Adaptive Multimedia Content Delivery in AdaptWeb®

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ABSTRACT

Nowadays it is essential to obtain personalization in e-learning environments, to provide customized help to students' activities. Adaptive educational systems adapt the presentation of content and the navigation to a student's model, considering for example: knowledge area of the user, navigational style, and use of different didactic resources as concepts, examples, exercises, or complementary material. In the Web-based learning AdaptWeb system, adaptation is explored in several ways as delivery of multimedia content in different formats, content presentation according to the user's background; or personalized navigation styles. We assume the learning process can be improved, if the content is accessible in several media formats, including text, images, audio, and videos adapted to the network bandwidth. Addressing these variation possibilities AdaptWeb allows the delivery of variable resolution and quality of videos according to the net bandwidth offered at the presentation moment. This paper describes the AdaptWeb[1] platform and the Adaptive Multimedia Content Delivery (AMCD) responsible for multimedia adaptation over network bandwidth in AdaptWeb.

KEYWORDS

Adaptive content, adaptive multimedia, e-learning, AdaptWeb.

INTRODUCTION

The importance of the World Wide Web in educational empowerment and training is unquestionable today. There is a strong need for adaptive courseware to provide educational content that fits to the participant's cognitive learning style and previous background knowledge. In this paper, we focus on a special application for Adaptive Web-based courses.

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In this project, the adaptation is supported by the creation of a student profile, where information about the student's background, objectives, hyperspace experience, and learning log files are stored and continuously updated. The purpose of AdaptWeb environment is to enable the adequacy of instructional contents to students from different university programs, with distinct personal preferences and technological resources. The trade-off between author's and user's desires must be managed in the AdaptWeb environment. This kind of adaptability is feasible by allowing the user to select different navigation mode as free navigation or tutorial navigation. It's also possible to view different presentation links and to access different conceptual structure and content depending on the student's program.

The AdaptWeb System (Adaptive Web-based learning Environment) is a web-based learning environment very different from others web-based applications as WebCT and Moodle. These last ones have a lot of tools and resources, but they can't adapt the course/discipline for each student. So, each student view the same content and the same list of links in a discipline. AdaptWeb has the purpose to adapt the content, the presentation and the navigation in an educational web course, according to the student model, and is divided into an authoring environment and a run-time environment module. The authoring environment component helps the author to develop multiple presentation contents for a course, with alternatives for different programs and learning styles. The course creation process is based on the creation of a hierarchy of component topics. The run-time environment provides the course sequence of contents according to the student's program and characteristics.

The adaptive process also includes the choice of one or more components regarding the composition of the didactic material or document (texts, images, animations, videos). The diverse media and techniques are needs for attending the diversity of user's preferences and abilities [3, 16, 22, 23]. Much research has been developed trying to adapt didactic material to different student's learning styles [3, 4, 11, 14, 23] using diverse medias and techniques. The AdaptWeb environment [9] was developed with the aim of fulfilling this need. The environment is implemented in PHP and MySQL is available at SourceForge [2].

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In this paper, we describe the AdaptWeb environment and the module Adaptive Multimedia Content Delivery (AMCD) for accessing and adapting the available multimedia content taking advantage of the user's preferences, network characteristics, time of presentation, and quality of didactic material components presentation.
This paper is organized as follows: section 2 presents the related works. Section 3 presents an overview of AdaptWeb, describing the authoring and organizing content, the adaptive content model based on student's model and the adaptive navigation module. Section 4 presents the AMCD module. Finally, section 5 presents concluding remarks.

RELATED WORK

Many papers have been published in the literature about adaptive content delivery [1, 3, 4, 5, 6, 11, 13, 16, 18, 26]. The Synchronized Multimedia Integration Language (SMIL) [25] is a markup language, a W3C standard that enables the synchronized delivery of video streams, audio streams, images, and texts streams. The adaptive conditions in SMIL [25] includes: switch command, network bandwidth [12, 17, and 20], screen resolutions [25] and operating systems language.

Other works take advantage by adaptive content delivery, addressing quality presentation or scalability media delivery [2], presentation time [22], client capabilities [2, 16], user's preferences [10, 24], content summarization [10], and network characteristics [1, 16]. According to Brusilovsky [4, 5, 6], an adaptive system must allow to specify pre-requirement among the contents. The progress of navigation in the available content depends on whether the pre-requirement contents are effectively visited or if you declare to know the content. This type of information should be extracted from different sources, in order to construct the user's model. These data can be obtained implicitly through observation of the user's interaction or explicitly requesting of data directly to the user. The user's model is employed to adapt the content allowing it to match the different user's needs. Some works generate the adaptive content in function of the available time of user to see the presentation [22]. One inconvenient of this solution is the increased effort in authoring process as it will be necessary to produce different contents and identify different situations for adaptive contents.

In our system, the adaptation is based on the student's model, which is composed by information about the student's background, the navigational preferences, the navigation history, and the net bandwidth. We allow the support of multiple different presentations availability of the same concept for a discipline or didactic object using adaptive contents.

ADAPTWEB

AdaptWeb [2] is a web-based learning environment that provides several alternatives of adaptability through the authorship and presentation of contents according to the student's model [9]. The purpose of this environment is to enable the adequacy of instructional contents to students from different university programs, with distinct personal preferences and technological resources. The trade-off between author's and user's desires must be managed in the AdaptWeb environment. This kind of adaptability is feasible by allowing the user to select different navigation mode as free navigation or tutorial navigation. It's also possible to view different presentation links and to access different conceptual structure and content depending on the student's program. The system architecture is composed of 5 modules, Figure 1: the Authoring module (1), the storing XML files module (2), Content adaptive module (3), the Adaptive navigation module (4) and the Adaptive Multimedia Content Delivery (5).

In the authoring module, the author registers the concepts structure organized through the authorship methodology. For each concept registered, the author register for which university program will be available, the pre-requirements and the file related to each concept, which may have examples, exercises and complementary material. For each learning material (examples, exercises, and extra material) the author specifies the target public. After structuring content, the system analyses whether the material is consistent, and in positive case, XML files containing the overall structure of the instructional content are generated. Filters will be applied to those XML files, making possible to generate and present the instructional content adapted to the student's course.

The Student's model in AdaptWeb environment uses learner's characteristics profile. The first one is the *LearningGoal* points to an element of the course which customizes a discipline content directed to the background and objectives of a specific group of students. *Preferences* indicate if the student currently prefers to work in a tutored mode or a freedom mode, according to his hyperspace experience. Using a simple overlay model, the student's *knowledge* on each topic of the Knowledge Model is indicated, i.e. if an instance exists relating the student to an instance of the class Concept/Topic, then the system believes the student has knowledge about this topic. *NetworkConnection* indicates the kind of Network Connection the student has declared in the current session, and *locationLearningTrajectory* indicates the URL where the current learning trajectory for the student is [15].

Authoring – Structuring and Organizing Content

The Authoring module is responsible for structuring and organizing instructional content. In this module the content is organized through concepts, hierarchically in a single structure adapted to each different course. The instructional content is composed of the following educational resources: Concept, Exercise, Example and Complementary Material. To structure this content the author has a pre-authorship guideline as support, which helps the contents organization and the identification of material related to each concept.

After this phase the author uses the authorship tool, where he/she registers all concepts and materials related to each concept. For each concept registered, the author informs description, keywords, pre-requirements, for which courses the concepts will be available and the file associated to the concept. In this phase the author can also specify exercises, examples and complementary material, for each profile.
The author may include videos in the complementary material and the system will create a package with different formats of such video. These formats will be used by adaptive multimedia content delivered. More details about this module are presented at section 4. Figure 2 shows a snapshot of the screen of authoring module for a case study, where concept 2.2.1 will be put available only for two university courses (Computer Science and Engineering).

At the end of the authoring process the structured content will be stored in XML documents that are processed by the module 2 (Storing XML files). Such format is employed to generate different presentations based on the same content, once XML separates structure, content and presentation. For the creation of XML files two DTD (Document Type Definition) have been defined. One DTD filedefined by the author. The other describes the specific content of each concept. The definition of the documents structure is given by these DTD. Such documents will be handled during the process of generation and presentation of the educational material. Based on these DTD it was defined and implemented an algorithm to store the structured content at the authoring phase in XML files. This algorithm creates a XML file for each subject with its respective concepts structure and the features of each concept. For each concept it is generated a specific XML file that includes in its body, tags for concepts, examples, exercises and complementary material.

Storing the contents in XML format allows structuring data in a hierarchy, as there is a unique XML file with the conceptual structure of the subject and many XML files with content as the concepts defined (see figure 3). For example, if the author creates ten concepts in the authoring module, the AdaptWeb will create eleven XML documents, one to store all the structure of concepts that works as an index and one XML file for each one of the ten concepts. All the process of XML file generation is always validate through a parser that scans the documents.

The algorithm employed to generate XML files verifies the consistency of the structured content and generates a synthetic table of occurrences, and the XML files are generated only if there is no inconsistency. Among several aspects, the algorithm verifies if all the files of each concept has been uploaded, as well if the author has select at least one university program. XML validated files that will be sent to the server compose the output of this module. The process to generate the XML files is validated through a parser that scans the documents. The validated XML and content files will be employed as the input for the content adaptation module (3) that will apply filters to the files in order to adapt the content to be presented according to the student model.

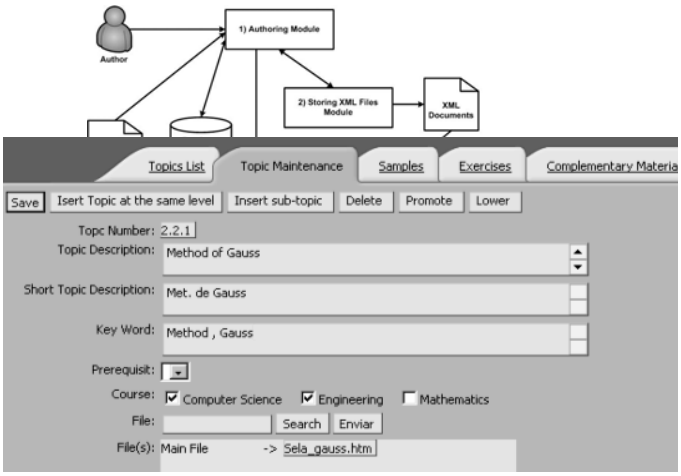

Figure 2. ***Authorship tools and the structured content***

Adaptive Content based on the Student's Model

The adaptive content module takes as input a XML file that is accessible through the API DOM [8], making its content available in the form of a tree, which will be adapted according to the student's model, generating an instance of XML file. The adaptation module can then manipulate this XML, allowing that different conceptual structure be prepared at runtime, according to the university program of that student.

In order to select the educational content to be presented to the student, two filters are applied to XML files of each subject. The first filter, applied to XML file of the conceptual structure, generates a new tree of this document containing only the concepts that make part of the course followed by the student.

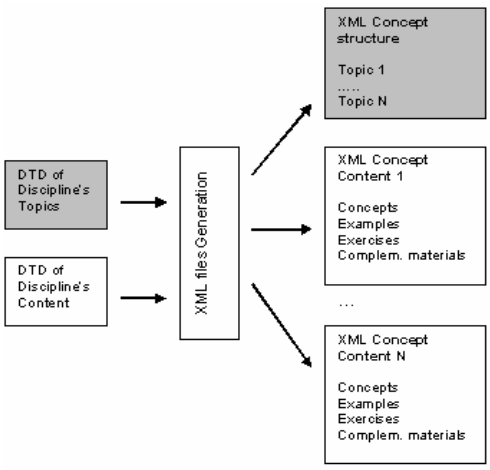

Figure 3. ***Generation of XML files***

During the application of this filter a log file of the student behavior is verified. The log contains information on the navigation through the subjects' concepts that allows retrieving from the XML document which concepts the student has accessed and which is the current concept. The second filter is applied to XML files during the student's navigation through concepts. According to the chosen concept and to the student's course, the filter is applied over the respective XML content file and the presentation is dynamically generated. XML files adapted to the student's model, i.e., the XML with the subject index structure and the XML file corresponding to the concepts the student can access, are output data from the Content Adaptation module based on the Student's Model. These XML files are shared in the memory with the Adaptive navigation module, responsible for the presentation adapted to the links menu the student uses to navigate.

This module also receives information of the Adaptive Multimedia Content Delivery, which detects the network bandwidth at presentation time and chooses the suitable video format to delivery.

Adaptive Navigation Module

Adaptive navigation module presents all kinds of educational resources, the concepts, examples, exercises and extra material for each concept and it is responsible for the adaptation of the student's navigation in the environment. This adaptation occurs in the links that are available for the user, according to his/her model. The actual content depends also on the Adaptive Media Delivery module.

Each time the student acquires new knowledge, a function that updates the log file is activated, and it registers the new concept studied updating the user's model. The student's background is used to adapt the concepts menu, with associated exercises, examples and complementary material. A given educational material may have different examples or exercises for different university courses. For that end, the Adaptive navigation module checks the XML conceptual structure related to that university course.

The navigation history provides information to the Adaptive navigation module about the requirements defined in the Authorship module. If the user studied the concept of pre-requirement, then the concept that depends on it can be enabled. A concept can assume three categories:

- "Studied", it means that the student has already accessed the concept;
- "Under study", it refers to the concept that is being accessed, also named current;
- "Available, but not studied", the concept was not studied yet, but is enabled once the requirements of such concept were studied.
- "Not available, the concept is not available as its pre-requirements were not studied yet. According to the navigation mode selected by the student, the adaptive navigation module can work in two ways:
- In the tutorial mode, pre-requirement criteria among concepts determine the available concepts according to the student's model that contains the register of concepts studied: at each new access of the same student, colors of the menu links are restored. Concepts whose pre-requirements were studied are enabled and concepts studied, not studied and the current concept is displayed in different colors.
- In the free mode, the student can study any concept visible in the navigation menu.

Colors employed follow the usability rules presented by Nielsen [19]. For the implementation of the navigational adaptability, methods of global orientation, direct guidance, and links disabling and links annotation [9, 10, and 23] were used. XML documents are accessed in order to dynamically generate the navigation menu links.

ADAPTIVE MULTIMEDIA CONTENT DELIVERY MODULE

The adaptive Media Delivery Module works automatically for choosing the suitable format video of multimedia content for presentation [13]. It contains the Streaming Module that manages the production and transmission of video. In authoring module the video production generates different versions of video suitable for different bandwidths as is shown in figure 4. For example, a complementary didactic material for a same concept of a discipline could be created in text, audio, and two different videos. The difference between these two films could be the resolution quality, where one could be transmit at a rate of 56Kbps and the other at a 256Kbps one.

The player (Adaptplayer) is able to evaluate the conditions of bandwidth of network at the moment of beginning the presentation transmission. Then, there is a mechanism for choosing the adequate content media compatible with the available bandwidth. This mechanism can be automatic or semi-automatic by user intervention and his profile.

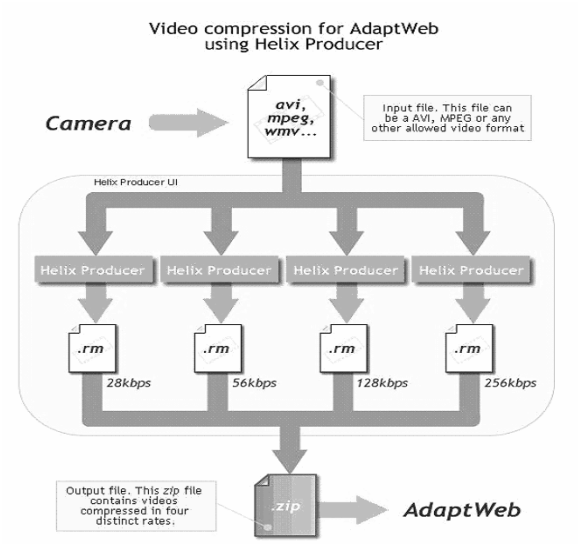

Figure 4. ***Generation of a single zip file with different videos***

In order to produce videos in different compressed rates, it was developed an application based on the Helix DNA Producer developed in Java and integrated to AdaptWeb. With this application, the author transforms a video file in stream, compresses in Zip format, which will contain the different formats of the original videos with their respective compress rate. The input file can be generated by a digital camera and the formats allowed are AVI or MPEG, while the compressed video files will be in the RealMedia format [21].

The files generated will have unique names and control information to AdaptWeb (see Figure 5). The Helix DNA Producer, depending on the available bandwidth, generates video files appropriated for different rate transmissions, including 28kbps, 56kbps, 128kbps and 256kbps. This generation process is illustrated by figure 4 where the interface of producer is presented. Figure 6 illustrates the AdaptWeb producer interface used for author in authorship module.

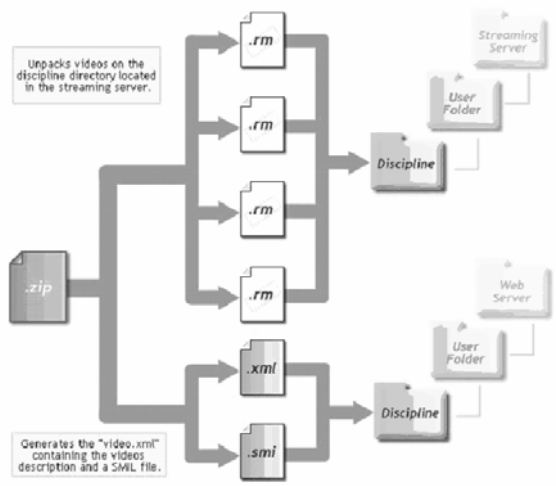

Figure 5. ***Storage of Compressed Video***

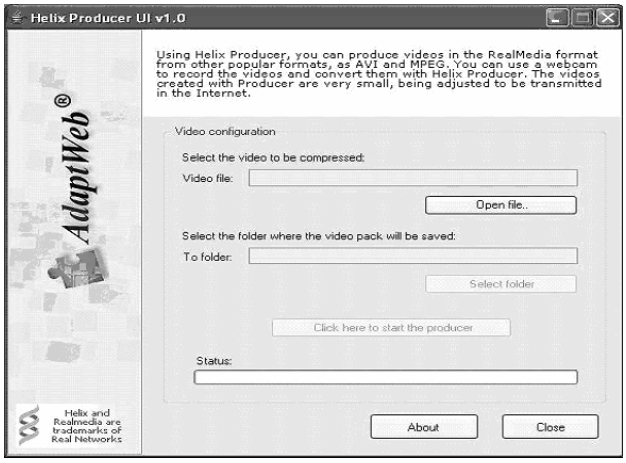

Figure 6. ***Producer interface***

For each generated compressed video the system can trigger the storage mechanism in server. This storage mechanism prepares the environment to generating a SMIL [25] (Synchronized Multimedia Integration Language) presentation able to present in flexible way with streaming video control.

Independently of established pre-requirements among the topics of discipline defined by a professor, the video access could be authorized or not take accounting not only the related pre-requirements but also the student desires in exploiting the didactic materials as free way navigation.
Before initialize the presentation, the player (AdaptPlayer) executes an algorithm to evaluate the network bandwidth, based on a JavaScript procedure that downloads a pre-determined quantity of bits and measures the time to complete the process. Then, according to the bandwidth available at the execution time the Player on-the-fly decides the best version of video possible and sends it to the student. In a second moment, the player loads the execution controls, plug-ins RealPlayer [21] in this project, and executes the presentation. The execution controls provide actions as such “pause”, “forward”, and “reward” without recalculating the available network bandwidth.

The use of videos, as part of didactic content, in the education environment provides more details to the courses, motivating the interactivity between student and didactic material. As the same connection could presents different realities of bandwidth to the long day, the adaptive presentation is mandatory. The pre-defined transmission rates were chosen according to the current net connections most common at home and business, but can be changed if needed. Once the net traffic varies during the day, the adaptation performed on-the-fly avoids troubles to the students, since the multimedia content can be viewed at an appropriate rate according to the network bandwidth detected without slowing or freezing the course.

CONCLUDING REMARKS

This paper focuses on the adaptive aspect concerning the choice of different media to compose an adaptive presentation of a didactic material. This choice is a necessity when is mandatory to substitute a complete video for other, a small one, for the reason that the available net bandwidth is not enough for download the bigger version. Also, is important to remember here, another reason for this choice could be the user's preference, as in the case where the student may prefer to watch an explanation in a small superposed window. This possibility of choices makes AdaptWeb an adaptive educational environment very competitive in different situations such as distinct textual and multimedia content, different time duration of presentation, and so on. The pre-authorship systematic and the authorship tool allow the author to organize the different media content in a way that it adapts to the student, with-out wasting time and effort.

The environment changing the navigation provides adaptability of the educational content based on the student's model and net bandwidth conditions at the moment of presentation. User's followed formation; the course in which he/she takes part makes possible the system to makes available only the suitable content to the course, speeding up the student's learning. The navigational preferences, tutorial or free, allows the student to navigate according to his/her preference, following the steps the author determined or navigating freely, stepping up some topics already known. Analyzing the user's navigational history, the environment indicates where the student stopped and the point where from he can continue.

The extended adaptability provided by AdaptWeb prevents the user to be disoriented; once the objectives, preferences and knowledge were identified, AdaptWeb offers support to navigation, limiting the navigation space and suggesting links. Thus, we have an environment where content presented to the student is according to his/her objectives and preferences, thus providing a more efficient learning, without forgetting the net bandwidth conditions.

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