ADAPTIVE HYPERMEDIA FOR eLEARNING: AN IMPLEMENTATION FRAMEWORK

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ABSTRACT

eLearning can be defined as an approach to teaching and learning that utilises Internet technologies to communicate and collaborate in an educational context. This includes technology that supplements traditional classroom training with web-based components and learning environments where the educational process is experienced online. The use of hypertext as an educational tool has a very rich history. The advent of the internet and one of its major application, the world wide web (WWW), has given a tremendous boost to the theory and practice of hypermedia systems for educational purposes. However, the web suffers from an inability to satisfy the heterogeneous needs of a large number of users. For example, web-based courses present the same static learning material to students with widely differing knowledge of the subject. Adaptive hypermedia techniques can be used to improve the adaptability of eLearning. In this paper we report an approach to the design a unified implementation framework suitable for web-based eLearning that accommodates the three main dimensions of hypermedia adaptation: content, navigation, and presentation. The framework externalises the adaptation strategies using XML notation. The separation of the adaptation strategies from the source code of the eLearning software enables a system using the framework to quickly implement a variety of adaptation strategies. This work is a part of our more general ongoing work on the design of a framework for adaptive content delivery. Parts of the framework discussed in this paper have been implemented in a commercial eLearning engine.

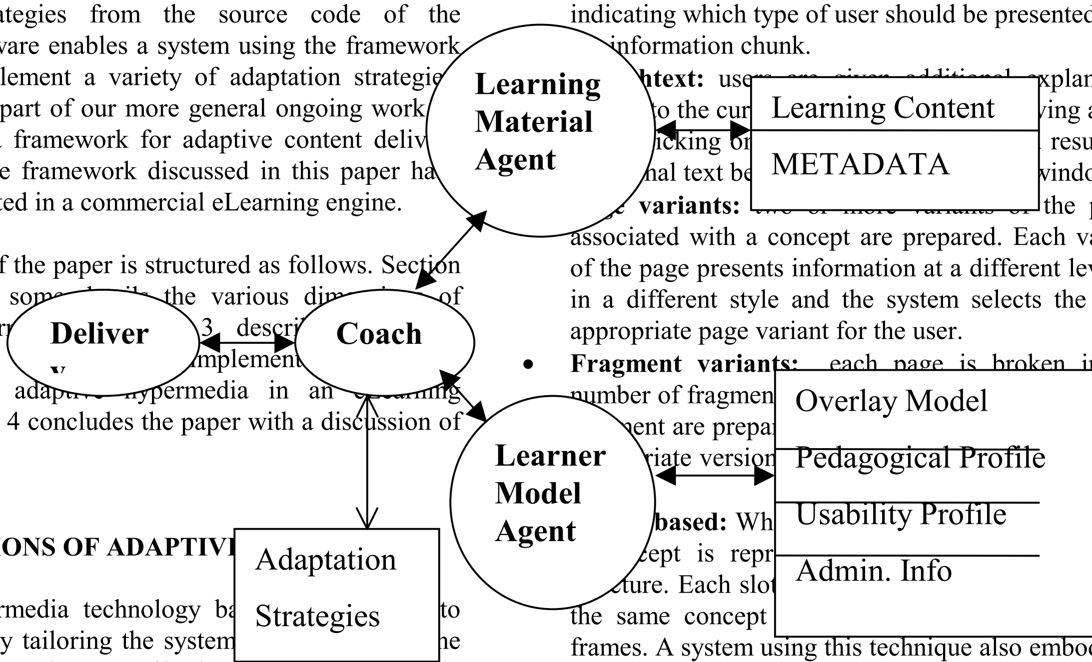
1. INTRODUCTION

In today's world, new modes of technology enabled learning promises to transform the experience of the classroom in a number of fundamental ways: by augmenting traditional textbook materials with online resources and content portals; by enhancing customary 'talk and chalk' lectures through the use of rich multimedia and interactive content; and by extending student discussions beyond the walls of the classroom via a wide range of new communication platforms supporting both asynchronous as well as synchronous collaboration.

The world wide web is playing an ever increasing role in the above revolution. However, presenting study materials on the WWW by itself does not result in a learning system. In fact, most of the 'eLearning' systems found today on the web are nothing but HTML versions of the erstwhile 'page turner' CBTs. In order for learning systems to cater to the educational needs of a large and heterogeneous number of users (the key attributes of any web-based system), they have to adapt their operation to the varying requirements of the learners. Techniques developed for adaptive hypermedia systems may be used to address the problem of lack of adaptability in web-based systems in general [1], and eLearning systems in particular.

Hypertext and hypermedia are core concepts of the way we read, write, and access information in the electronic age. Adaptive hypermedia belongs to the class of user-adaptive software systems [1]. A distinctive feature of an adaptive system is an explicit user model that that represents user knowledge, goals, interests, and other features that enables the system to distinguish between different users. The user model is used to provide an adaptation effect, i.e., tailor interaction to different users in the same context.

In this paper we report an approach to the design a unified implementation framework suitable for web-based eLearning that accommodates the three main dimensions of hypermedia adaptation: content, navigation, and presentation. The framework externalises the adaptation strategies using XML notation. The separation of the



adaptation strategies from the source code of the eLearning software enables a system using the framework to quickly implement a variety of adaptation strategie[illegible] This work is a part of our more general ongoing work [illegible] the design of a framework for adaptive content deliv[illegible] [2]. Parts of the framework discussed in this paper ha[illegible] been implemented in a commercial eLearning engine.

The rest of the paper is structured as follows. Section 2 discusses in so[illegible] the various di[illegible] of adaptive hyper[illegible] 3 descri[illegible] approach may [illegible] implement[illegible] dimensions of ada[illegible] hypermedia in an [illegible] system. Section 4 concludes the paper with a discussion of future work.

2. DIMENSIONS OF ADAPTIV[illegible]

Adaptive hypermedia technology ba[illegible] to support users by tailoring the system[illegible] he delivery of information. An effective adaptive hypermedia system will be capable of filtering out details that are outside a user's current field of interest or beyond their level of comprehension. In effect, adaptation controls the size of the hyperspace available to a user at a particular point in time. Control of information within a hypermedia system offers the prospects of addressing both the *lost in hyperspace* and the *information overload* problems.

Adaptation is a powerful way of augmenting the functionality of a hypermedia system. There are three main components of a hypermedia system that can be adapted: (i) adaptive content selection, (ii) adaptive navigation support, and (iii) adaptive presentation of the content. Adaptation of hypermedia links mainly affects navigation within a hypermedia system whereas adaptation of the nodes themselves affects the content and presentation of information.. These adaptation techniques are presented briefly below following [3].

2.1. Adaptive Content Selection

Content adaptation aims to adapt the information being presented to the user with a view to hiding details not of current interest. Techniques used to accomplish content adaptation are *conditional tex*t, *stretchtex*t, *page variant*s, *fragment variants* and *frame-based* representations.

- **Conditional text:** a concept is divided into chunks of text; each chunk of text is associated with a condition indicating which type of user should be presented with [illegible] information chunk.
- **[illegible]htext:** use[illegible] xplanation [illegible] o the cur[illegible] ing a new [illegible] icking on [illegible] results in [illegible] nal text be[illegible] window.
- **[illegible] variants:** [illegible] the pages associated with a concept are prepared. Each variant of the page presents information at a different level or in a different style and the system selects the most appropriate page variant for the user.
- **Fragment variants:** each page is broken into a number of fragmen[illegible] each [illegible] ent are prepa[illegible] most [illegible] riate version [illegible] the [illegible]
- **[illegible]based:** Wh[illegible] ique [illegible] cept is repr[illegible] rame [illegible] cture. Each slot[illegible] nt of the same concept [illegible] other frames. A system using this technique also embodies a set of rules to calculate the most appropriate slot to be presented to a specific user.

2.2. Adaptive Navigation support

The aim of navigational adaptation is to assist users by manipulating the navigational aids (links, labels, hotwords) within the system suggesting appropriate directions to take relevant link to follow; links can also be activated, de-activated or dynamically added. Techniques to accomplish link manipulation can be grouped into five categories as follows: *Annotation, Ordering or link sorting, Direct guidance, Hiding, and Mapping*.

- **Annotation:** links are enriched with extra comments or visual cues. The use of annotation links aims to provide users with more information about the destination of a link prior to selection. Annotations can take the form of text and icons or can be encoded by colours, different font sizes or typefaces
- **Ordering or link sorting:** sorts or reorders the links on a specific page or topic according to a user model.
- **Direct guidance:** the system indicates to the user the best node to visit next, or the next node.
- **Hiding:** controls access to information by hiding or disabling links to pages, which are irrelevant to the user's requirements.
- **Mapping:** A map allows a user to understand the overall structure of the hyperspace and also to locate themselves within it.

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3.2. Separable Hyperstructures

Our basic mechanism for supporting the various dimensions o adaptive hypermedia is the use of "separable hyperstructures" [8], i.e., links held separately from data and the use of "late binding", i.e., last minute reconciliation of the links to the data. Thus, the "pages" that are sent to the user are virtual documents that are created on the fly based on various elements of the user model.

The structure of a course is maintained separately from the course contents. The course structure is stored in an XML file in the form of a tree (Figure 2). This is the so-called manifest file [7]. Associated with each "item" is a "resource" that constitutes the learning content that is to be delivered for that item. Various traversal orders of the course structure tree results in various navigation sequences. Filtering of the course structure tree generates subsets of the course structure.

The eLearning engine performs these ordering and filtering operations on the course structure tree based on the various parameters of the user model and delivers customised pages to the user's browser. These pages contain only the filtered content and the navigation sequence that is appropriate for the learner.

3.3. Representing Adaptation Logic

In our approach the representation of adaptation logic is based upon three foundational concepts: *learner qualifiers (LQ)*, *content qualifiers (CQ)*, and *strategies*. Learner qualifiers are used to identify learners (a single learner or a group of learners) based on the four types of information stored about learners: (i) pedagogical profile (e.g., learning style, learning approach, etc.), (ii) usability profile (e.g., look and feel preferences of a learner), (iii) administrative information (e.g., units for which the learner is registered, whether the learner is a paying student or a 'free' one, etc.), and (iv) information already known by the learner for a particular subject (e.g., topics already mastered as determined by formative or summative evaluations).

LQ Definition: Senior Inductive Learner

Pedagogical.LearningStyle == Inductive
Profile.Age > 45

Figure 3: Learner Qualifier

Here reference is made of two types of information from the user model (pedagogical and user profile) to define a specific type of learner.

Content qualifiers are used to identify or categorise the kind of content that is to be delivered. They are defined based on the metadata about the learning content that is stored [9]. The use of metadata for adaptive delivery of tailored educational experiences is also proposed by [10].

CQ Definition: Expert Bengali Content in WORD

General.Language == Bengali
Technical.Format == MSWORD
Educational.SemanticDensity == Hi

Figure 4: Content Qualifier

Here reference is made of three of the nine categories of metadata [9] to define a specific type of content.

Strategies are used to represent rules for adaptation and are defined as triples

<learner qualifier scope, content qualifier scope, action>

LQ scope is used to define the LQs on which the adaptation rule is applicable. It may take the following values: (i) [NOT] MATCHING Match_LQ – any LQ whose properties matches (or does not match if NOT is used) the given Match_LQ, (ii) [NOT] ENUMERATED LQ_1 LQ_2 … - any LQ matching (or not matching) the set of given LQs, (iii) ALL – applicable to all the LQs defined in the system, (iv) combination of (i) and (ii).

Similarly, CQ scope is defined based on content qualifiers.

A number of pre-defined actions are provided for implementing various types of adaptive behaviour (the different actions take different action parameters):

- SELECTUPTO – Selects material up to a certain depth of the learning material tree with different depths on the different branches.
- SELECTVARIANT – Selects variant subtrees
- SELECTINORDER – Navigate the nodes of the learning material tree with different orderings
- SERIALISE – Navigate the given list of nodes of the tree in the given order.

The above actions may be used to implement both content adaptation techniques as well as navigation adaptation techniques. For example, the SELECTVARIANT action may be used to implement conditional text as well as page and fragment variants; he SELECTUPTO action may be used implement stretchtext type functionality. The SELECTINODER and SERIALISE actions my be used to implement navigation adaptation techniques such as link ordering, link sorting, direct guidance, and hiding. Some example strategies are given below:

Strategy: Novice Less Expert More

LQ_Scope: ENUMERATED
LQ_List: NOVICE, INTERMEDIATE, EXPERT
CQ_Scope: ENUMERATED
CQ_List: E_Content, I_Content, N_Content
ACTION: SELECTUPTO
Action_Parameters:
LQ_Order: NOVICE, INTERMEDIATE, EXPERT
CQ_Order: N_Content, I_Content, E_Content
LQ_CQ_Association: NOVICE::N_Content
INTERMEDIATE::I_Content
EXPERT::E_Content

Figure 5: Example Strategy

The above rule is used to implement the strategy where an expert learner is provided with the content that is selected for the novice learner while he/she is provided with additional advanced material that is only meaningful to the expert learner.

Strategy: Separate material for Expert and Novice

LQ_Scope: ENUMERATED
LQ_List: NOVICE, EXPERT
CQ_Scope: MATCHING
Match_CQ: Expert_Novice_OR_Node
ACTION: SELECTVARIANT
Action_Parameters:
LQ_CQ_Pairs: NOVICE::N_Content
EXPERT::E_Content

Figure 6: Example Strategy

The above rule is used to implement the strategy where novice learners and expert learners are provided with different types of learning materials without any common content.

3.4. Tool Support

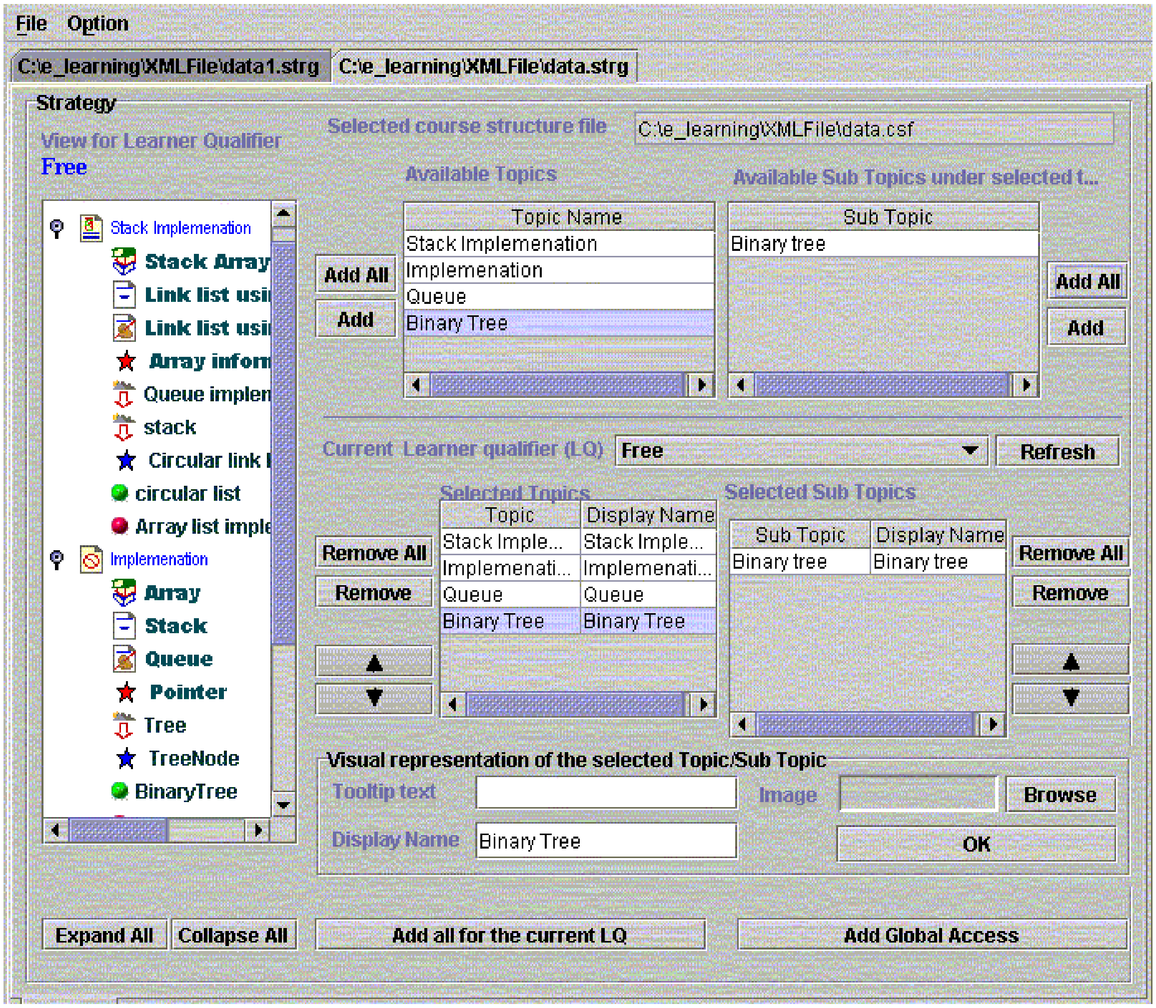
In order to enable users to easily define strategies and experiment with them it is essential that proper tool support be provided. It is mentioned in [11] that "providing adaptive authoring support for adaptive hypermedia will have a strong impact on the authors' motivation and efficiency in performing their tasks and consequently will increase the popularity of adaptive hypermedia." As a part of our work we have developed a GUI based tool (implemented with Java Swing) that may be used to define strategies (currently only parts of the strategy may be generated by this tool). A screen shot from the tool is given in figure 7.

The figure shows how the tool permits a user to define adaptive filtering. Here, for a particular Learner Qualifier (e.g., "Free" shown above representing a categorisation based on the administrative dimension) you indicate which elements of the course structure will be visible and which elements will not be visible. When a learner logs in to the eLearning system, he or she will only see those parts of the course structure that has been defined for the LQ that was assigned to the learner. The screen above also shows how the tool permits a user to define adaptive ordering. Here, for a particular LQ you define the order in which the various elements of the course structure will be displayed. When a learner logs in to the eLearning system, he or she will see the course contents in the order that has been defined for the LQ that was assigned to the learner. Also shown are support for adaptive presentation (customisation of look and feel) through the use of "tool tips", display names (that may be different from the topic name), and images.

4. CONCLUSION

The design of our framework has been done so as to support multiple dimensions of adaptive hypermedia. For all the dimensions, the basic mechanism is to dynamically determine a subtree of the course material tree and deliver it to the learner. The determination of what to deliver is based upon matching the characteristics of the learner against the learner qualifier defined in the strategy and matching the online content being delivered against the content qualifier defined in the strategy. The differences in the treatment of the dimensions are mainly reflected in the in the source of information being used to define the qualifiers. For the pedagogical dimension, the LQ is defined based on the pedagogical profile of the learner while the CQ is defined based on the educational category of the metadata; for the usability dimension the LQ is based on the usability profile while the CQ is based on the technical category.

The framework supports the implementation of the three major types of adaptive hypermedia techniques:



content, navigation, and presentation. The externalization of the delivery strategies in XML notation enables the system to support an infinite variety of delivery strategies. Thus the same content may be delivered using different strategies based on student model or other conditions. This externalisation of delivery strategies allows teachers and administrators to quickly implement their strategies of choice and provide their learners with customised learning experiences.

Our current research in adaptive hypermedia is concerned with investigating the use of XUL [12] and related technologies to support presentation adaptation through the mechanism of skin definitions.. Another area of research is concerned with dynamically generating multimedia content (say Flash files) based on higher level representations of subject matter such as simulations and assessments.

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