Social Reference Model for Adaptive Web Learning

Fawaz Ghali and Alexandra I. Cristea

Department of Computer Science, University of Warwick,
Coventry, CV4 7AL, United Kingdom
{F.Ghali, A.I.Cristea}@warwick.ac.uk

Abstract. In this paper, we describe the design steps of extending LAOS, a five-layer framework for generic adaptive web learning authoring, by adding a social layer to capture (and adapt) information from 1) *collaborative authoring* (i.e. editing the content of other learners, describing the content using tags, rating the content, and commenting on the content, etc); and 2) *authoring for collaboration* (i.e., adding authors' activities, such as defining groups of authors, subscribing to other authors, etc). Moreover, the paper presents MOT 2.0, an adaptive E-learning 2.0 system, which is built on the proposed reference model, and finally, we report on our evaluations to validate the new *Social Layer* by comparing MOT 2.0 with its predecessor, MOT 1.0.

Keywords: Social LAOS, Adaptive Web Learning, MOT 2.0.

1 Introduction

Over the past decade, the Web has constantly evolved. Since the early 2000s, many applications rely on the users and their relations more than on the information itself. A large part of the modern web, the *Social Web*, is powered by the users, as its information is produced by them rather than by websites owners.

Conversely, *personalization* has been an important trend for almost 40 years now if we speak of user modelling [17], almost 30 years if we refer to intelligent tutoring systems [18], and almost 20 years since adaptive (educational) hypermedia systems (AEH-S) arrived [2]. From the late 1990s, adaptive A(E)H-S research took a more systematic approach, and a set of reference models have been developed. Still, these models do not include the recent expansion of social activities in their architectures.

In this paper, we briefly discuss previous models and frameworks, to highlight the motivation behind extending LAOS, a five-layer framework for generic adaptive (educational) hypermedia authoring, by adding a new *Social Layer* to capture and adapt information collected from 1) *collaborative authoring* (i.e. editing, describing, rating other users' content, etc); and 2) *authoring for collaboration* (i.e., adding author activities, e.g., defining groups, subscribing to authors, etc). Moreover, we validate the new *Social Layer*, by developing MOT 2.0, an adaptive e-learning 2.0 authoring and learning system for AEH, and we report on our comparative evaluations with MOT 1.0 [6], a previously built A(E)H authoring tool.

2 Models of Adaptive Hypermedia

Many adaptive (educational) hypermedia systems have been launched since the early 1990s; in the late 1990s, structural design for adaptive hypermedia systems started to appear. In this section, we analyse similarities and differences of these models.

1. The Adaptive Hypermedia Application Model (**AHAM**): AHAM [9] is based on the Dexter model [13], a reference model for hypertext systems. AHAM consists of: the *Run-time Layer*, the *Storage Layer* and the *Within-Component Layer*, connected by the interfaces *Presentation Specifications* and *Anchoring*. The Storage Layer has three sub-models: 1) *the Domain Model* that consists of a set of concepts and concept relationships; 2) *the User Model*, containing concepts with attributes storing user preferences; 3) *the Adaptation Model* with adaptation rules that use the attribute values of concepts in the user model in order to determine if and how to present concepts and links from the domain model.
2. The **Munich Reference Model**: [14] is an UML-based visual model similar to AHAM (although independently developed). Just like the AHAM model, the Munich model represents prerequisites in the domain model and bases its domain structure on pages, adding information about how the content will be presented to the final user directly in the domain model.
3. **WebML**[5]: is also a visual language, like UML, but specifically designed for describing the content structure of web applications. WebML has four orthogonal perspectives: 1) *Structural Model*: describes the content in terms of the relevant entities and relationships; 2) *Hypertext Model*: describes how the contents are published on the application hypertext [4]; 3) *Presentation Model*: describes the layout and graphic appearance of pages, independently of the output device and of the rendition language, via an abstract XML syntax; 4) *Personalization Model*: describes users and their organization in groups in the form of entities and defines personalization based on these entities.
4. The XML Adaptive Hypermedia Model (**XAHM**): XAHM [3] is an XML-based model for AH systems, with an *application domain* -, a *user* - and an *adaptation model*. It is composed of a *graph-based layered model* for describing the logical structure of the hypermedia, and *XML-based models* for describing the metadata on basic information fragments and "neutral" pages to be adapted.
5. The Goldsmiths Adaptive Hypermedia Model (**GAHM**) [16]: is a conceptual model with three groups of functions: 1) The *H-region functions* that model non-personalisable hypermedia-based interaction, where hyper-pages are represented as formal specifications; 2) the *P-region functions* that model user-initiated tailoring of hypermedia content; 3) the *A-region functions* that model system-initiated tailoring of hypermedia content.
6. The Generic Adaptivity Model (**GAM**) [10]: is a *state-machine*-based model. At each interaction an event gets generated. This event induces an action that results into a state change in the system, which can be parameterized by external values. A user model can be the source of such values. Compared to AHAM, GAM is a more low-level model and does not provide hypermedia specific concepts.
7. The **LAOS framework** [7]: is a general framework for authoring of A(E)H, based mainly on the AHAM model, presenting however some features of the WebML language, in that it has a presentation model. It consists of: *Domain Model* (DM),

Goal and constraints Model (GM), *User Model* (UM), *Adaptation Model* (AM) and *Presentation Model* (PM). LAOS differs from other modules as follows. LAOS introduced the *GM* model. This layer stores the original aim of the adaptive hypermedia, from the perspective of the designer, or teacher, in learning environments: thus, pedagogic information; or business logics for commercial sites, something that was missing in previous models (see [7]). Furthermore, LAOS's AM model is different from that of AHAM. The adaptation model is based on the LAG model [8], a three layer model for authoring adaptation, which allows different entry and reuse levels for adaptation specification, depending if the author has programming skills or not. Thus, the initial threshold for creating adaptation is lowered. The major difference to AHAM (and other models) is a higher level of reuse, due to the clear separation of *primitive information (content* – in the DM*)* - and *presentation-goal related information* (e.g., pedagogical information in educational systems and prerequisites in the GM). In this way LAOS facilitates a high degree of information reuse, by separating information from its specific context. Another important difference to AHAM is given by the notion of 'concept' used in the domain model. In LAOS, concepts have different representations defined via attributes, and are restricted to represent a *semantic unity* (unlike in AHAM). This is further enforced by allowing only self-contained attributes (without direct or indirect dependencies). Unlike some of the other models, such as XAHM or GAM, LAOS does not prescribe a unique representation for each layer, but just specifies its contents. Thus, each layer could be represented via databases, XML, state machines, etc. Moreover, the adaptation model, LAG, only specifies the different entry levels for reuse (whole strategy, high level adaptation language patterns, or low level adaptation 'assembly' language patterns such as IF-THEN rules) but does not enforce a specific language[1]. For these reasons, we have selected the LAOS framework for further development in our research, as discussed in the following.

3 Social LAOS

None of the previous models, including LAOS, have modelled or included social activities from the Social Web, which focuses on the relations between the users (learners and authors in this paper's context), and their collaborative activities[2]. In addition to information stored in previous models, social annotation can be used to recommend adaptive materials for the delivering/authoring process. The aim behind including collaborative authoring and social annotation in LAOS is to define improved adaptive (educational) materials based on communities of practice [20].

Authors who share the same interests can collaborate to provide more valuable adaptive educational content within their communities, based on their different backgrounds and knowledge. The collaborative facilities in the *Social LAOS framework* rely on Web 2.0 techniques, such as group-based authoring, cooperation in

[1] some implementations exist, i.e., the LAG language [8], or the LAG-XLS language [19].

[2] although the GAHM [16] comes closest to it.

creating the courses, tagging (labelling) the learning content, rating it, and feedback. The collective learning content works as a *state-based system*, as each particular instance of it can be used to improve the authoring process, by recommending *related learning content* to authors, which then can decide on the next state of the collective content based on these recommendations. Additionally, *related authors* (i.e., authors with same interests) can be recommended, who can help in the authoring process.

Furthermore, in the Social LAOS framework, teachers are no longer the only authors of the learning content; students can also be authors, as they too can add their contributions, controlled by a set of privileges set by the teachers. Fig.1 illustrates the addition of a new layer, the *Social Layer* onto LAOS, expressing all social activities within AEH-S. These social activities include, but are not limited to 1) *collaborative authoring* (i.e. editing learning content of other users, describing it using tags, rating, commenting on the content, etc); 2) *authoring for collaboration* (i.e., adding author activities, e.g. defining author groups, subscribing to other authors, etc); 3) *group-based adaptive authoring* via group-based privileges; 4) *social annotation* i.e., tagging, rating, and feedback on the learning content via group-based privileges.

The *Social Layer* is defined vertically, and not horizontally, as it affects all other layers directly. For example, the *Domain Model Layer* will include new entities to describe tags, feedback, comments, rating of the learning concepts, and the relations between these concepts. *The Goal Model* will include new entities to describe the new constrains on the social activities, i.e., determining who can do what. Moreover, the *User Model* will contain new entities to describe the groups and the roles (privileges) on these groups. Additionally, the *Adaptation Layer* will hold new entities to handle the collaborative adaptive strategies. Finally, the *Presentation Layer* will also contain new entities to describe how to present information to group of users. More information about how the social information can be represented in the various layers of LAOS can be found in previous work [12].

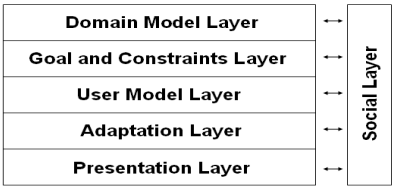

Fig 1. Social LAOS.

4 Implemented Example: MOT 2.0

In the following, we show for exemplification the definitions of the Social Layer for a specific new system developed at the University of Warwick: the MOT 2.0 system, an adaptive e-learning 2.0 authoring and learning system for AEHS, previously described in [11]. MOT 2.0 is loosely based on the MOT 1.0 authoring system for AEHS [6], but it goes beyond it, as it not only incorporates social aspects, but it also, by removing the boundary between authoring and learning, becomes both an authoring as well as a learning system. The screenshots presented below demonstrate different functionality and features of MOT 2.0, as follows.

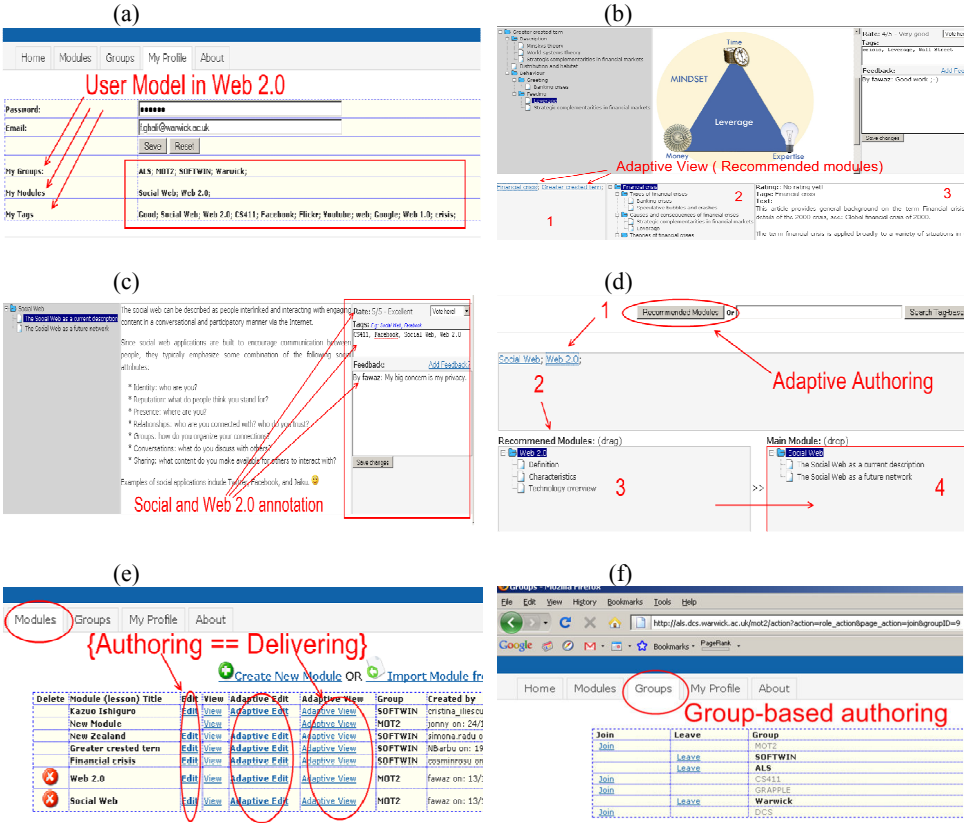

Fig 2. MOT 2.0 Screenshots.

Figure 2 (**a**): the user model captures the results of all actions the users (tutors and learners) made using MOT 2.0, which facilitates creating the user model in the Social Web; these action results contain which groups the user has already subscribed to, what modules the user has created/edited, what tags the user has already used and for which module. In future version, MOT 2.0 will capture more information, such as user's subscribers, user's subscriptions, user's ratings, etc. Figure 2 (**b**) expresses the *adaptive view of the lesson*, which shows other related recommended materials for further reading based on the similarity of the tags (keywords that label the content); in the following implementation round, we plan to apply other adaptive strategies, as the specification of the strategy will be external and exchangeable, according to the LAG model [8]. Figure 2 (**c**) describes the *social annotations* for the actual lesson based on the user's privileges for the selected group/course. These social activities include: rating the content of the item, feedback, and tagging items with a set of keywords. These social activities are captured and added to the user model in order to provide more adaptive features, and thus more flexibility in the adaptation process. In such a way, the recommended content is based not only on the background and trace of the user, as in classical adaptive hypermedia, but also on social activities, e.g., on how popular the item is with other readers, on who recommends it (e.g., trusted users versus unknown users), etc. Figure 2 (**d**) shows how the *adaptive authoring* works, by

displaying other related recommended courses which can be used in creating the course. In future version, the authoring process can use different adaptive strategies as defined by the LAG model. Figure 2 (**e**) is about *merging the authoring and the learning* processes, as the users may still change the content of the course during or after the learning, or they may annotate it during its creation. This explains why adaptive strategies can be applied not only for the learning process, but also for the authoring one. Figure 2 (**f**) shows the *group-based authoring* concept, where users can create groups, and have different privileges on different groups. This setup allows the definition of advanced levels of the relation between tutors and learners based on the latter's user model. In future version, MOT 2.0 will update the privileges automatically and semi-automatically, based on the user model.

5 Evaluations and Discussion

The new *Social Layer* and MOT 2.0 as presented above have been evaluated with the help of 1) a group of eight *course designers* from Softwin, an e-learning company in Bucharest, Romania, in addition to 2) a group of seven *students* studying 'Dynamic Web-based systems', a 4th year module in the department of Computer Science at the University of Warwick, UK. The course designers and the students were separately introduced to the system after they had a few lectures on adaptive hypermedia, user modelling, semantic web and social web. The aim was to find out what added value the instantiation of the *Social Layer* in LAOS could bring to an authoring system. Thus we analysed MOT 1.0, the prior authoring-only environment for adaptive hypermedia engineering that is built based on LAOS, versus MOT 2.0 that is built based on the Social LAOS, which includes the *Social Layer*. For evaluating authoring environments, the ideal is to use course designers, who are experts in e-content-based courses. This group of users was represented by the Softwin group. However, as MOT 2.0 blurs the borders between authoring and learning, it was necessary to get feedback from the other end of the spectrum as well, thus from students, as represented by the Warwick group of students.

The evaluations reported here are based on the comparative analysis of *two stages of experiments*. The first stage involved two experiments, one carried out by the course designers and one by the students, separately, each consisting in participants following five scenarios within the authoring system for adaptive hypermedia MOT 1.0 [6] which is based on the LAOS framework. Similarly, the second stage involved two experiments, also carried out by the course designers and the students respectively, this time using MOT 2.0, which is based on the Social LAOS framework. In the second stage, the course designers and the students were asked to perform some standard authoring tasks as in MOT 1.0, as well as specific new tasks with the MOT 2.0 system, which highlighted the new *Social Layer*. These tasks involved reusing the adaptive lectures that they had created previously, as well as creating material from scratch, and, of course, using the social tools (rating, tagging, feedback, etc.). The two stages were carried out in the same year, separated in time by the period it took to build MOT2.0.

After performing each experiment, participants in all experiments were asked to respond to specially neutralized questions[3] as exemplified by the two questions in Table 1. The bulk of the questions were kept identical in the two stages of the experiments, in order to compare the two systems, representing the initial LAOS framework and the extended Social one. A few extra questions were added in the second stage, in order to extract feedback on some specific issues related to the social aspects. However, here we concentrate only on the identical set of questions and its comparative results. The table also shows the *mean* value of their response on the scale of 1-5 (*(not at all useful) 1 2 3 4 5 (very useful)*), as well as the standard deviation of the results. The scale was kept numerical for further interval processing.

Table 1. Questionnaires statistics. M: Means (1 - 5); SD:Standard Deviation.

Questions: *What do you think about*:	**MOT 1.0 Designers**	**MOT 2.0 Designers**	**Probability** (p <=0.05?) **Designers**	**MOT1.0 Students**	**MOT2.0 Students**	**Probability** (p <=0.05?) **Students**
browsing other author's domain maps / modules?	M: 4.50 SD: 0.76	M: 4.38 SD: 0.74	**p=0.76** *for* **Diff** = 4.38-4.50 =-0.12	M: 3.71 SD: 0.95	M: 4.71 SD: 0.49	**p=0.06** *for* **Diff** = 1.0
keyword-based access for other authors' content?	M: 3.5 SD: 0.93	M: 4.25 SD: 0.71	**p=0.08** *for* **Diff** = 0.75	M: 3.29 SD: 1.5	M: 4.14 SD: 1.21	**p=0.05** *for* **Diff** = 0.85

In order to show a comparative analysis of the results, we have reported the means, standard deviation, and performed *paired T-tests* on the two groups, designers and students, separately, to check whether either group (for MOT 1.0 and for MOT 2.0; or before and after adding the new *Social Layer*) scored *significantly* higher in total.

Analyzing the results, we can say that students showed a significant preference for keyword-based access of other author's content in social MOT 2.0, and an almost significant preference for browsing other author's domain maps and modules. The results for the designers show an (almost significant) increase in preference for keyword-based access, but none in browsing other author's domain maps. Looking for the reasons given in their qualitative feedback, at least two designers mention copyright as a concern in their reply to both questions. As MOT 2.0 allows a higher degree of sharing, the designers' answer to *browsing other author's modules* shows an increase of this concern. Clearly there is a difference in mentality between the Web 2.0 free-for-all concept and company-driven views related to ownership and profit. Such issues need to be solved in the future not only at the relatively small scale of an adaptive social authoring tool, but for Web 2.0 in general, in order to be used in commercial applications. In our system, we plan to solve this in two ways: One is to have a *private*, *group* and *public* label for created content. Private content will thus be only visible to the author, group to the author's group, and public to all. Moreover, we plan on allowing authors to tag their content with the exact copyright restrictions they aim at, so that even publicly available content has copyright information.

Other questions we asked concerned *browsing other author's lessons* (with a slight *Diff=0.1* difference in means for designers, and *Diff=0.66* for students) showing an almost significant (*p=0.08*) preference for MOT 2.0; adding *collaborative authoring*

[3] i.e., questions starting with 'what do you think of …?' instead of 'Do you like ..?' etc.

(i.e., tagging, rating, commenting) (with *Diff=0.5* for designers and *Diff=0.09* for students) showing thus a slight, non-significant preference for MOT 2.0. Here, evaluations on a larger scale can establish if these differences are significant.

When asked about *copying items across the author's own modules; linking to concepts from someone else's domain map(s); creating lessons based on someone else's; adding authoring for collaboration* (i.e. defining groups of authors, subscribing to other authors), preferences for MOT2.0 were shown by authors, but no significance could be established. From the designers' qualitative feedback, issues such as rights, of access, copyrights, etc. were raised and need to be integrated into the system, as explained previously. To some extent surprisingly, students showed identical average preference for both systems for this latter set of questions. A question like the one on authoring for collaboration was only of theoretical nature when asked whilst using MOT 1.0, but referred to implemented and usable functionality in MOT 2.0. So a simple explanation could be that the students' initial expectations were met in MOT 2.0. Moreover, analysing the students' data for these questions for which the average evaluation for MOT 1.0 and MOT 2.0 remained the same, we noticed that all these averages are equal or greater than 4. This means that these questions obtained already a higher mark for MOT 1.0, and there was not enough space left for improvements. To analyse this issue further and understand if students really thought the two systems faired alike for this set of questions, we looked at the qualitative students' comments. Here, when talking about collaboration techniques in MOT 2.0, a student writes "team based creation is very useful & not available in MOT 1.0". This shows a clear preference for MOT2.0, although the mark he gave for both was the same.

Nevertheless, more evaluations are necessary to establish if the social authoring system is an overall better paradigm. Moreover, from a learning perspective, evaluation of the learning outcome also needs to be targeted, to establish the overall performance of the merger between authoring and learning in MOT 2.0.

In the current paper we have focused on the evaluation of the authoring aspect only. As such, the initial results are promising and point to future development needs. The right combination of grouping and permissions need to be achieved. In the words of one of the designers: "It is useful that authors collaborate to create good content. In my opinion a good approach would be creating 'working groups' for developing modules. Every member of a working group should have full access to create, edit, tag, rate, comment, etc each item of the specified module. This way you know that the content is developed by known authors which form a developing team and collaborate to create the content. The team should be decided by a supervisor and should include teachers, developers, testers, etc (all roles involved in content development)."

These are the directions in which the further work on MOT 2.0 will continue, with the added benefit that these social interactions will be possible in the context of adaptation, and this adaptation will be available not only to learners, but also to designers and teachers, supporting them all the way, as exemplified in the initial experiments and in the screenshots shown in Figure 2.

6 Related Work

A significant research has been done in the area of modelling adaptive educational hypermedia systems, as mentioned above in section 2. However, none of the adaptive hypermedia reference models has modelled the social activities, which include collaborative authoring and social annotation.

Nonetheless, previous work has already been established to study the relation between adaptive educational hypermedia and the social web. For example, in [15] they study how to use a user tagging history to build adaptive user profiles; whereas in our approach, we use all users' social actions to update the user model; these actions include editing the content, tagging the content, rating the content and commenting on the content. Moreover, we use users' relations in updating their profiles; these relations include joining/leaving/creating a group, subscribing to other users, etc.

Other work focuses on personal recommendations based on the relatedness between the tags, as in [21]; in our approach, we currently use the same technique; however for future versions, we plan to apply other adaptive learning strategies as described by the LAG language. Furthermore, in [1] user groups are created based on the user tags; whereas in our method, we allow the end users to have full control on creating/joining/leaving the groups based on the user's privileges within the system.

7 Conclusion and Future Work

In this paper, we have presented the theoretical fundaments of combining the Social Web with adaptive educational hypermedia, by bringing together well-known reference models of Adaptive Educational Hypermedia, and comparing their features. In addition, we have defined a new layer in LAOS, the *Social Layer*, which has been exemplified by developing an adaptive e-learning 2.0 engine, MOT 2.0, based on the Social LAOS framework. The new Social Layer and the MOT 2.0 system have been evaluated and validated through a set of experiments, which confirmed, overall, that this merger is of value and interest and the new Social Layer is necessary in modelling of adaptive educational hypermedia systems.

Our main contributions are: 1) adding a new *Social Layer* in LAOS; 2) blending the authoring and learning phases; 3) allowing students to contribute in the authoring phase with different sets of privileges; 3) recognizing between *collaborative authoring* (i.e. editing the content of other users, describing the content using tags, rating the content, commenting on the content, etc); and *authoring for collaboration* (i.e., adding authors activities, such as defining groups of authors, subscribing to other authors, communications between authors, etc).

In the current implementation, for simplifying the experiment, we only based recommendations on similar tags between modules, as the focus was on the *added value of social interactions and grouping*. For future work we shall incorporate generic adaptation strategies into MOT 2.0, e.g., based on LAG [6]. In this way, interactions and adaptive behaviour can be specified independent on the content and/or the learners involved, and reuse of adaptive behaviour becomes possible.

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