A Step towards Commercial Adaptive Hypermedia

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Abstract. As is well known in the Adaptive Hypermedia (AH) community, AH systems (AHS) have a tendency to be academic systems only, mainly used as personalized learning tools. There is, however, a strong desire in AH to extend beyond the world of education and research, and move towards the "real" world, i.e., the *commercial world*. We are here presenting such an expansion, in the form of an extension of an existing commercial authoring tool for WYSIWYG (Web-)content, Content-e, with AH capability. The extended product is called Content-e/LAOS, as it is based on the LAOS framework for authoring of adaptive hypermedia. The paper presents Content-e/LAOS, one of the first commercial AHS, as well as some evaluation results.

1 Introduction

In the current *dot com* world, personalization is highly valued. Indeed, almost all commercial sites display some simulacra of adaptivity to the user, be it only that it requires a login, and thereafter addresses the user by her name. As commerce is highly driven by the market, this is a clear sign that clients expect to be treated as individuals. However, if we look at the depth and variety of adaptivity offered, companies on-line don't score very high. Amazon, the famous online store, provides some group-based adaptive recommendations, in the sense of "customers who bought this also bought". Moreover, users who create accounts and set preferences can experience some adaptable recommendations. A study on privacy issues and disclosure in online commercial sites [8] shows (as a side-effect) that users react positively to adaptation, even if it is faked. This points to a serious need of adaptation in commercial online environments, even if the actual range of the potential adaptation is maybe poorly understood.

Adaptive hypermedia (AH) [1], on the other hand, is already providing a systematic, model-based approach to different levels of personalization. The main application field of AH has been, however, education. Furthermore, AH systems are mainly found in academia, many as beta-systems or proof-of-concept only, very few being in actual use (and if in use, mainly for delivering academic courses).

Clearly, a marriage of adaptive hypermedia and commerce has a lot of potential. In this paper, we present the preliminaries of such a union, in the form of an extension to a commercial authoring system, Content-e, with a module permitting authoring of

adaptive presentation material, based on a previous adaptive hypermedia authoring tool, MOT [6] and a framework for adaptive hypermedia authoring, LAOS [7].
The remainder of the paper is organized as follows. The LAOS framework is presented next. Following, MOT and Content-e/LAOS systems are described. Then, comparative evaluation results of the two systems are shown. Finally, conclusions are drawn.

2 LAOS

LAOS [7],[11] is a generic framework for *authoring of adaptive hypermedia*, which has been used for building the MOT [4] system, for conversion formats and systems between adaptive hypermedia or learning systems (such as AHA! [8], WHURLE [11], and the commercial LMS Blackboard [1]), and lately, for the current Content-e/LAOS extension to Content-e.

LAOS advises the *separation of concerns*, with the goal of reuse, flexibility, expressivity, non-redundancy, cooperation and role-distribution of authoring tasks, interoperability and standardization. Therefore, LAOS prescribes the authoring of five layers, corresponding to basic high-level elements of AH: the *domain model (DM)*, the *goal and constraints model (GM)*, the *user model (UM)*, the *presentation model (PM)* and the *adaptation model (AM)*.

The *DM* further details prescriptions about the content, structure and content metadata, grouping the information in the form of *concept maps*. Concept maps consist of linked *concepts* (*hierarchically*, or otherwise: e.g., via *relatedness relations*) and their *attributes*. The DM can be seen as the book or reference manual on which a (learning/ shopping/ browsing, etc.) experience is based. Attribute names define types of content, whilst attribute content links directly to actual resources.

The *GM* filters elements of this book and brings them closer to the actual presentation. Ordering of elements becomes important, as this represents an initial version of the ordering of the not yet adapted material. Moreover, the GM adds labels and weights (e.g., pedagogical labels, specifying what material is appropriate for beginners or advanced learners; or commercial labels, specifying what material/ reductions/etc. is appropriate for first-time shoppers versus old customers, etc.). The representation form is also via *concept maps*.

The *UM* contains information about the user, to be employed in the personalization: knowledge, background experience, preferences, etc.

The *PM* contains information about the environment of the user, such as device information (handheld versus desktop), quality of service information (bandwidth, traffic), but also can contain variables such as color schemes available, etc.

The *AM* puts all the static models above together dynamically, via *adaptation strategies* (corresponding, in a learning environment, to *pedagogic strategies*; and in a commercial environment to *sale strategies*). If an adaptation strategy doesn't specify a modified, dynamic re-ordering of the concepts (based, e.g., on interactions with the user, on direct user input and requests), the default order in the GM is applied. LAOS

AM is further detailed by the LAG model [8], which is not directly relevant to the current paper and thus skipped.

3 Adaptive Hypermedia Authoring Systems: Academia and Commerce

This section describes two adaptive hypermedia authoring systems: MOT (in short) and Content-e/LAOS.

3.1 MOT

MOT [6] is an Adaptive Hypermedia Authoring Tool that closely follows the principles of the LAOS framework. It has been used, together with the LAOS framework, as the model on which the Content-e system extension was done. Here, only the details of MOT directly relevant to the design, implementation and testing of the resulting Content-e/LAOS hybrid are presented; more information can be found in: [6],[12].

MOT is still a beta-version; currently, only the Domain Model (DM) and Goal and Constraints Model (GM) layers are in use via editable web forms. The other layers have to be authored via other means, and then uploaded in the target delivery system.

In MOT, authors can create and modify DM and GM maps, and reuse (parts of) other maps (created by themselves or other users) as well. Some authoring tasks are automated. E.g., *Relatedness relations* between concepts can be calculated by the system (via keyword matching within text attributes). Also, a DM map can be semi-automatically converted into a GM map, by choosing which type of elements are allowed to be included, and then performing the conversion for whole maps only. If specific elements only of a DM map are needed in a GM map, these have to be selected manually one-by-one. (Re-)ordering concepts in MOT GM maps is done in an interface where the different sub-concepts and attributes of a concept can be allocated numbers, representing their respective order (representing the initial version of the not-yet-adapted material).

Authored DM and GM maps can be saved from MOT as CAF [6] (Common Adaptivity Format) files. Using CAF as an intermediate step, and using the LAG language [8] to edit maps for the other models (UM, GM, AM), MOT has been successfully used to author for both AHA! [9] and WHURLE [13] AH delivery systems.

3.2 Content-e/LAOS

Content-e. is an online authoring tool for structured content, developed by a Dutch company called Turpin Vision [14]. Among its features are concurrent authoring, single source / multiple destination publishing, and a highly modular architecture. This enables it to be extended with new content-types as well as interface with other systems through import and export modules. The central idea of Content-e is that a document is a tree of content objects. Each different kind of content object may have its

its own authoring interface, enabling highly specialized, structured content-objects with their own semantics.

Content-e has been used for authoring e-learning and multimedia environments for many years for clients from academia and beyond (e.g., TU/e, Spectrum Electronic Publishing, Thieme Meulenhoff publishing, Open University Heerlen), for stand-alone and on-line content, as well as CD-ROMs. However, these environments had one thing in common: they were not adaptive.

Content-e/LAOS: Goals. In order to add adaptivity to the Content-e system, we extended it with functionality for AH authoring, according to the LAOS model. The primary goal was therefore to create a LAOS-based authoring tool for adaptation, similar to MOT, which would however be more suitable for a commercial environment, and, very importantly for a company, keep the Content-e 'look and feel'.

The initial, more ambitious goal, to completely implement all LAOS models (DM, GM, AM, PM, UM) within a uniform interface, was later dropped for the time-being, due to two main reasons: firstly, the limitations imposed by the company in the changes to their main system, Content-e (understandably, they wished to see a smaller-scale, running version first and to have it tested, before committing to large-scale modifications), and secondly, the scale of the timeframe involved. Therefore, the decision was taken to simulate the (preferably improved, or at least equivalent) MOT system in Content-e, and to also export CAF files, which than can be converted and delivered in the AHA! (see Figure 1) system. The figure shows the input and output of Content-e/LAOS system being the same as the one of the MOT system: domain maps (DM) and goal and constraints maps (GM) for input; CAF files as outputs. The figure also shows that the adaptive strategy is added via LAG strategies (incorporating the rest of the LAOS framework specifications) edited in text editors. Finally, the static (CAF) and dynamic (LAG) material is converted into a format readable by the delivery engine, in this case, the AHA! system.

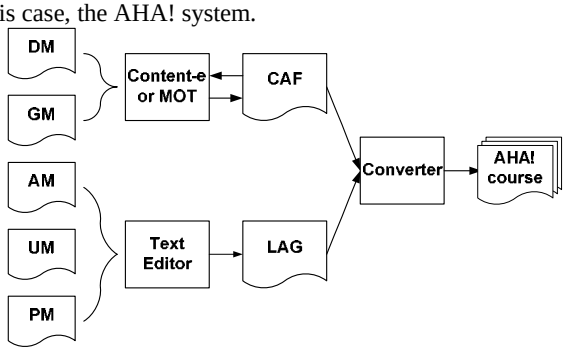

Fig. 1. MOT and Content-e/LAOS: from authoring to delivery and usage.

Next, the primary goal was broken down into three sub-goals.

The *first sub-goal* was to implement a DM (domain model) and GM (goal and constraints model) authoring extension for Content/e (see Figure 1), called Content-e/LAOS, with at least equivalent functionality to MOT, but functioning on commercial software and aiming at commercial use.

The *second sub-goal* was to improve user friendliness for AH authoring in Content-e/LAOS. MOT used to be the only simple generic tool available, but is not always user-friendly (as previous experiments show [5]).

The *third sub-goal* was to improve the Content-e/LAOS functionality, compared to MOT, and more fully support the LAOS model (as advised by previous evaluations and tests of MOT [5]).

Content-e/LAOS: Design and Implementation. The extension of Content-e was implemented by creating two additional modules (one to *import* and one to *generate* CAF format files) and two additional content object types (to represent DM and GM models, respectively).

Since DM maps are usually authored on a concept by concept basis, in Content-e/LAOS each concept was decided to be represented by a separate "concept" content object. Its special purpose interface provides tools to add and remove attributes, enter content into them, as well as create relations to other concepts (Figure 2). DM's are concept trees, and Content-e documents are trees of content objects, so some existing mechanisms in Content-e were re-used to design the builder of DM maps.

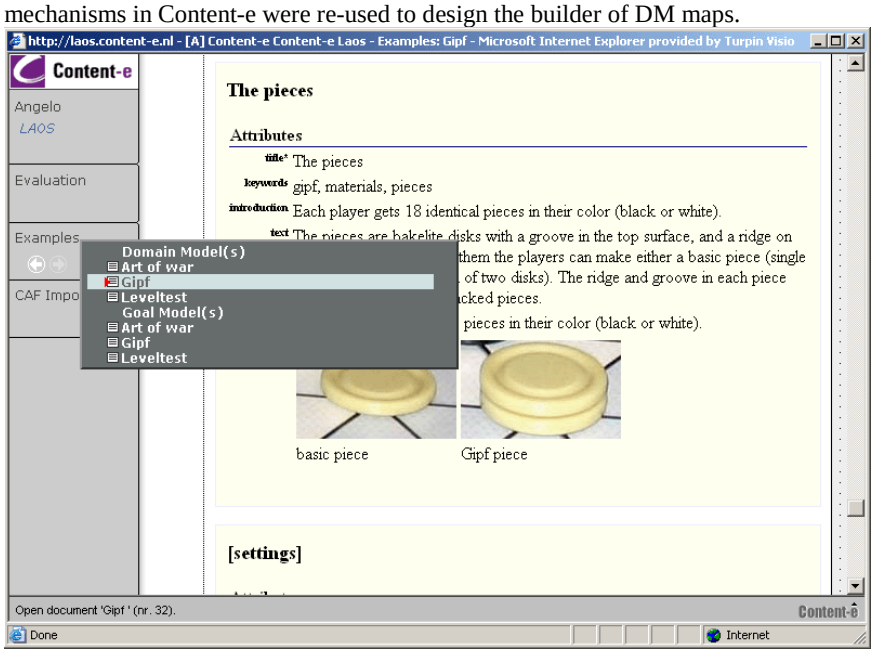

Fig. 2. Content-e/LAOS: DM map authoring.

For GM maps on the other hand, it was considered more desirable and efficient to author the entire model at once (to support, like in MOT, enhanced semi-automatic transformations from DM maps to GM maps). Thus, each GM map is represented by a single "goalmodel" content object. Its specially created interface shows DM and GM maps side by side, as two tree representations (Figure 3). The author can click and drag *parts* from one or more DM trees (right) to the GM tree (left) to build a new GM map, providing more flexibility than the predefined conversions possible in MOT

(where only a whole map could be semi-automatically converted). (Re-)ordering the GM map is done in a similar manner, via clicking and dragging. Labels and weights are set in the same interface. Setting of multiple labels and/or weights at once is possible (unlike in MOT).

The expectation was that with these interface improvements, authoring in Content-e/LAOS would take less time, and become more intuitive than in MOT. Next we set to evaluate this assumption.

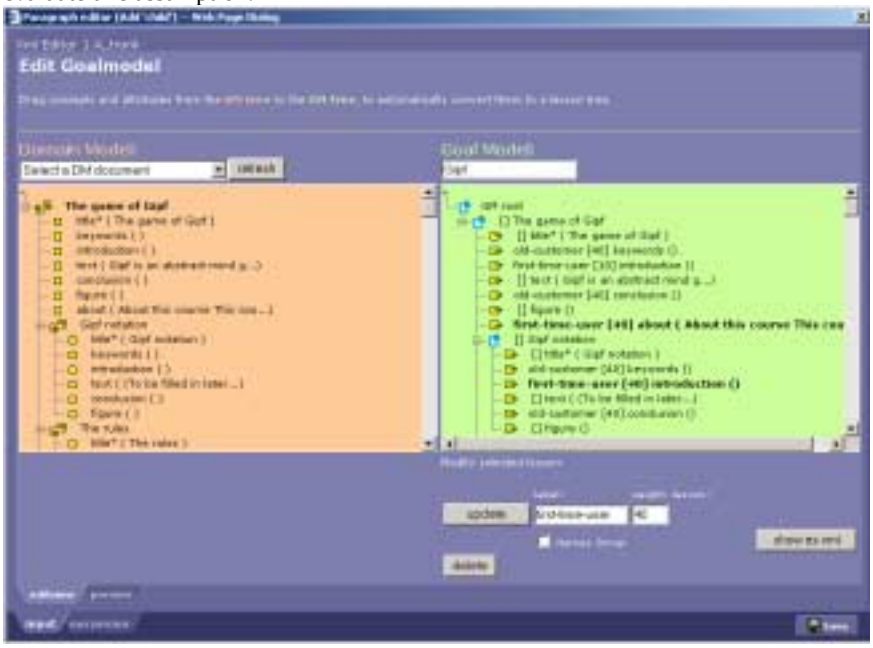

Fig. 3. Content-e/LAOS: GM map authoring.

4 Content-e/LAOS evaluation

Evaluation was performed with the help of an initial group of 63 students, doing an intensive, 2-weeks SOCRATES course on Adaptive Hypermedia at the 'Politehnica' University of Bucharest, Romania, in January 2005 [1] (part of a larger course on Intelligent Systems). The course was divided into 2 parts: 1 week *theory*, and 1 week *project* work.

As the initial number of students was too large to be manageable for the project and evaluation, after the theory week, an exam was given, to decide if a student can continue with the second part. This also allowed us to make sure that students had a basic understanding of the underlying theory. 43 students continued with the project and were divided into 7 large groups, to make sure they had time to do the small tasks. Students who participated in the project were than asked to fill-in some questionnaires to evaluate their experience (these were obligatory, but students were explained that

their marks were based on the theory and praxis exams *only*). To ensure that the questionnaires reflect real experience, students were told in advance that at the end of the second week, a practical exam will follow, based only on their practical knowledge about the systems they used, and the tasks they performed.

The *tasks* [1] they had to perform in the project were to go through some standard operations on DM and GM maps in both MOT and Content-e/LAOS (adding & editing of concept attributes, creating-modifying a GM map, adding labels – according to a given adaptation strategy -, modifying the predefined order of GM concepts, converting to CAF files, uploading and converting into AHA! format) and finally visualizing their adaptive e-product in the AHA! delivery system. By using both authoring systems, MOT and Content-e/LAOS, students were able to form an opinion about the differences in the features, usability and performance of the two systems, and compare them. To eliminate the effect the order of task performing could have, we divided the students equally into students starting with MOT (and continuing with Content-e/LAOS), and students starting with Content-e/LAOS (and then using MOT).

At the end of their project and after the practical exam, students answered three questionnaires: a standard *SUS usability questionnaire* [14] on both MOT and Content-e/LAOS, and a final *specific questionnaire* designed by ourselves, asking questions not covered by SUS, as well as requesting for comments from the students.

The SUS scores were both above 50%, showing that both systems were appreciated as usable. However, SUS scores are more reliable in comparing systems. The SUS score for MOT was a little higher (65,34%) than that of Content-e/LAOS (60,8%), showing thus from a pure systemic, functional point of view a small preference towards the old, academic system.

In order to obtain more precise quantitative results, we also designed a specific questionnaire. From the quantitative results of the specific questionnaire (scale: *0* for answer 'no'; *1* for 'mostly'; *2* for 'yes'), we learned that all students replied, in average, between 'mostly' and 'yes' to questions such as: '*If the system implemented all of LAOS, would it make AH creation easier?*'; or system-specific questions, one for each system, Content-e/LAOS and MOT: "*Was the system easy to use?*"; "*Did you consider the UI sufficient?*"; "*Did you enjoy working with the system?*"; "*Was DM editing in general easy?*"; "*Was adding/modifying sub-concepts easy?*"; "*Was modifying attributes easy?*"; "*Was GM editing in general easy?*"; "*Was conversion from DM easy?*"; "*Was adding/modifying labels easy?*"; "*Was reordering easy?*"; "*Was conversion to CAF easy?*".

As said, students claimed to understand how both systems worked; however, they claimed to understand MOT slightly better. The average response for Content-e/LAOS was of 1,43 with standard deviation (STDV) of 0,49. Students said that authoring in Content-e/LAOS also makes AH creation easier, to some degree (average: 1,36; standard deviation: 0,5; versus 1,54; STDV:0,58 for MOT). Given the fact that Content-e/LAOS has actually more functionality, we have looked elsewhere for the reasons of this outcome. At the question 'Was the system easy to use?' students replied affirmatively for both systems, with an average of 1,20 for Content-e/LAOS (STDV:0,65) and an average of 1,63 for MOT (STDV: 0,48). Therefore, their overall perceived difficulty in using the system extrapolated towards the perceived flexibility in creation of adaptive hypermedia (t>0,5). We therefore next looked at what their

major (numerically expressed) difficulty with the system was. The minimum value is scored by the ease of the CAF conversion (for Content-e/LAOS, average: 1,12; STDV: 0,72). Although the average is still somewhere between 'mostly' and 'yes', it is the lowest among the scores of all questions. Moreover, the standard deviation is high (reflecting probably the successful conversions versus unsuccessful ones). In the meantime it is known that there were some problems with one of the servers in the Netherlands at some hours during Thursday and Friday. This was very close to the practical exam of the Romanian students. Therefore, students who attempted conversions during server-downtime or during partial re-installation of the supporting software (Apache and Tomcat servers, MySQL program, Perl, etc.) experienced problems. Some of them did in fact report problems orally, during the Q&A sessions. These problems might have influenced the rest of the evaluations. Another explanation is a bug that Content-e/LAOS inherited from the original Content-e: when exporting a finished book, the name of this book in the selection box does not contain the path. This is due to the fact that Content-e authors are expected to work in small, controlled environments such as defined by LAN company software. As our students were performing similar tasks on documents with similar names, this became a problem, as more documents with the same name appeared. When selecting which document to export (to CAF), students found it difficult to find their own files. This problem was bypassed and solved during the testing, but students may have remembered an reported on the initial difficulties.

It is interesting to note that students perceived Content-e/LAOS as closer to LAOS than MOT (average 1,22; STDV:0,59; t>0,5). Also, they considered Content-e/LAOS system interface sufficient to a higher degree than that of the MOT system (average: 1,27; STDV: 0,61; t>0,5). Moreover, students perceived adding/modifying labels, as well as adding/modifying weights as easier in Content-e/LAOS (average: 1,84; STDV: 0,51; t>0,5). Indeed, multiple concepts can be selected in Content-e/LAOS at the same time, and labeled and weighted with the same values. This saves time, if one has a number of concepts that the 'first-time-user', e.g., needs to see (see Figure 3).

We compared the responses of the students with their results in the practical exam. Correlation analysis shows that there is little connection between the students' claimed understanding of the Content-e/LAOS system and their generic score on the exam (correlation: 0,15). There is however a small correlation between DM ease of authoring question and the score on the operational part of the exam for Content-e/LAOS (0,246), but less for the GM authoring (0,11). This shows that students' perceived usability and preference has little to do with their own performance on the system.

In the specific questionnaire, we finally asked for a direct comparison of the two systems: *"If I had to choose between Content-e and MOT, I would choose:?"*. The results to this question are displayed in Figure 4. Students expressed a clear preference of LAOS/Content-e (20 students) versus MOT (9 students) for the domain model (DM) authoring, as well as a preference for LAOS/Content-e (18 students) versus MOT (13 students) for the goal and constraints model (GM) authoring. GM authoring has indeed superior features in LAOS/Content-e as compared to MOT, as complete or partial trees can be simply dragged and dropped to form new GMs; moreover, multiple labels and weights can be set at once. So far, the comparison results confirm what we expected. There were also a lot of students with no preference, showing maybe

how close to each other the two systems are. Subtle differences in functionality may have not been discovered by all students. However, the difference between the direct choice question and the SUS scores is surprising. A possible explanation is that an explicitly expressed preference like that in the direct choice question describes the overall experience with the system, whereas in the SUS questionnaires, system usability from a generic functionality-oriented point of view only is evaluated. However, it remained for the qualitative results to confirm or refute this explanation.

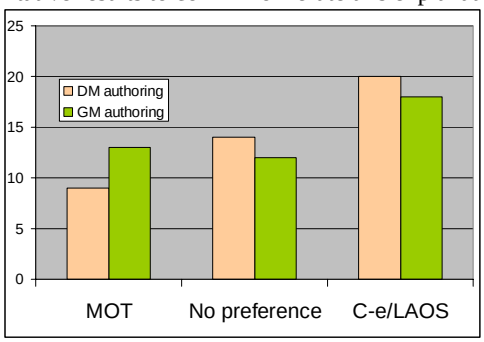

Fig. 4. Students' directly expressed preference.

Comparing this result with the comments, we can say that MOT was viewed as more stable, while Content-e/LAOS was "prettier" (the graphical user interface (UI) was more advanced). The wealth of options in Content-e is mentioned by many, but only rarely as a positive thing. In other words: a more specific (and thus less confusing) tool is appreciated more than a very flexible (yet more complex) one. This shows why MOT was more appreciated from a functional point of view (SUS questionnaires), whereas Content-e/LAOS won the overall impression (specific questionnaire).

5 Discussions and Conclusion

From the point of view of the three sub-goals that we set out to fulfill, the students' answers show that the first sub-goal, of re-implementing the DM and GM with the respective MOT functionality, was achieved.

The second sub-goal, of user-friendliness, seems to be achieved to some degree, based on the specific questionnaire results. However, more research needs to be done to clearly isolate students' opinions. Some of the answers on UI/friendliness-oriented questions have been given with performance/stability in mind (e.g., for "was GM editing easy?" some answered "no, there were many bugs".) Nevertheless, the elimination of such answers would actually increase the user-friendliness evaluation of Content-e/LAOS, confirming the hypothesis.

The third sub-goal, to extend functionality based on LAOS, is partially fulfilled. For example, MOT doesn't fully implement authoring of arbitrary relations. Content-e/LAOS does, and is also capable of importing CAF files, a feature still lacking in MOT. However, this extended functionality was perceived as increasing the complexity of the system. Combined with students' complaints about how their allocated pro-

ject time was too brief, this leads to believe that Content-e/LAOS has a higher learning threshold, but might in the long run be more appreciated for its extra options. It would be very interesting to see how students who had several weeks to work on heavier tasks would see this.

In conclusion, this work represents one of the first attempts to systematically create an authoring environment for personalized learning in a commercial setting, therefore adapting commercial learning environments for adaptivity.

6 Acknowledgements

This work was supported by Turpin Vision; it is a continuation of the EU Minerva ADAPT project and feeds into the PROLEARN Network of Excellence.

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