science
University of Crete

Abstract. In the context of digital libraries for e-learning, adaptation should continuously deliver, during the use of the system, the most appropriate interactive learning content to each individual learner. To this purpose, an architectural framework is proposed, based on a series of models, which encapsulates the adaptation logic for the reasoning mechanism to accomplish both interface and course adaptation, on the basis of the key attributes captured in the models.

1. Introduction

Digital Libraries are acquiring a fundamental role in shaping new inclusive forms of education in the emerging Information Society. A variety of courseware Digital Libraries appear in different domains, targeted to different educational purposes and audiences, and technology is called to support anybody, anywhere, anytime access to learning opportunities. In such a context, it is particularly important to investigate the role of content and interaction adaptation in courseware Digital Libraries, and to provide appropriate approaches to facilitate authoring and delivering of adaptive courseware.

In the application domain of education, adaptation has been investigated in a number of recent research efforts, mainly falling into the category of Intelligent Tutoring Systems and Adaptive Hypermedia ([1], [4], [2]). In these efforts, several adaptation techniques have been developed, the e.g., curriculum sequencing, adaptive navigation, and adaptive presentation ([10], [9]).

In Human-Computer Interaction, automatic adaptation of a system’s interactive behaviour has been proposed as a framework for providing accessibility and high interaction quality to all potential users, on the basis of each user’s individual abilities, requirements and preferences, as well as of the context in which interaction takes place and of the adopted interaction technology ([8]). Under this perspective, adaptation implies the capability of assembling, coherently presenting, and managing at run-time the appropriate alternatives for the current user(s), purpose(s) of use and context. The self-adapting behaviour of a system is based on knowledge concerning: (i) the available alternatives, (ii) the characteristics of users, the purpose and context of use, etc, and (iii) the optimal matching between alternatives and characteristics. As a consequence, a self-adapting system should include appropriate sources of knowledge, in the form of models, as well as appropriate reasoning mechanisms for deriving adaptation decisions related to what content the user should be presented with and through which interface. In interactive eLearning applications, a clear separation regarding User Interface and content is difficult to draw, because content is also interactive and supplies interaction objects and techniques. Therefore, appropriate technical approaches are required to accommodate content and interface adaptation in the context of digital libraries for e-learning.

3. Digital Library architecture

This section discusses a proposed architecture for learner-based content and interaction adaptation in a distributed digital library of courseware, comprising three main blocks of components: authoring facilities, metadata and data, and course delivery facilities. The overall architecture is depicted in Figure 1.

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3.1 Meta-Data for Learners, Course, Learning Objects and Process

Both the authoring and the course delivery tools in the proposed architecture rely on models of learners, course structure, content elements, and training process. Predefined models (metadata) enable courseware authors to define instances of learners (i.e., profiles), courses (i.e., structure), learning objects (i.e., imported, semantically indexed, content), and training processes. In Figure 2 the role of meta-data is illustrated. Information regarding learners is addressed through a learner meta-model, which needs to be general enough to address various categories of course delivery, such as, for example, formal classroom based, casual informal, etc. Alternative templates are supplied for specific domains. Models of the data to be delivered in a course and of the delivery process are also necessary. Content information is logically separated from the course information, providing semantic information regarding the overall course structure. This logical split enables a course to be delivered in different forms, by controlling various semantic parameters, such as level of detail, type of explanation, and complexity of examples. The content model identifies the elementary constituent units of content, and the structure in which elementary constituents are organised. Units of content are referred to as ‘learning objects’ ([3]), and can be a paragraph of text, an image, a video clip, etc. As content can manifest itself in different forms, learning objects should not have a singular mapping to content resource items (i.e., content entities), but should be abstract, i.e., capable of linking to different content items. Additionally, they should not be physically attached to content. This can be accomplished by associating learning objects to content via resource identifiers, as opposed to embedding content within learning objects. Such a logical split also supports a greater degree of reusability of resources.

The structure of a course may vary depending on many factors. For instance, educational material for a course may be structured as a hypermedia book, a tutorial, a training session, a seminar, etc. Course structures are usually specified on the basis of a hierarchical organisation model, in which the most primitive constituent components are the learning objects. From the point of view of adaptation, the process model constitutes the main backbone for matching the content to be provided to the learners’ characteristics. Different templates can be provided for different type of courses.

An important related requirement is that they cater for alternatives to be made available to different users in different situations, and provide information for selecting amongst alternatives, i.e., they define multiple courses in one hierarchical structure.
An example of such an abstract hierarchical structure is the Polymorphic Task Hierarchy, originally elaborated in the context of a design method for user interfaces exhibiting automatic adaptation behaviour ([5]), which compactly and systematically captures design spaces of interrelated alternatives along with the underlying run-time adaptation logic.

Learning objects’ templates and course templates should appropriately link, in order to enable the implementation of facilities such as, for example, search, evaluation, selection, and acquisition of learning objects, sharing across different courses, etc. The process model also provides information for course management at run-time (e.g., start date, expected duration, end date, real duration, sessions, plan, enrolled learners, tutors, course topic index, completion status, etc).

3.2 Authoring facilities

The authoring tool consists of five inter-operating editors, which provide support for learner profile editing, course construction, editing of learning objects, organising learning sessions and processes, and configuring the content adaptation strategy through rules. Content adaptation can be applied each time a particular course topic is to be entered, based on criteria depending on learner’s characteristics, course-specific information, types of learning objects involved, and process-related information. As courseware authors or tutors will need to provide their own strategies and criteria for content adaptation, the proposed architecture includes an editable adaptation strategy mechanism, allowing to easily defining criteria for linking together learner-, course-, learning object- and process- attributes.

The adaptation logic provides the reasoning mechanism required for accomplishing both interaction and course adaptation. The reasoning processes place both at the beginning of and during each learning session, and provides a decision mechanism for dynamically selecting, among the multiple instances of course components and learning objects available, the one(s) appropriate for presentation at a given point in a learning session of a specific user. Although general adaptation rules can be defined, it is unlikely that all adaptation cases for a variety of learners’ characteristics and courses can be captured at a general level. Therefore, adaptation rules need to be editable, i.e., course authors should be allowed (and supported in) defining their own adaptation logic. The Decision-Making Specification Language (DMLS, [6]), elaborated in order to support the easy design time definition and run-time application of user interface adaptations, provides an example of such an editable adaptation logic. DMSL rules specify run-time adaptation patterns based on adaptation determinants (e.g., diverse user characteristics and requirements) established at design time. DMSL rules can also be automatically derived from Polymorphic Task Hierarchies, and verified for consistency and correctness of the defined adaptation logic ([7]).

All editors include querying facilities for searching editable items. The authoring tool will explicitly provide structured content, in which authors will have to easily “fill in the gaps” by supplying appropriate material (e.g., formatted text, HTML pages, audio, video) on the basis of a course “road map” (i.e., content model). The overall course “assembly” process is automatic.

3.3 Course Delivery Facilities

Course Delivery facilities manage distributed course execution. The first step is the collection of the learning objects comprising an adapted course, carried out on the basis of learner and course
identification. Then, content adaptation is carried out, on the basis of the identified adaptation factors, leading to the creation of the final course structure. Finally, the physical form of the selected learning objects is retrieved and the collected items are assembled into a dynamic Web document by applying an appropriate display template. In this context, delivery may imply the presence of mechanisms to assemble not only an acceptable, but also high-quality physical structures. (e.g., high-quality visual document structure). Additionally, the delivery platform should be able to handle the retrieval and display of physical data (i.e., text and images in their particular format). Some of the learning resources may also support tele-conference, collaboration and communication facilities as embedded software components. The delivery interface and the content interface are considered as distinct. The former provides standard facilities such as history control, navigation, and communication, while the latter provides content-specific interaction depending on the physical delivery of a learning object (i.e., its form). Interface adaptation affects both levels, and is carried out both at the beginning of a learning session, by supplying an interface instance which better suits the particular characteristics of each learner, and during interaction, by providing adaptive prompting and help in cases particular interaction problems are detected. The delivery interface can be equipped with the capability to automatically adapt according to information on learners’ computer-use skills, while the content interface can adapt through on-line selection of the most appropriate physical form for each learning object. The content assembly process can be based, for example, on domain-specific HTML templates.

4. Summary

This paper has discussed some important aspects of a proposed architectural framework suitable for supporting content and interaction adaptation in a courseware Digital Library. Important constituents of the architecture are the adaptation logic and the delivery mechanism. The adaptation logic is required for reasoning on the available alternatives and select the optimal material to be presented to learners according to the set parameters. Given the wide variety of possible applications and knowledge domains, it is likely that adaptation rules will vary, and as a consequence, it should also be possible to define different rules to cater for different cases. The delivery mechanism role is to assemble in a coherent unit the material chosen for presentation, and offer it to the learner.

References