Interoperability as an Aid to Authoring: Accessing User Models in Multiple AEH Systems

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Abstract. Adaptive Educational Hypermedia (AEH) is very time consuming and complex to produce. Moreover, with the rapid rate of AEH development, content generated within a given system can become outdated very rapidly. Both of these contribute to the slow uptake of AEH outside of the research community. We consider interoperability between AEH systems to be an important part of the solution to this problem. This paper describes our research into a one-to-one conversion between the AEH systems MOT and WHURLE. Here we focus on the conversion of User Model data, drawing conclusions as to the effectiveness of the conversion and identifying common aspects of the two systems' user models.

1 Introduction

Adaptive Hypermedia (AH) [1,3] personalises content and presentation for each user in order to deliver the appropriate material to each individual, to better help the user achieve their objectives. Adaptive Hypermedia can be considered the solution to the problems of traditional Hypermedia systems such as: static content, "lost in hyper-space" syndrome and the "one-size-fits-all" approach. Adaptive Educational Hyper-media (AEH) [2] seeks to apply the personalised possibilities of AH to the domain of Education, thereby granting each learner a lesson individually tailored to them.

Authoring for AEH systems can be an extremely complex and time consuming task. An author must consider many options, such as: how are the lesson's objectives to be achieved for a heterogeneous group of learners; which traits are to be modelled; given that there exists a heterogeneous group of learners, how many versions of the same material need to be created? And these are just some of the problems that an author faces when they start to develop learning materials for AEH.

Considering these difficulties in not only authoring but also maintaining AEH systems, the idea of providing interoperability between different adaptive systems becomes not only desirable but also necessary, as this will enable re-use of previously created materials without the cost of recreating them from scratch. The aim of our research is to enable this interoperability between AEH systems. This requires interoperability of materials, content, adaptation rules, user models and presentation.

This paper focuses on our work to provide interoperability of materials and user models between two AEH systems (MOT [4] and WHURLE [8]).

2 Scenario and Approach

The idea of interoperability between AEH systems is based on the "many-to-many" [9] paradigm which enables an AH author to create and author content in one system, and transfer the authored material along with the user information into another adaptive system. This will give a user the opportunity to use more than one AH system where their interactions will be recorded and their user models will be updated accordingly in all the AH systems they are involved with, stimulating better personalisation and adaptivity.

It is known from the literature [5,6,7] that interoperability of materials is necessary due to the high cost of authoring adaptive content. Additionally, providing interoperability of user models, so as to enable exchange of user information between different systems, would add more value towards the goal of interoperability.

AEH interoperability could be done either via a *conversion* approach or a *lingua franca* approach [5]. Since the lingua franca approach requires cooperation of AH system providers, who have to subscribe to a common exchange format or XML-type specific format where some element of interoperability is inbuilt, here we focused on the conversion approach, as it requires little or no third-party cooperation.

In our work, we implemented the interoperability of materials and user models between two AEH systems, WHURLE and MOT, via the conversion approach [10]. This conversion process transfers the users and users' information along with the learning material and attached lessons from MOT to a WHURLE-compatible format, and enables, for instance, a teacher to transfer and use the content authored in MOT to create lessons in WHURLE.

Our aim is to use this conversion program to help us extract the common variables to support interoperability between AH systems. The next step in achieving this 'many-to-many' paradigm will be accomplished by implementing interoperability of user models with the aid of a standard user model framework based on Formal Concept Analysis theory, which is hoped will become a standard user model (UM) interface in any application area where information about the users is essential.

3 MOT UM vs. WHURLE UM

Although the MOT and WHURLE user models are from two distinctive systems, they have some properties in common despite being so conceptually different. Both the WHURLE UM and the MOT UM implement a combination of the two techniques that are widely used in AH systems: the *overlay model* [1] and the *stereotype model*, but in different ways. The MOT UM, which is an implementation of the UM layer of the LAOS framework [6], supports overlay variables over the existing Domain Model and/or Goals and Constraints Model maps of MOT as well as allowing the authors to define "free" variables. In the WHURLE UM, the overlay model is modified in order

to measure user's knowledge level with respect to semantic domains. Therefore, instead of the classical measurement of the knowledge through "concept-value" pairs that the MOT UM recommends, the WHURLE UM uses "domain-value" pairs in order to manage multiple knowledge domains concurrently.

The WHURLE UM implements two different sets of stereotypes: *level stereotypes* and *category stereotypes*. Users are assigned to a single class of level stereotypes within any given domain that they study, i.e. "beg", "int" or "adv", according to their own knowledge levels. The MOT UM can assign stereotypes to both domain maps and lessons whereas the WHURLE UM assigns the stereotypes to semantic domains. WHURLE uses category stereotypes to assign users according to their type of study or occupation into different categories as well. Additionally, the MOT UM is flexible in terms of allowing the authors to add extra free or overlay variables to express their needs that are not supported by the system's default ones. WHURLE is rather strict in this manner, not allowing the authors to create or add any variables in the UM.

A summary of all the conceptual similarities and differences in the MOT and WHURLE user models is given in Table 1.

Table 1. High-level comparison of MOT and WHURLE UMs

Features	MOT	WHURLE
Add/Change variables	Yes	No
Overlay Model	Yes	Yes
Stereotypes	Yes	Yes
Overlay Model uses	Multiple levels: Concept-Value, Domain-Value, Attribute-Value	Domain-Value
Stereotype influence	Normally: Lessons (can also be Domain)	Domains

4 The Transfer of User Models from MOT to WHURLE

Since the MOT user model and WHURLE user model are from two distinct AEH systems, there are many differences in the type and format of the data they store. For instance, the MOT UM can store more details about the users such as user's gender, date of birth, address information, whilst WHURLE does not. Nevertheless, there are many variables common to both user models such as username, user id, first name, last name, domain id and stereotype information, even though there are some conceptual differences in the way some of these are used in the two systems. The username, user id, first name, last name and password are the required variables in WHURLE. Since no learner password information is present in the MOT UM, each user is given their username as their password in the beginning as this is the only variable value that is set and only known by the user in the MOT system. The users are allowed to change their passwords later when they log into the WHURLE system.

The second important piece of information that has to be provided in the WHURLE user model is the stereotype information about the concepts in order to

allow the system to provide adaptivity. As mentioned before, the MOT UM classifies the users' knowledge level with respect to involved concepts into classes as "beginner" or "beg", "intermediate" or "int", "advanced" or "adv" and "expert" or "exp". However, while the WHURLE UM uses the stereotypes to classify the user's knowledge with respect to semantic domains into classes as "beg", "int" and "adv", these stereotypes are not dedicated to any particular topic. In other words, stereotypes are assigned to lessons in the MOT UM and to domains in the WHURLE UM.

These differences were resolved in the transfer process by gathering all the domains that a particular lesson is composed of, and assigning the stereotype corresponding to that lesson to all these domains in the WHURLE user model.

5 MOT2WHURLE Conceptual Conversion

The main idea behind the conversion described above is to help in extracting commonalities to assist in building a general conversion. For this reason, we focused our attention in finding both the common and divergent factors in these two systems' user models, in order to identify the 'types' of information that can and cannot be transferred.

The MOT UM utilizes 34 default variables to store information about the users in its database. WHURLE user model employs 26 in total to store data about its users. The two systems have only 8 variables in common, these are detailed in Figure 1.

The divergent MOT specific variables are lost during transfer, and the values for the WHURLE specific variables have to have default values assigned during the conversion process.

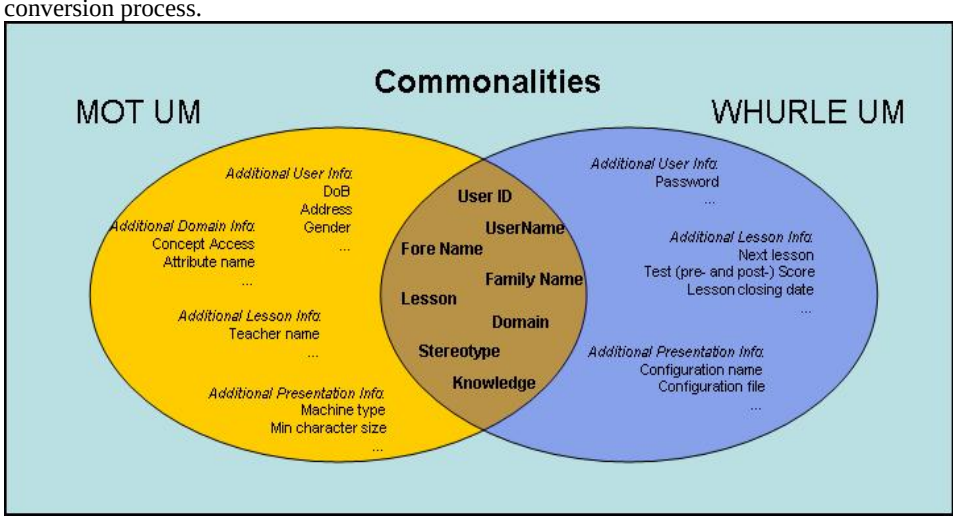

Figure 1. Conceptual Overlap of MOT and WHURLE UMs.

As can be seen from the conceptual overlap diagram (Figure 1), *User ID*, *Lesson*, *Domain*, *Stereotype*, *Knowledge*, *UserName*, *Fore Name* and *Family Name* are

common user details in both systems. The following section shows how even with only 8 common variables it is possible to have a meaningful conversion of UM data.

By identifying the commonalities in these two systems, we further seek to find if the same commonalities apply to other systems, thus help us to describe an interoperable user model that will address more AEH systems.

6 MOT2WHURLE Conversion Program

The MOT2WHURLE conversion program is the software developed in order to transfer the UM data from MOT to WHURLE. The MOT2WHURLE conversion program is a CGI script, *user.cgi*, coded in the Perl programming language.

The conversion starts by connecting to the MOT UM database to get the list of all the users recorded in the MOT system with their user_id and username. The personal details of each user such as first_name, last_name, gender, city, etc are also extracted from the MOT UM database. The common variables of each user are then transferred to the WHURLE UM database, with default values being assigned for the WHURLE specific variables.

As WHURLE assigns each user a list of lessons they can access, once the user model data has been transferred, the MOT lessons must also be transferred using the MOT to WHURLE lesson conversion system [10].

7 Discussion

The research performed so far, i.e. the conversion of materials and user models between two AEH systems, is aimed at extracting common factors for finding a way to accomplish the goal of providing interoperability between AEH systems.

The conversion of AEH core learning materials has been discussed elsewhere [9]. This paper describes the work done to transfer user modelling information from one AEH system to another. It can be seen that for the two sample systems we investigate, many of the UM variables have no equivalent from one system to another. However only a small core set of variables is required for a ‘user’ from MOT to be fully functional in WHURLE. There have been several assumptions made during this conversion process (e.g. that a MOT lesson name can be used to identify associated lesson domains in WHURLE), that need to be more fully considered, especially in light of a more general many-to-many conversion system.

Another conclusion that can be drawn is that not all of the AEH system specific variables can be converted, therefore an approach is needed to retain this data so that it is not lost between conversions. A common data storage framework would be of value here and will be one of the areas of our future research.

The interoperability of user models can be achieved either by a middleware program, like in the case of interoperability of materials, where the middleware will sit between the AEH systems and seamlessly integrate the different user models; or by building a standard user model that can handle all the functionalities of the existing

user models, but in a standard architecture bounded by rules and specifications, so that all the AEH systems can share and exchange user information.

The work done here explained the first steps taken in the direction of extracting the factors required to build this middleware that will allow interoperability of user models in AEH systems. The transfer of user models from one AEH system to another has been implemented.

Our future work will be concentrating on improving the conversions to satisfy the one-to-many and many-to-many paradigms and working on the development of a standard user model framework based on Formal Concept Analyses, which will combine the two ways of solving the interoperability of AEH systems problem into one.

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