Adaptation of interactive courseware

Margherita Antona¹, Anthony Savidis¹, Constantine Stephanidis¹.²

¹ Institute of Computer Science
Foundation for Research and Technology - Hellas
Science and Technology Park of Crete
GR-71110, Heraklion, Crete, Greece
Email: cs@ics.forth.gr

² Department of Computer Science, University of Crete

Abstract

This paper focuses on the notion of content and interaction adaptation in web-based courseware. The adopted perspective is that adaptation should continuously deliver, at any time during the use of the system, the most appropriate interactive learning content to each individual learner. To this purpose, the paper briefly discusses the concept of adaptation in educational applications from the wider perspective of universal access to Information Society Technologies, and discusses some aspects of a proposed architectural framework suitable for supporting content and interaction adaptation in such a context.

1. Introduction

Long distance computer-based instruction, and in particular web-based instruction, is progressively acquiring a fundamental role in shaping new inclusive forms of education in the emerging Information Society, and is attracting considerable attention at both government and industrial level [see, e.g., European Commission, 2000; Kerrey et al., 2000; Hodgins, 2000]. The advent of the World Wide Web (WWW) and of multimedia technologies has marked a turning point in the way computer-based education is conceived, designed, delivered and experienced. The WWW enables the wide distribution of educational material in which content is presented using a wide variety of media (hypertext, graphics, animation, audio, video, etc). Web-based learning involves an increasing variety of target learner groups, including, for example, adults, children in secondary education, people in geographically dispersed areas, (re-)trainees, disabled and homebound, etc., in an increasingly wider variety of educational activities, including pre-university and university courses delivered on the web, training in industry, life-long learning, learning on demand, and many others. As a consequence, distance learning is evolving from a form of education in which the learner and the teacher are physically separated, to the provision of “whatever educational opportunities to anybody, anywhere and at anytime, characterised by a great diversity in practice” [Spodick, 1995, p.1]. The role of technology, in this context, is not only limited to providing more efficient, simple and cost-effective solutions for overcoming distance and time in education, but also to create and make widely available new forms of learning, exploiting the capability of dynamic electronic content to be manipulated, structured, retrieved and presented in a variety of ways. In this respect, one of the most promising characteristics of Web-based learning is the concrete possibility of providing adaptation and individualisation of learning resources.

2. Adaptation in interactive learning system

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. The goal of Intelligent Tutoring Systems is to use the knowledge about domains, learners, and teaching strategies to support flexible individualized learning and tutoring [Brusilovsky, 1999; Murray,1999]. Adaptive hypermedia systems apply different forms of user models to adapt the content and the links of hypermedia pages to the user, and have found in education one of their main applications [Brusilovsky, 1996; De Bra, 1999]. In these efforts, several adaptation techniques have been developed, the most relevant of which are curriculum sequencing [Vassileva, 1997;
Huebscher, 2000; Stern and Park Woolf, 2000], adaptive navigation [Calvi & De Bra, 1997; Weber and Specht, 1997], and adaptive presentation [Brusilovsky et al., 1998].

On the other hand, in recent years, the concept of adaptation has been investigated in the broader perspective of providing built-in accessibility and high interaction quality in applications and services in the emerging Information Society [Stephanidis, 2001a; Stephanidis, 2001b]. Adaptation characterises software products that automatically adapt themselves according to the individual attributes of users (e.g., mental / motor / sensory characteristics, preferences), and to the particular context of use (e.g., hardware and software platform, environment of use). In this respect, adaptation concerns the interactive behaviour of applications and services as well as the content. In Human-Computer Interaction, self-adaptation of a system’s interactive behaviour have 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 [Stephanidis, 2001b]. Therefore, adaptation implies the capability, on the part of the system, of capturing and representing knowledge concerning alternative instantiations suitable for different users, contexts, purposes, etc, as well as of reasoning about those alternatives to arrive at adaptation decisions. Furthermore, 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 [Savidis and Stephanidis, 2001].

From the point of view of interactive courseware, all the types of adaptation mentioned above are relevant. In a learner-centred perspective, content should adapt, as a minimum requirement, to the learner’s previous knowledge, individual progress, learning goals and learning style. Content adaptation should be applied each time a particular course topic is to be entered, so that the learner is initially presented with the appropriate material, as well as during learning sessions, so that the subsequently presented material is selected on the basis of learner specific requirements at run-time. Interaction, on the other hand, should be adapted, as a minimum requirement, to the learner’s computing experience. This implies that both course structure and learning sessions are flexible and can be assembled on the fly and modified at run-time as necessary, and that the learners’ characteristics, the educational material, the course structure and the course delivery process are appropriately modelled, so that the best match between their characteristics can be established at any point in time during the use of the system.

3. Learning system architecture

This section discusses a proposed architecture for learner-based content and interaction adaptation in a courseware environment comprising both authoring and delivering facilities, and in which concrete learning object instances are physically distributed. Adaptation is considered to be based on learner information, course information, learning objects, and process information. A high-level representation of an architecture for the core of such a system is depicted in Figure 1.

3.1 Learner Model

A learner model contains explicitly modelled assumptions that represent the characteristics of learners that are relevant to the system. Several techniques are commonly used for learners’ modelling in Intelligent Tutoring Systems, such as fixed stereotypes, overlay models, or combinations of the above. A number of sources of information may be used to construct a learner model. The system acquires data about the user and infers learner characteristics from this data. The validity of the assumptions depends on the technique used to acquire the information. Automatic modelling may be unreliable, and therefore collaborative and cooperative modelling is frequently chosen [Conlan and Wade, 2000]. The properties chosen to represent the user should be pertinent to the potential adaptation by the system. Learner characteristics frequently modelled are the user's previous knowledge, goals and objectives, cognitive style, learning style, maturity, general ability, confidence, motivation, preferences and background [Specht & Weber, 1996]. For interaction adaptation, knowledge about relevant learners’ characteristics is also necessary, including: sensory, motor and cognitive abilities, expertise in the use of computers, of the web, and of the particular system, knowledge
about specific interface components, colour and media preferences, preferences in interaction and navigation styles, etc.

In order to ensure wide applicability and reusability, the learner’s model should be general enough to address different categories of knowledge domains, learning purposes and training processes. For example, it should be possible to create learner profiles for formal classroom education, professional training, informal learning, etc. This implies the need of differentiating the type of information to be modeled according to its relevance for the specific case. For instance, in classroom-based training, evaluation records may need to be maintained, while in professional training, organizational-role specific information will need to be managed. To achieve such a flexibility, the learner model should be based on meta-data taking into account currently proposed standards [IEEE-LTSC, 2000b, IMS, 2001a], and encompass appropriate abstract attributes, enabling concrete learner models to be instantiated. As intensive use of modeling is required, models should be easy to create, consult and up-date. A possible technique for model information input is the provision of alternative templates for specific domains. Query facilities for existing profiles should also be provided.

3.2 Course Model

Besides information about learners, appropriate models of the data to be delivered in a course and of the delivery process are necessary. Content information should be logically separated from course information. This enables a course to be delivered in different form by controlling semantic parameters. The content model identifies: (i) the elementary constituent units of content; and (ii) the structure in which elementary constituents are organised. In recent standardisation efforts, units of content are referred to as ‘learning objects’ [IEEE-LTSC, 2000a]. Such a unit can be a paragraph or other piece of text, an image, a video clip, etc. The unit internal structure should not be relevant for the model. The knowledge domain can be described in the content model in terms of concepts (or terms) and relationships between concepts. Concepts are used for defining prerequisites providing meaningful paths through the information [De Bra, 1999]. The granularity at which the content is stored affects the level of content adaptation that may be achieved, as well as the reuse potential [Conlan and Wade, 2000].

In the proposed approach, content can manifest itself in different forms, and, therefore, learning objects should not have a singular mapping to content resource items, and should not be physically attached to content. Rather they should be abstract, i.e., capable of linking to different content items. This can be accomplished by associating learning objects to content via resource identifiers, as opposed to embedding content within learning objects, also supporting a greater degree of reusability. Alternative templates can be supplied for different meta-data categories. For interaction adaptation, learning objects should also include information concerning their interaction characteristics (e.g. color, font, interface objects, required interaction techniques), to be matched with learners’ interaction requirements and preferences. Current proposed standard specification can be considered as a comprehensive modelling of learning objects, aiming to be domain-free [IEEE-LTSC, 2000a]. However, due to intended generality, such a specification offers a taxonomy of semantic attributes which do not allow for domain-specific concepts. Therefore, domain specific templates should also be defined.

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 [IMS, 2001b]. Different templates can be provided for different type of courses. An important requirement on course templates 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, depending on the learner’s level, purpose of learning, background, acquired prerequisites, etc. 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, etc. The process model should also provide information for course management at run-time.

3.3 Adaptation Logic

In Adaptive Hypermedia and Intelligent Tutoring Systems, adaptation decision-making is often embodied in the “pedagogical knowledge” of the system and is implemented through rule-based approaches (e.g., Vassileva, 1997; De Bra et al., 1999). Alternative approaches include Bayesian networks for calulating probabilities (Henze, 2000), fuzzy logic (Nkambou, 1997), and neural network and connectionist methos (Mullier et al., 1999).
In the proposed architecture, the adaptation logic is the component in charge of providing the reasoning mechanism required for accomplishing both interaction and course adaptation, on the basis of the relevant characteristics captured in the models. The reasoning process is assumed to take place both at the beginning of and during each learning session, and to drive to decisions concerning: (i) the learning material to be displayed, and (ii) how it should be assembled. In other words, the adaptation logic 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. In this respect, the adaptation logic combines the information provided in all models in a coherent whole. Although general adaptation criteria 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 criteria should be editable, i.e., course authors should be allowed (and supported in) defining their own adaptation logic on the basis of the knowledge domains, learners and purposes their course is designed for.

3.4 Delivery Mechanism

Apart from deciding which learning objects should be supplied to learners, the physical form of such objects should be retrieved and delivered appropriately. Delivery may imply the presence of mechanisms to assemble a physical structure that is not only “acceptable”, but also high-quality. For instance, assume that the learning objects correspond to independent paragraphs in a document, while the necessary physical data are supplied in different locations, and may contain both text and images. The assembly of those items into a single document should be carried out in a way leading to a high-quality visual document structure. Additionally, the delivery platform should be able to handle the retrieval and display of such physical data (i.e., text and images in their particular format). The content assembly process can be based, for example, on domain-specific HTML templates.

In web-based learning systems, a clear separation between the content and the user interface is not easily performed. The reason is that content is also interactive, supplying all kinds of interaction objects and techniques which are normally classified as belonging to the interfacing layer. Therefore, two types of user interface can be identified: the delivery interface, and the content interface. The former provides some standard facilities such as history control, navigation, and communication, while the latter provides content-specific interaction methods depending on the physical delivery of a learning object (i.e., embedded in form). Consequently, to accomplish user interface adaptation, both levels of interfacing need to be affected. The delivery interface can realise adaptation according to information on learner’s interaction requirements and preferences. While the delivery interface is chosen at the beginning of a session, the content interface is chosen at run-time in case interaction alternatives exist.

4. Conclusions

This paper has discussed some important aspects of a proposed architectural framework suitable for supporting content and interaction adaptation in web-based courseware. A wide range of research issues emerges from the above analysis. To mention only some examples, the granularity at which content should be broken down and analysed constitutes a very important aspect, likely to highly affect the adaptation process and the necessary information. Appropriate granularity levels are likely to vary for different knowledge domains and media, and different modelling solutions are required to be supported. Another important issue concerns the source of knowledge for continuous learner modelling during system use. It is likely that completely automated assessment of the user progresses is not a viable solution, and that human assessment is required at some point in the process. However, on-line monitoring of dynamic user characteristics, which may change in the time-frame of a session, is also required. Therefore, learner characteristics should be carefully investigated with respect to when and how their values and history need to be up-dated.

References


