E-Infrastructures and Technologies for Lifelong Learning:

Next Generation Environments

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Chapter 4
Social, Personalized Lifelong Learning

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ABSTRACT

This chapter discusses a challenging hot topic in the area of Web 2.0 technologies for Lifelong Learning: how to merge such technologies with research on personalization and adaptive e-learning, in order to provide the best learning experience, customized for a specific learner or group of learners, in the context of communities of learning and authoring. The authors of this chapter discuss the most well-known frameworks and then show how an existing framework for personalized e-learning can be extended, in order to allow the specification of the complex new relationships that social aspects bring to e-learning platforms. This is not just about creating learning content, but also about developing new ways of learning. For instance, adaptation does not refer to an individual only, but also to groups, which can be groups of learners, designers or course authors. Their interests, objectives, capabilities, and backgrounds need to be catered to, as well as their group interaction. Furthermore, the boundaries between authors and learners become less distinct in the Web 2.0 context. This chapter presents the theoretical basis for this framework extension, as well as its implementation and evaluation, and concludes by discussing the results and drawing conclusions and interesting pointers for further research.

INTRODUCTION

Lifelong learning (Aspin & Chapman, 2000) is a key element of our information society (and recently knowledge society) through which the potential exists for those who want to learn (Fischer, 2001). Lifelong learning is not restricted just to formal learning in schools and universities, but also throughout our life, at work and at home, and

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more importantly – for the purpose of the current chapter – on the web.

The term "Web 2.0" is attributed both to DiNucci (1999) and O'Reilly (2005), and became more widely known when it was proposed by O'Reilly during the Web 2.0 conference (O'Reilly, 2005). Currently it broadly refers to a web development stage which harnesses the power of the users, in which (for example) web-based communities and social networking sites, wikis, blogs, mashups and folksonomies, are integral parts. The infrastructure of Web 2.0 (or the "Social Web") arguably also permits new means of lifelong learning, where the learners have not only reading but also writing access (rating, commenting, contributing with items, etc.) to communities, which collaborate in order to achieve specific goals (generally these goals are for the learners to learn and expand their knowledge level). These communities provide not only significant (sometimes also supplementary) learning material but also facilitate information sharing and collaboration between experts and(or) peers (Klamma *et al.*, 2007). The shift towards the Web 2.0 (read/write) concept is changing the way in which content and services are being produced (Tapscott & Williams, 2006), and in lifelong learning this change can be seen as a type of communication in which learners can exchange with their teachers the role of being active and leading the processes of learning and knowledge construction (Roberts, 2005). According to Klamma *et al*. (2007), some of the key factors of Web 2.0 which make it a good opportunity for lifelong learning are as follows.

1. *User generated content.* Web 2.0 is based on the users and the content created by them. Thus, learners can add to the knowledge collection using a constructivist learning approach (Duffy and Jonassen, 1992). A typical Web 2.0 problem is, however, that a lot of content may be produced but quality may be an issue. A constructivist learning approach will only be useful if the construction achieves both understanding and a clear expression of the understanding. This problem can be ameliorated via dynamic, changeable privilege settings, depending on the contribution quality, as we shall show later on.
2. *Various user types and roles.* Users in Web 2.0 can be learners (also referred to in this chapter as students), teachers, authors, administrators, etc. The Web 2.0 context allows for all of these roles to interact with each other, in an ad-hoc, synchronous or asynchronous manner, appropriate for lifelong learning. These roles all contribute to the content and knowledge, in various ways and personalization can be applied to any of these roles, as will be shown later on.
3. *Facilitating collaborative creation, sharing, and commenting on the content*. This moves peer discussion and learning from the synchronous, curriculum-led classroom environments, to the more informal and socially discursive, asynchronous web environments, where learning can take place outside of scheduled times, and thus becomes more amenable for lifelong learning.
4. *Augmenting the content in bottom-up and/or top-down fashion* (Carcillo & Rosati, 2007). In the top-down annotation, the system uses predefined metadata (generally ontologies) to index and tag the created content. In the bottom-up annotation approach, the system allows the users (individually or in groups) to annotate the content with freely chosen tags (keywords). This approach allows for both teacher recommendations (usually top-down), as well as peer and student recommendations (bottom up).
5. *Emerging groups/communities.* This concept identifies a set of individuals who have similar interests, goals, etc. In the context of lifelong learning, where collaborative settings are more frequent than competitive settings, students may recognize that

they can reach their learning goals if (and if working on a common group goal, only if) the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). Whilst there is no guarantee in general that students would recognize this fact, by visualizing the common goal this recognition could be brought forward by the system. Groups also can be adapted to, as will be shown later.

The successor to Web 2.0 is Web 3.0 (Metz, 2007), where the semantic search and browsing are made possible by natural language processing and Semantic Web technologies (Social Semantic Web), and Web 4.0 and beyond (Metz, 2007) are already being discussed. Clearly, these new technologies attract both developers and users alike, and, as lifelong learners are to be found in both categories, lifelong learning providers have to expect a discerning public that expects teaching to use the latest technologies.

Thus, lifelong learning and Web 2.0 complement each other: where lifelong learning is about learning anywhere, anytime, Web 2.0 allows for collaboration during learning, as well as during the creation of the learning content. Additionally, both lifelong learning and Web 2.0 rely on the users (learners) more than the content itself, where the users (learners) determine their own learning pace (in lifelong learning), or create, evaluate (rate) and edit the content (in Web 2.0). E-learning 2.0 thus emerges from the combination of 'regular' e-learning and Web 2.0 technologies, and in the case of lifelong learning this leads to Lifelong Learning 2.0.

However, with the massive amount of (general) information available through Web 2.0, it is becoming harder for learners to learn, or even to find, related communities, peers, and content, and this makes the process of lifelong learning using Web 2.0 less efficient. To overcome this challenge, we perceive adaptive and personalized techniques as the key elements for extending learning activities and making the learning process more effective.

Personalization, customization and adaptation to the user, are terms frequently used in the areas of user modeling (Rich, 1979) and adaptive hypermedia (Brusilovsky, 1996), and refer to showing each user the exact information they need, when they need it, and where they need it.

Adaptivity and personalization can be applied to content, in the sense of delivering appropriate information to the user. More importantly for Web 2.0 applications, unlike adaptation in regular personalized e-learning systems where adaptation is focused on the individual, adaptation can take into account the different interacting users of a system. This means that adaptation can be delivered based on user groups. This can take the form of showing similar content to users with similar interests. Also unlike classical personalization, adaptation can also take the form of bringing users with similar interests together, and allowing them to communicate directly with each other. In educational applications, these users are the learners. Finally, adaptation can also be applied to recommend experts or teachers to learners, or point out to teachers which students are in need of help.

In this chapter, we therefore approach the lifelong learning paradigm from the point of view of *merging research on personalization and adaptive e-learning with Web 2.0 technologies*.

As the whole book is dedicated to lifelong learning, we will not attempt to define this paradigm, leaving this to chapters elsewhere. Instead, we tackle the two other topics – adaptation and Web 2.0 – and finally, using a concrete case study, we illustrate how the merge can be achieved. To better understand the theoretical framework underlying such a merge, we begin by making a comparative analysis of previous models and frameworks for adaptive, personalized systems. This analysis allows us later to explain how a social reference framework for adaptive e-learning can be built, both from a theoretical as well as from a practical point of view. We illustrate this with a sample implementation, and discuss the results based on an evaluation with real users (learners and teachers).

The remainder of this chapter is organized as follows. The following section discusses related research from the areas of Web 2.0 and personalization, and includes a comparative analysis of models and frameworks for adaptive personalized systems. The third section presents a reference framework for social adaptive e-learning, as an illustrative example of the merger of the new technologies and older concepts. The fourth section instantiates this framework based on a prototype implementation, and presents and discusses a sample system. The fifth section presents a case study evaluation of the new paradigm, e-learning 2.0, in which an implemented system is used to support experiments with both students and teachers. The sixth section discusses the findings of the study, and the seventh section addresses future research directions. The final section draws conclusions.

WEB 2.0, PERSONALIZATION AND ADAPTATION

Web 2.0

The individual technologies which collectively make Web 2.0 have for several years attracted the interest of educators, and of these, Blogs (Downes, 2004) and Wikis (Lamb, 2004; Guth, 2007) have high profiles. More recently, the availability of such technologies on mobile devices has contributed to an interest in mobile delivery of Web 2.0 based educational services (Yau & Joy, 2008). Web 2.0 is still a controversial term which encompasses a large number of concepts and technologies, each of which has to some extent been applied in an educational context. Whilst a detailed discussion of all of these is beyond the scope of this chapter, the reader should view our research into personalization as one aspect of educational Web 2.0 which inevitably overlaps with other pedagogic research.

Personalization in Web 2.0 brings together a whole new set of requirements and contexts, and to differentiate it from single-user based personalization, we can call it "Adaptation 2.0". Web 2.0 is principally defined by the content and the users. Each user has a profile (such as preferences and interests), which can be represented by a set of attributes, and similarly the content also has a set of attributes (type, size, etc.). Therefore, Adaptation 2.0 inherits from previous single user personalization approaches matching between the user and content attributes (De Bra, 1999). On the other hand, another important feature of Adaptation 2.0 is that it can be applied to a group of users who share similar profiles, and thus, adaptation is no longer only about the individual, but about the group.

From the point of view of social networks and Web 2.0 applications, their increasing rise in popularity means that ever more users must be accommodated, and for some applications millions of users may need to be supported – for example, Facebook (2009) announced that it reached a user base of 200 million people in May 2009, out of which 70% are outside the US. For such massive applications, introducing personalization and adaptation is a useful way of reducing the overall search space. Of course, introducing personalization always raises issues of privacy (Kobsa, 2007), which are out of the scope of the current chapter, but it is sufficient to note here that a balance between personalization and privacy must be struck, as they both affect each other.

Personalization: Models of Adaptive (Educational) Hypermedia

Past research into personalization for the web belongs to the larger category of adaptive hypermedia research – the web being an instance of hypermedia, where nodes are pages and links are hyperlinks, and personalization is a user-based adaptation. In this section we examine the most important frameworks for personalization on the web, in order to consider the different aspects of adaptation and personalization on the one hand, and on the other to select a platform on which to base social extensions. Many adaptive (educational) hypermedia systems have been launched since the early 1990s; however, until the late 1990s, there was no structural design or standard model for learning adaptive hypermedia systems. One of the first models designed was the Adaptive Hypermedia Application Model (AHAM) (De Bra *et al*., 1999), followed by the Web Modeling Language (WebML) (Ceri *et al.,* 2000), the Goldsmiths Adaptive Hypermedia Model (GAHM) (Ohene-Djan, 2000), the Munich reference model (Koch, 2001), the XML Adaptive Hypermedia Model (XAHM) (Cannataro *et al.,* 2002), the LAOS framework (Cristea & De Mooij, 2003), and the Generic Adaptivity Model (GAM) (De Vrieze, 2004). The goal of each of these models is to record important concepts in current adaptive (educational) hypermedia systems, such as the node/link structure, user model, adaptation patterns and presentation settings. In this section, we analyze the similarities and differences between these models.

The Adaptive Hypermedia Application Model (AHAM)

AHAM (De Bra *et al.,* 1999) is based on the Dexter model (Halasz, 1994), a reference model for hypertext systems. AHAM divides adaptive (educational) hypermedia systems into three layers: the *run-time layer*, the *storage layer* and the *within-component layer*, connected by the interfaces *presentation specifications* and *anchoring*. The focus of AHAM is the storage layer with its three sub-models:

1. *the domain model*, consisting of a set of concepts and concept relationships;
2. *the user model*, containing concepts with attributes, used to store user preferences or other information (such as knowledge-of or interest-in domain model concepts); and
3. *the adaptation model*, which consists of 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.

The main advantages of AHAM are that it is a relatively simple model which allows for separations of concerns. The separation into layers helps to define the main components that need to be created by an author. However, AHAM does not make full use of other potential advantages of the separation into layers: for instance, reusability is not supported. In principle, having separate layers would allow for one domain model to be used in different adaptation or user models. However, this is not possible in AHAM, due to the fact that the adaptation rules apply to concrete domain model concepts, and cannot be re-applied to others. Moreover, reusability would mean that authors could be assigned different roles on each layer, and this would speed up the development process by enabling developers to work in parallel on the different layers – which is not possible in AHAM due to the interdependencies between the layers. An example system based on AHAM is AHA! (De Bra & Ruiter, 2001), proposed by Eindhoven University of Technology.

The Munich Reference Model

The Munich Reference Model (Koch, 2001), developed at the Ludwig-Maximilians University of Munich, also extends the Dexter storage layer with *user* and *adaptation models*, and has a *run-time layer*, a *storage layer* and a *component layer*. It is very similar to AHAM, but its main differences are (Koch, 2001) that it:

1. uses an object-oriented software engineering approach, whereas AHAM uses a database approach;
2. uses the Unified Modeling Language (UML) specification (AHAM uses an adaptation rule language); and
3. includes the AHAM adaptive engine in the adaptation model, as data and functionality are integrated in the object-oriented method. This integration is less useful for an authoring perspective, as it mixes delivery and authoring, not allowing for authoring for different systems, for instance.

The main advantage of the Munich Reference Model is that both (1) and (2) ensure a more widespread approach, in the sense that software engineering and UML are well understood outside the personalization and adaptation communities. On the other hand, the Munich Reference model shares both the other advantages and disadvantages of the AHAM model. For example, 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. This makes reuse of any of the layers almost impossible, as they are heavily interconnected.

WebML

WebML (Ceri *et al.,* 2000) is also a visual language like UML, but is specifically designed for describing the content structure of web applications. The specification of a website in WebML has four orthogonal perspectives.

1. The *structural model* describes the content in terms of the relevant entities and relationships.
2. The *hypertext model* describes how the contents are published on the application hypertext (Ceri *et al*., 2000).
3. The *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. The *personalization model* describes users and their organization in groups in the form of entities called *user* and *group*, and defines personalization based on the data stored in these entities.

The main advantages of WebML as reported by Wright and Dietrich (2008) are platform independence, the inclusion of a CASE tool, and messaging capabilities (allowing the WebML model to access query parameters directly). However WebML lacks browser control, lifecycles, UI modeling, standards and meta-models. From the point of view of this chapter, another advantage of WebML is the only one that allows the concept of group adaptation, in addition to enabling separation of concerns, thus allowing for different authoring roles. However, a disadvantages is the fact that group interaction is not representable (recommendation of one user to another, for instance). Also, the high-level definition of content and structure is closely related both to a given XML DTD[1] syntax, which makes it less flexible, and to low-level, presentation-driven aspects (such as scroll), despite the fact that WebML includes a separate presentation model. An example of a WebML model-based system is WebRatio (Roberto, *et al.,* 2004), which allows modelling and automatic generation of Java web applications.

The XML Adaptive Hypermedia Model (XAHM)

The XML Adaptive Hypermedia Model (XAHM) (Cannataro *et al*., 2002) is an XML-based model for adaptive hypermedia systems with an *application domain*, a *user* and an *adaptation model*. Here however the similarity with previous models ends. XAHM not only describes the different (sub-) models from a theoretical point of view, but it also dictates the composition of the instances of these models, e.g. the fact that presentation descriptions need to be in XML, fixed by a DTD. Moreover, XAHM is highly reliant on mathematical models, graph theory and probability computations. The user model contains, in addition to data on the current profile, probability distribution functions that map a user over a number of profiles. Moreover, adaptation is represented as a function defined on a three-dimensional input-output space: the *user's behaviour*, the *technology* and the *external environment*. Finally, the *application domain* is composed of a *graph-based layered model* for describing the logical structure of the hypermedia and *XML-based models* for describing the metadata for basic information fragments, as well as elementary *abstract concepts* connected via weighted, dynamically computed links for navigation between elements (that transform into probabilities of users actually choosing those paths).

The main advantage of XAHM is that it is the first attempt to create elegant mathematical modelling of the adaptation process; another advantages is that of allowing the adaptation in three dimensions (Cannataro, *et al.,* 2001): the behaviour of the user (i.e., preferences and activity history); the technology dimension (operating system, internet connection, access device, etc.); and the external environment (weather, time-zone, geographical location, etc.), which are not sufficiently treated and separated in previous models. However, the main disadvantage is that it hides adaptation and personalization, partially in the user model (via probability density computations), partially in the application domain model (where weights are probabilistically computed between navigational elements), and finally, in the adaptation model. This distribution of adaptation is hard to follow, and tools based on it can be difficult to handle by teachers, for instance. An example of a tool based on XAHM is the Java Adaptive Hypermedia Suite (JAHS) (Cannataro & Pugliese, 2002)

LAOS

The LAOS framework (Cristea & De Mooij, 2003) is a general framework for authoring adaptive hypermedia, based mainly on the AHAM model, presenting however some of the features of the WebML language with which it shares the presentation model. It consists of a *Domain Model* (DM), a *Goal and Constraints Model* (GM), a *User Model* (UM), an *Adaptation Model* (AM) and a *Presentation Model* (PM). LAOS differs from other models by introducing the goal and constraints model. This layer supports the original aim of adaptive hypermedia from the perspective of the designer (or teacher, in educational environments, hence pedagogic information, or business logics for commercial sites), something that was missing in previous models (Cristea & De Mooij, 2003).

Furthermore, the LAOS AM model is different from that of AHAM. The adaptation model is based on the three layer LAG model (Cristea & Verschoor, 2004) for authoring adaptation, which allows different entry and reuse levels for adaptation specification, depending on whether the author has programming skills or not. Thus, the initial threshold for creating adaptation is lowered.

The major difference between LAOS and AHAM (and other models) is a higher level of reuse, due to the clear separation of *primitive information (content)* and *presentation-goal related information,* such as pedagogical information in educational systems and prerequisites. For instance, since prerequisites are not hard-wired in the domain model, elements of the domain can be used in different settings and sequences to those initially intended. In this way LAOS facilitates a high degree of information reuse by separating information from its specific context. This separation is expressed by having two different models, instead of one: a *domain model* (DM) and a *goal and constraints model* (GM). The separation can be understood easily if we use the following metaphor: DM represents the book(s) on which the presentation (such as a PowerPoint presentation represented by the GM) is built. From one book (or DM) one can construct several presentations (here, GMs), depending on the goal. This goal, in a learning environment, can be a set of learning objectives, which are either implicit, or would need to be expressed separately. A presentation does not contain a whole book, just some (constrained) part of it. Furthermore, a presentation can contain information from several books. The separation therefore gives a high degree of flexibility, based on the DM–GM multi-multi dependency.

Another important difference 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 representing a *semantic unity* (unlike in AHAM). This is further enforced by allowing only self-contained attributes (without direct or indirect dependencies). This setting allows attributes to be flexibly re-ordered, and links are therefore external and can be dynamic.

Unlike some of the other models, such as XAHM or WebML, LAOS does not prescribe a unique representation for each layer, but just specifies its contents. Thus, each layer could be represented by 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. An example authoring system built on LAOS is MOT (Cristea & De Mooij, 2003).

To summarize the main features examined in the previous models and how they compare with LAOS in short, we provide Table 1 with a comparison between these models.

For the reasons above, and due to the fact that it provided most of the desired features, as shown in Table 1, we have selected the LAOS framework for further development in our research.

Table 1. Comparison between models of adaptive (educational) hypermedia

	AHAM	Munich	WebML	XAHM	LAOS
Separation of concerns	Yes	Yes	Yes	Yes	Yes
Reusability	No	No	To some extent	To some extent	Yes
Different user roles	No	No	Yes	No	Yes
Flexibility (different formats, etc.)	Yes	No	No	No	Yes
Pedagogic layer	No	No	No	No	Yes (via Goal and Constraints model)
Group representation	No	No	Yes	No	No
Social interaction	No	No	No	No	No
Approaches	Database /XML	Object-oriented	UML	XML	Database /XML
Target	A(E)HS	A(E)HS	Web App	AHS	A(E)HS

Notes:
A(E)HS: Adaptive (Educational) Hypermedia Systems
AHS: Adaptive Hypermedia Systems
Web App: Web Applications

A SOCIAL REFERENCE FRAMEWORK FOR ADAPTIVE E-LEARNING

The Social Personalized Adaptive Lifelong Learning Scenarios

To illustrate the type of adaptation that can be expected in the new framework, we present five social, personalized, adaptive lifelong learning scenarios using SLAOS (Social LAOS). The first scenario, "Help! I'm lost", explains the situation of a student helping another student. The second scenario, "A group project", represents the case of the system balancing workload between students. The third scenario, "I am done. What now?", explains how the system might recommend reading material or another project for an individual student. In the fourth scenario the system recommends a better group for the current student, and in the fifth it recommends content to an author. These scenarios are by no means intended to be exhaustive, and they can be extended with other typical lifelong learning situations. The scenarios below are used as running examples, to introduce later the Social LAOS framework and its definitions, and are also related to the screenshots presented in the implementation section.

Scenario 1: Help! I'm Lost

Mary is a hairdresser and a part-time student of Economics. She is following lessons on an online system with social support, adaptation and personalization, based on SLAOS. She is stuck on the topic of 'Banking crises' (see a snapshot in Figure 4, left hand menu). The system could recommend her to contact a specific teacher, or some customized reading material (modules or items, such as in Figure 4, where 'Strategic complementarities in financial markets' is recommended for a student reading about 'Speculative bubbles and crashes'). She is however a very social student, and would prefer to chat with another student about her progress, instead of going through the official channels. She 'asks' the system to recommend someone, and the system finds student Jane for her, who has just finished the item related to 'Banking crises'. Mary then contacts Jane, who is willing to move on to a chat tool to give her some direct guidance, and maybe to gain a new friend.

Requirements: the system should allow personalization of material (items in a module) to a learner, and recommendations of 'expert students'[2]

Scenario 2: A Group Project

Students Mary and Jane (a previously full-time mother who is planning to return to work and is upgrading her CV) later participate in a group project 'writing an essay on theories of Financial crises' (thus they need to author a module with topics such as those illustrated in Figure 5). It's a three-person project, so after the two register for it, the system recommends another student, Bob (a company worker aiming at climbing up the management ladder), as a third person, who had registered earlier looking for partners for the same project. The activities associated with the work are: Internet search for 'Marxist theories' (15% of workload), Internet search for 'Minsky's theory' (15%), Internet search for 'Models and Games' (10%), Essay Writing (50%), and Essay Revision (10%). Jane loves writing, so she decides that she will take Essay Writing. Mary then decides that her strength is in browsing, so she takes over all browsing activities. Bob is new in the partnership, so he accepts the remaining revision activity. However, after they log in their initial preferences, the system notices the big discrepancies in their workloads, and thus advises the students to share the load in a more equal manner. Consistent with the initial preferences, the system encourages Bob to take over some part of the writing and searching activities together with the essay revision. Similarly, Jane is advised to keep up to an equivalent workload of 33-34% of writing activity. Finally, Mary is advised to reduce one or more of her browsing activities. Although the system makes some suggestions, it is up to the students to decide on the final workload distribution. In our case, Mary takes only two browsing activities, on topics 'Marxist theories' and 'Models and Games', deciding to do some of the writing (up to the 33% workload) about these topics. Bob takes over the search on the topic 'Minsky's theory', as well as some of the writing on this topic (up to a 33% workload). Jane remains with a slightly higher, but acceptable, workload of 34% in writing only.

Requirements: the system should group work, offer recommendationsof peers (students), workload allocation, individual and group feedback

Scenario 3: I'm Done. What Now?

John, a company worker, is studying a selected subset of modules that have been recommended by his company. He has finished the whole module on 'Financial crisis' (see Figure 5) that Mary was studying earlier. He is wondering what to do next. The system recommends to him related modules to have a look at. In addition to 'Advanced concepts on Economic crises', the course also suggests 'Famous financial crises in history', as well as some other topics. As John is not yet sure about following the higher level module, he reads a little, for his own amusement and interest, about the famous financial crises in history.

Requirements: the system should offer recommendations of similar topics (modules)

Scenario 4: Group Mismatch

Student Mario, another company worker studying from his workplace in a different company, has joined students Sara and Jessica from his own company in the group project on 'writing an essay on theories of financial crises'. However, Sara and Jessica have only just finished the prerequisite study for this group project, whereas Mario has studied much further, and only now has decided to join this group. The system recommends him to join students John and Lisa who are more advanced, and who also wish to do the same project. The system furthermore recommends the trio to attempt a more complex project, about 'Economic crises in general', as this can give them credit towards the easier group project as well.

Requirements: the system should offer recommendations for matching tasks and recommendations of peers (students)

Scenario 5: Has this Been Done Before?

Helen is a teacher of Economics and is authoring some of the material for this course. She has just started creating an item on 'Financial crisis' (see Figure 6). She is wondering whether it has been done before. The system finds for her a publicly available item on the 'Strategic complementarities in financial markets'. Helen decides (by skimming through the information provided by the system) that she will be able to use this in her module, and adds it to her module by linking to it.

Requirements: the system should allow personalization of material for authors

The Properties of a Social Personalized Adaptive Lifelong Learning System

None of the previously visited personalization and adaptation frameworks and models has modelled or included the social activities from the Social Web which focus on the relations between the users on the web and their collaborative activities, as sketched in the scenarios above. In addition to the information stored in previous models, the information collected from social annotation can be used to recommend adaptive materials for the delivery/authoring process. The aim behind including collaborative authoring and social annotation modelling is to create a comprehensive framework that allows for the definition of improved adaptive materials based on communities of practice (Wenger, 1998), where the learners collaborate actively in the form of groups (communities), rather than being passive in the learning process. The benefit of such a framework is that it is system independent, and thus can be applied to any system wishing to integrate adaptation and Web 2.0 technology. It makes sense, however, not to start from scratch, but to add the social model on top of an existing model for adaptation. Thus, based on reasons highlighted in the previous section, we have built our social model on top of the LAOS framework for authoring adaptive hypermedia. This is how the Social LAOS framework (SLAOS) came into existence, and why it has arguably been kept generic enough to be used by any adaptive Web 2.0 system.

In SLAOS (Social LAOS), authors who share the same interests can collaborate to provide more valuable adaptive content within their communities, based on their different backgrounds and knowledge. The collaborative facilities in SLAOS rely on Web 2.0techniques, such as group-based authoring, cooperation in creating the courses, tagging (labelling) the content, and rating and providing feedback on the content. The collective content works as a *state-based system*, as each particular instance of it can be used to improve the authoring process by recommending *related content* to authors, who then can decide on the next state of the collective content based on these recommendations. Additionally, *related authors* (authors with the same interests) can be recommended, who can help in the authoring process. Furthermore, in SLAOS, teachers are no longer the only authors of the content — students are also considered authors, as they too can add their contributions, controlled by a set of privileges set by the teachers. Thus, similar recommendations can be provided for students.

Figure 1 illustrates the smooth transition, in a sliding-scale fashion, between learners (students), teachers, authors and administrators. The *X*-axis represents the various users of a social e-learning system, whilst the *Y*-axis represents the rights these users have in the system.

Figure 1. Smooth transition from student to author and beyond in social e-learning

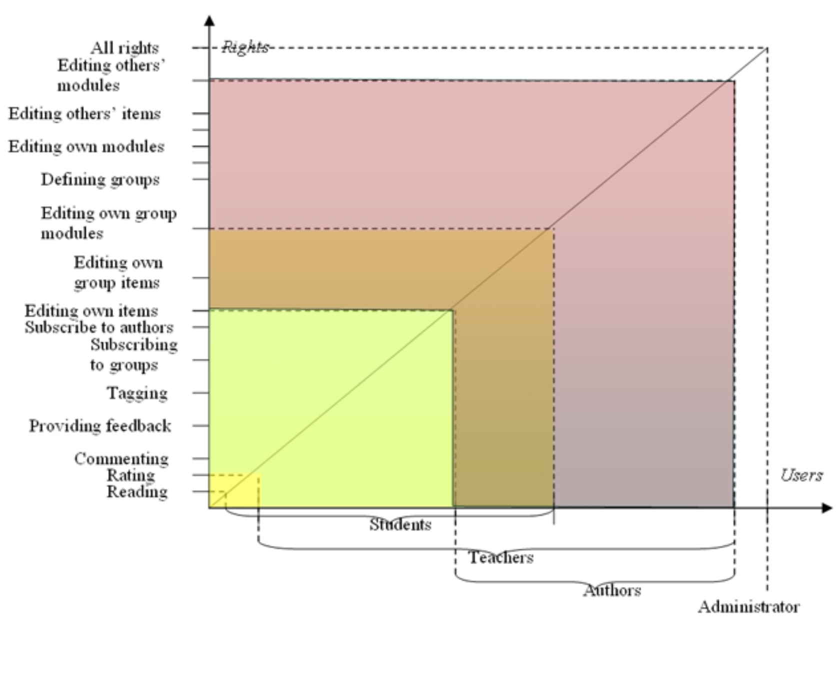


Figure 1 shows that the different categories of users are not represented by a single point in the users-rights space, but that they could be defined anywhere within a segment of the graph. For instance, a *student* could have only reading rights and nothing more, being at the beginning of the segment of students. However, a student could have tagging rights, or even rights of editing their own or group items – thus being placed at the end of the segment. Similarly, a *teacher* could just have rating rights, basically marking students, or could have complex authoring rights, being able to edit their own modules or even modules outside their own group. *Authors*, by definition, should have at least *some* authoring rights, e.g. rights for editing their own items. At the end of the scale, authors could author, in groups or by themselves, any given items or modules. Finally, the role with maximum rights is that of the *administrator*, who can do any of the tasks done by students, teachers and authors, and any other tasks which are present in the system.

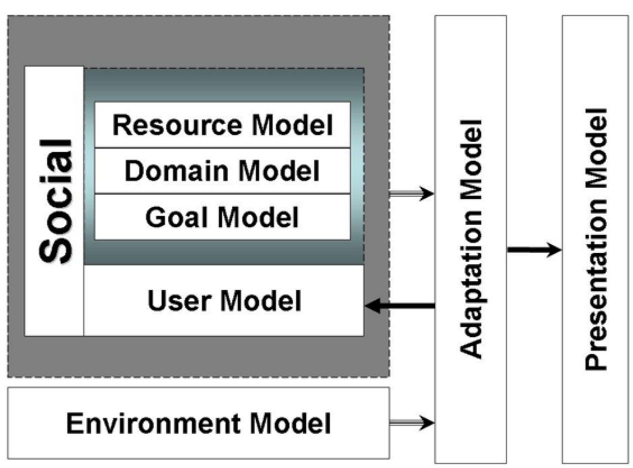
Note that this graph is for orientation only, and it does not represent all possible users or all possible rights. Whilst we attempted to order the rights for the figure, other orders are possible, depending on the system they are applied to. Also note that no monotonic increase is assumed.

Figure 1 already displays an extended idea of rights for student, teacher, and author, where teachers and authors are just students with more rights. However, in the context of lifelong learning, it is important to note that these segments can be extended even further, and that the fuzzy difference between the roles could disappear altogether, leaving only one type of user with a set of rights. The progression to a higher level of rights has to be established outside this figure, depending on the goal of the system. For example, if the goal of the system is to teach writers, and ultimately to allow them all to collaborate in a wiki-like manner, a user could progress from initial reading rights all the way to editing other modules, depending, for example, on peer evaluations, trust, etc.

Figure 2 illustrates the addition of a new layer, the *social layer*, to LAOS, which expresses all social activities within Adaptive Hypermedia Systems. These *social activities* include, but are not limited to:

1. *collaborative authoring* (editing content of other users, describing content using tags, rating, commenting on the content, etc.);

Figure 2. Social LAOS framework



2. *authoring for collaboration* (adding author activities, such as defining groups of authors, subscribing to other authors, etc.);
3. *group-based adaptive authoring* via group-based privileges; and
4. *social annotation* (tagging, rating, and providing feedback on the content via group-based privileges).

The Social Reference Model, SLAOS, follows the multi-layered approach of its predecessors, for similar reasons: extracting the semantically different layers (or models) of a generic system allows for mapping of different system components onto the different layers, and thus for a high degree of reuse of these components, in their interaction with others. For example, a domain model can be reused with different adaptation models. These models represent the normalization axes or principal components of, in our case, a generic social adaptation system.

SLAOS has taken over the composing models from LAOS, but refined and extended them, according to the social collaborative goals.

Beside the social model, the SLAOS framework encompasses two 'new' models[3]: the Resource model and the Environment model.

We have used a resource model, inspired by the Dexter model (Halasz, 1994), to separate resources from their domains, and thus allow for a higher degree of reuse.

Similarly, we have separated the environment model from the presentation model, to more clearly separate external factors from what is shown on the screen. The environment model is subsequently refined into a physical device model, a network model and an external environment model, emulating dimensions from the XAHM model.

The overall structure inherits the conceptual model based structure from LAOS. The figure shows also which models are overlaid, such as the resource, domain, goal, user and environment models, thus concepts from the resource level are used in the domain or goal model to add additional information to them, as will be detailed in the definitions below. Also concepts from the domain model (for instance) can be used by the environment model, if different content can be labelled according to the device it is able to work on, network conditions, etc.

The *social component* acts vertically, and not horizontally, as it affects most of the other layers directly. For example, the *resource model layer* includes new entities to describe tags, feedback, comments, ratings of the actual concepts, and the relations between these concepts. The *domain model* overlays the resource model, and thus inherits and manipulates the social activity descriptors. The *goal model* includes new entities to describe the new constraints on the social activities, i.e. determining who can do what. Moreover, the *user model* contains new entities to describe the groups and the roles (privileges) for these groups, which will be added to the user model. Additionally, the *adaptation layer* holds new entities to handle the collaborative adaptive strategies. The *presentation layer* also contains new entities to describe how to present information to groups of users. The adaptation and presentation models use these elements via data exchange with the package of socially enhanced models.

Figure 2 also shows the interaction between the individual models: the social resource, domain and goal model provide a content-based, metadata-enriched package to the adaptation model, together with a social user model, and an environment model. The adaptation model specifies how the input from these models is processed, and then how it is output into the presentation model (what the learner gets to see) and the update of the user model (how the information known about a user is updated).

SLAOS Components: General Definitions

In the following section, we describe in more formal terms the composition of the SLAOS model, based on, and using similar naming conventions to, the LAOS model (Cristea & De Mooij, 2003). We use the extended set of requirements, including social activities, for the smooth transition from student to author, as reflected in Figure 1 and Figure 2, as well as the five scenarios introduced above. These definitions are useful for building adaptive systems for the social web, especially in the field of education and lifelong learning.

The overall modelling structure follows the conceptual modelling structure.

For reading ease, we use **Bold** for marking sets of sets, *Italics* for marking sets, and no marker for single elements.

Definition 1: The **concept model CM** is the set of all **concept maps** that are used by all possible applications of social personalized adaptive educational systems, **C** is the set of all **concepts**, **A** is the set of all **attributes**, and **L** is the set of all **links**.

In the following, the composing models of the SLAOS framework are formally defined in turn: the *Social Resource Model*, the *Social Domain Model*, the *Social Goal and Constraints Model*, the *Social User Model*, the *Presentation Model* (in general, as well as represented only by one of its sub-layers, the *Physical Device Model*), and the *Adaptation Model*

Social Resource Model

Definition 2: The **item model IM** (also called **social resource model**) is formed by the **set of all items, their relations and their properties** (also called **resource model**; **IM** ⊆ **CM**), containing all content of the social adaptive system (SAS) relevant to the application: the **set of all items IC** ⊆ **C**, the **set of all item links between content items IL** ⊆ **L,** and the **set of all attributes describing items IA** ⊆ **A**.

Example: Any section in a module can be linked to one item, such as "Banking crises" (see Scenario 1 and Figure 4). This item can have a set of features described as attributes. This is expanded in the following definition. Links are currently not in use between items in the example system, but are kept in the definition for conformance purposes with the domain model, and for further developments.

Definition 3: An **item** i ∈ **IC** (or **resource**) is defined by the tuple <id, *T, F, R,* R_{all}> where id is the item identifier which can be used to link to the item's content, *T* ⊆ **IA** is a set of tags related to the item i, *F* ⊆ **IA** is a set of feedback related to the item i, *R* ⊆ **IA** is a set of ratings of item i, given by various users, and R_{all} is the overall rating for the item i.

Example: The "Leverage" item can have a set of tags (keywords) describing the content of this item, such as "crisis", "leverage" or "Wall Street" (see Figure 5). Also this item can have feedback (comments), from the authors and/or from the learners. The comments are generally related to the content of the item. Moreover, this item can have a set of ratings to value its content. The total rating of the item is defined in the following definition.

Definition 4: An **overall rating** for item i, R_{all} is defined as follows: $R_{all} = \sum_{j=1..n} R_{j,i} / n$, where $R_{j,i}$∈ **IA** is an arbitrary rating given by person j for item i, and n is the total number of the ratings for item i.

Example: The content of the "Leverage" item (Figure 5) has a rating value (typed or not typed; types can include relatedness, interest, correctness, etc.). The rating has a range from 1 to 5, and therefore any user (author or learner) can rate this item according to their point of view. If this item was rated by three users with values of 4, 3, 5, then the total rate will be (4+3+5)/3 = 4 out of 5, or "Very good" (see Figure 5). This could then render this item recommendable to Mary (in scenario 1).

Definition 5: An **item type** t ∈ **IA** is a tuple <id, $type_{all}$,*TA*> with id an item identifier, $type_{all}$ an overall type name, and *TA* a set of item type attributes, *TA* ⊆ **IA**.

Example: The item can be an image (so $type_{all}$ = "image"), thus can have attributes such as resolution, width, height, type (JPEG, TIFF). The content of the item type attributes is defined in the following definition.

Definition 6: An **item type attribute** ta ∈ **IA** is a tuple <id, $type_{all}$, type, val> where id is the item identifier, $type_{all}$ the overall type name, type is the name of a particular type attribute, and val is the value (contents) of the item type attribute.

Example**:** An item of an overall type 'image' can have a subset of attributes, such as width (type = width and value = 400px), resolution (type = resolution and value = 300dp), image file extension (type = file extension, and value = JPG), etc.

Social Domain Model

Definition 7: The **social domain model DM** is formed by the **set of all domain maps** (also called **modules**, **DM** ⊆ **CM**), containing all information on the social adaptive system (SAS) relevant to the domain of the application: the **set of all domain concepts** (**anchors**) **DC** ⊆ **C**, the **set of all domain links between domain anchors DL** ⊆ **L,** and the **set of all attributes describing anchors DA** ⊆ **A**.

Example: The collection of all modules is an abstract term, including collections of all modules taught in a social personalized adaptive environment: for example, in a university economics department, these might include "Financial crisis" (Figure 5, also the topic of scenarios 1-5), "The Industrial Revolution: Growth and Living Standards" and "Development Economics (Macroeconomics)".

The composing terms are defined below.

Definition 8: A **module** M ∈ **DM** (also called **domain concept map**) of the social adaptive system (SAS) is determined by the tuple *<DC, DL, DA>*, where *DC* ⊆**DC** is a set of domain concepts (*DC* ≠∅, there should be at least one domain concept – an anchor – in the module), *DL* ⊆**DL** is a set of domain links between the concepts and *DA* ⊆**DA**, where *DA* is a set of optional domain attributes, which describe the module in general.

Example: A lesson on the topic of the financial crisis can be represented as one module, which can have a set of sections (anchors to items) such as "Types of financial crisis" or "Banking crisis" (Figure 5). These sections can be interlinked hierarchically, or in other ways.

Definition 9: A **domain concept** (or **anchor**) dc ∈ **DC** is defined by the tuple < M_{dc}, i_{dc}, DA_{dc}, DL_{dc}> where M_{dc} ∈ **DM** is the module the domain concept belongs to, i_{dc} is an **item identifier**, DA_{dc} ∈ **DA** is a set of optional DM concept attributes; and DL_{dc} ⊆ **DL** is a set of domain links the domain concept is participating in.

Example: A domain concept (or anchor) links to a resource. For instance, it could point to a content item called "World system theory" (see Figure 5). Keeping domain concepts and content items separately ensures that a different domain concept could also point to the same item, thus effectively reusing the material within a different module.

Constraint 1: Each module M ∈ **DM** is required to have a minimal set of concepts DC_{min} (**DC** ⊇ DC_{min}≠∅) which corresponds, via the anchoring system, to a minimum set of items I_{min} (**IC** ⊇ I_{min}≠∅). Here, M is an instance of **DM**.

Example: As the module may represent a lesson, it should not be empty and should contain at least one item.

Definition 10: A **domain link** dl ∈ **DL** is a tuple<*S*, *E*> with *S*, *E* ⊆ **DC** (*S*, *E*≠∅), respectively *start* and *end* sets of domain model concepts.

Example: A simple example of domain links consists of *hierarchical* relations. Items can have hierarchical relations (links) between themselves, such as between "Theories of financial crisis" and "Minsky's theory" (see Figure 5). This relation (link) could be used for adaptation purpose, for instance to show the resources related to the item "Theories of financial crisis" before "Minsky's theory". This would fit a depth-first approach, used, for example, for sequential learners. Different adaptation strategies could, however, use this link in different ways. This can be used for instance in scenario 2 to recommend these items as parts of the same larger group project work.

The following constraint completes the definition of a module, as a linked set of concepts.

Constraint 2: For any concept in a module there is another concept in that module with which this concept has a relation.

Explanation: The expectation is that at least one hierarchical relation exists between the items/concepts, as is usual in educational environments, where chapters are grouped into hierarchically linked sections and sub-sections. Also, 'free', non-linked concepts will not be able to be visited by users when they navigate through the domain maps. Thus it is essential to have at least one type of link linking each concept in the map to at least one other concept.

Definition 11. A **domain attribute** a ∈ **DA** of a domain dc ∈ **DC** is a tuple <M_{dc}, type, val> where M_{dc} is the module the domain attribute belongs to, type is the name of the domain map attribute; and val is the value (contents) of the domain model attribute.

Example: An attribute for the "Financial crisis" module (Figure 5) could be the details on the author of this module. Another attribute could be the description of the domain contents gathered in the module. This type of description can help for instance Helen, the teacher in Scenario 5, to be automatically presented with a list of domain concepts and domains that are related and thus relevant to her authored new course. She can then choose from the list the ones that are most relevant (as in Figure 6).

Definition 12. A **domain concept attribute** a2 ∈ **DA** is a tuple <id_{dc}, type, val> where id_{dc} is an identifier for concept dc, type is the name of the DM attribute; and val is the value (contents) of the DM attribute.

Example: An example attribute for the "Leverage" concept (Figure 4) is the very title, "Leverage". In general, a domain concept attribute helps in making the link between the concepts (anchors) and the resource items, which are previously defined in the Social Resource Model.

Social Goal and Constraints Model

Definition 13: The **social goal and constraints model GM** is formed by the **set of all goal and constraints maps** (**GM ⊆ CM**), containing all information (resources and links between them) about the social adaptive system (SAS) relevant to the overall goal of the application: the **set of all goal model concepts GC ⊆ C**, the **set of all goal model links between goal concepts GL ⊆ L,** and the **set of all attributes describing goal concepts GA ⊆ A**.

Example: The previous lesson (module) of "Financial crisis" can have a set of adaptive modules. Furthermore, each of these adaptive modules (e.g. Figure 4) can have different pedagogic goals (adapt to user knowledge, personalize for preferences, etc.) which can be expressed as a set of constraints (conditions) in order to deliver adaptive course materials. These conditions can be defined as attributes as in the following definition.

Definition 14: A **goal and constraints map** GM ∈ **CM** of the social adaptive system (SAS) is an **enriched module**, which consists of a tuple <*GC*, *GL, GA*>, where *GC* ⊆**GC** represents a set of goal model concepts, *GL* ⊆**GL** is a set of goal model links and *GA* ⊆**GA** is a set of goal model attributes.

Example: To the "Speculative bubbles and crashes" item in the lesson on "Financial crisis" (Figure 4) can additionally be added, via this model, a label attribute, which defines the knowledge level required for this item (e.g. beginner, intermediate, or advanced). Thus, based on this label, the item can be part of different views (different delivery) based on the learner's knowledge level. For instance, in scenario 3, if 'Financial crisis' is all marked as beginner level, then John can be recommended 'Advanced concepts on

Economic crises' and 'Famous financial crises in history', both marked as intermediate.

Definition 15: A **goal and constraints concept** gc ∈ **GC** is defined by the tuple <M_{gc}, i_{gc}, GA_{gc}, GL_{gc}> where M_{gc} ∈ **GM** is the goal map the goal model concept belongs to, i_{gc} is a domain concept identifier, GA_{gc} ∈ **GA** is a set of goal model concept attributes; and GL_{gc} ⊆ **GL** is a set of goal model links the goal model concept is participating in.

Example: The goal and constraints concept of the item "Strategic complementarities in financial markets" (Figure 4) adds to this item a set of personalization and adaptation attributes, such as weight and label (e.g., weight = 70% and label = "beginner"), corresponding to the adaptive strategy.

Definition 16: A **goal and constraints link** gl ∈ **GL** is a tuple <*S*, *E, N*, *W*> with *S*, *E* ⊆ **GC**, (*S, E*≠∅), respectively, *start* and *end* sets of goal model concepts, *N* a set of labels of the link and *W* a set of weights of the link.

Example: The goal and constraints item "Types of financial crises" can be linked to the goal and constraints item "Banking crises" via a prerequisite link (See Figure 5). This now specifies that the item "Types of financial crises" should be shown before "Banking crises", as this is now part of the adaptation description. Unlike the use of the domain link between these items, the goal model link has one interpretation only. The purpose is also different, as goal model links can be of a pedagogic nature, whereas the domain links can only be of a domain-related nature - they are descriptive links, and not procedural links.

Definition 17: A **goal and constraints attribute** ga ∈ **GA** of a goal model gc ∈ **GC** is a tuple <GM_{gc}, *type*, *val*> where GM_{gc}. is the goal map the goal module attribute belongs to, *type* is the name of the goal map attribute; and *val* is the value (contents) of the goal model attribute.

Example: An attribute for the "Financial crisis" module (Figure 4) could be the details its author. Another attribute could be the description of the educational contents gathered in this module, etc.

Definition 18: A **goal and constraints concept attribute** ga2 ∈ **GA** is a tuple <id_{gc}, type, val> where id_{gc} is an **identifier** for concept gc, type is the name of the GM attribute; and val is the value (contents) of the GM attribute.

Example: The goal and constraints item "Banking crises", can have, for example, an attribute of type 'label' with values of 'visual' or 'verbal', which can be used in adapting this item in this case to a visual or to a verbal learning strategy respectively.

Constraint 3: Each goal and constraints item is required to have a **minimal set of (standard) attributes,** GA_{min} (**GA** ⊇ GA_{min}≠∅).

Example: In order to adapt any item, it should have at least one metadata attribute (such as 'visual' as per the previous example) which can be used with the adaptive strategy; without these attributes, the strategy cannot adapt the item.

Constraint 4: Each goal and constraints item *g* must be involved in at least one special link gl, called the **prerequisite link** (link to ancestor item).

Example: See the Example for Definition 16.

Constraint 5: Each goal and constraints concept g must have at least one special, numerical goal and constraints attribute ga, called an **order attribute**. This attribute reflects the order of the concept among siblings with the same prerequisite goal and constraints parent concept.

Example: If "World systems theory" and "Minsky's theory" have the same parent prerequisite, "Theories of financial crises" (see Figure 4), than there must be an order between them, for example, "World systems theory" has order = 1 and "Minsky's theory" has order = 2. This is a weak prerequisite structure, where elements with lower order should be shown before elements with higher order, or could, in principle, appear on the same page.

Social User Model

Definition 19: The **social user model UM** is formed by the set of all **user maps** (**UM** ⊆ **CM**), containing all information (resources and links between them) about the users: the **set of all user concepts UC ⊆ C**, the **set of all links between users UL ⊆ L,** and the **set of all attributes describing users UA ⊆ A**.

Definition 20: A **user map** UM ∈ **UM** of the social adaptive system (SAS) is determined by the tuple <*UC, UL, UA*>, where *UC* ⊆**UC** is a set of user concepts, *UL* ⊆**UL** is a set of links between users and *UA* ⊆**UA** is a set of optional user attributes, which describe the user model in general.

Example: The set of attributes can include knowledge level, interest, display preferences, age, etc. Links within user models could appear if, for example, an attribute such as interest can be related, via a formula, to the knowledge level of the user (this is not currently implemented in the example system).

Definition 21: A **user concept** (or, simply, **generic user**) uc ∈ **UC** is defined by the tuple <UM_{uc}, UA_{uc}, UL_{uc}> where UM_{uc} ∈ **UM** is the module the generic user is supposed to study, UA_{uc} ∈ **UA** is a set of UM concept attributes, and UL_{uc} ⊆ **UL** is a set of user links the user is participating in.

Example: A user of the social adaptive system could be represented by their set of preferences, such as knowledge, interest, etc., and could also be related to other users via various relations, such as friendship or class membership. The generic user (or user model) stores the type of attributes that are used for a given module. E.g., it stores the fact that a user's knowledge and age is important, that the knowledge default value is 0, and that the age default value is 30. Please note that this does *not* represent user Jonny, who has a knowledge of 79 and age of 44, which would be an instance of this generic user.

Definition 22: A **user model link** ul ∈ **UL** is a tuple <*S, E, W, L*> with *S, E* ⊆ **UC** (*S, E*≠∅), respectively, *start* and *end* sets of user model concepts, *W* a set of weights describing the link, and *L* a set of labels describing the link.

Example: User links can be subscriptions to other users, or grouping of users, etc. Adding a subscription link between two generic user models, one containing a user's knowledge and interest, and another one containing a user's knowledge and availability, for instance, means that in the target design system, a specific user belonging to the first user category can be linked to the second. For instance, a user with low knowledge and high interest can subscribe to a user with high knowledge and availability set to true. The thresholds for what represents high and low knowledge, etc., can be set as user model concept attributes, as defined in Definition 24.

Definition 23: A **user model attribute** ua ∈ **UA** of a user model map is a tuple <UM, type, val> where UM. is the user map the user model attribute belongs to, type is the name of the user map attribute, and val is the value (contents) of the user model attribute.

Example: A user map would map all generic user types that can appear in a social adaptive system (learner, teacher, etc.). At this level, attributes could represent the number of teachers or of learners the application overall allows for, or the type of groups allowed.

Definition 24. A **user model concept attribute** ua2 ∈ **UA** is a tuple <id_{uc}, type, val> where id_{uc} is an **identifier** for user uc ∈ **UC**, type is the name of the user model attribute; and val is the value (contents) of the user model concept attribute; val can also take the form <type, val>, to allow for more complex, nested attributes.

Example: In the previous example, each attribute can be represented as having the following default values: knowledge level = beginner, interest = 1, display preference = text and images, age = 40. Note that at this modelling level, only generic users are modelled, not actual users (e.g. any user with knowledge level beginner, but not the user Johnny, who also happens to be a beginner). Instances of these attributes can be used to represent the fact that Sara and Jessica are intermediate learners, but Mario, Lisa and John are advanced, as in Scenario 4.

Definition 25: A **user group** ug ∈ **UL** of a user uc ∈ **UC** is a special kind of user model link, where S = {uc}, W = ∅, **L** = {group-name}, where group-name is the name of the user group, and E = {ui | ui∈**UC**, ui is a user concept in the group labelled group-name}.

For simplification from the implementation point of view, however, the following definition is used.

Definition 26: The **groups of a user** gu ∈ **UA** is a special kind of user model concept attribute, where type = "group" and val a set of groups that the user belongs to.

Example: A learner can join different groups, such as ALS group, Warwick group (see Figure 4), and in each of these groups, the learner can have different roles, as defined next. The definition above also allows for a user to create new groups directly, or have an administrator – or teacher – create the groups for them. Mary, Jane and Bob form a group in Scenario 2, and in Scenario 4, first Sara, Jessica and Mario form a group, which is disbanded based on the recommendation of the system, in order to form the group of John, Lisa and Mario.

Definition 27: A **user role attribute** ur ∈ **UA** is special kind of user model concept attribute, <id_{uc}, "role", type, val> where id_{uc} is an **identifier** for user uc, "role" is the name of the main user model attribute, type is the name of the role attribute, and val is the value (contents) of the role attribute.

Example: The role can be defined as key-value pairs, such as, read = 1, edit = 0, tag = 1, etc. Please note this user model concept attribute uses nested attributes.

Definition 28: A **user subscriber** us ∈ **UL** of a user uc ∈ **UC** is a special kind of user model link, where S = {uc}, W = ∅, L = {subscribers} and E = { ui | ui∈**UC**, ui is a subscriber to uc}.

Example: A learner can subscribe to different users, who share same interests, same topics, etc. This can be used to recommend other related users during adaptation.

Constraint 6: Each user concept is required to have a **minimal set of (standard) attributes,** UA_{min} (**UA** ⊇ UA_{min} ≠ ∅).

Example: Read and write roles should be defined with default values.

Physical Device Model

The Environment Model in Figure 2 can be demonstrated by one of its most important sub-models, the Physical Device Model. The other environment models (network model, external environment model), and even the presentation model (which has the role to decide what, where and how something is being shown to the user) can be defined in similar way.

Definition 29: The **physical device model PDM** is formed by the set of all **physical device maps** (**PDM** ⊆ **CM**), containing all information (resources and links between them) of machine types on which the presentation is performed: the **set of all physical device concepts PDC** ⊆ **C**, the **set of all physical device links PDL** ⊆ **L,** and the **set of all attributes describing machines PDA** ⊆ **A**.

Example: Types of physical device media can be PDA, Desktop Computers, Laptops, etc. There is a need to adapt to the nature of this media, even if the user (learner, author, teacher) is the same, as different screen sizes can affect the information transmitted.

Definition 30: A **physical device concept** pc ∈ **PDC** is defined by the tuple <pm, PA>, where pm is the presentation media, and PA ≠ ∅ is a set of PDM attributes.

Example: A PDA is a physical presentation media device. The attributes are defined below.

Definition 31: A **physical device attribute** pa ∈ **PDA** of a physical device item is a tuple <type, val>, where type is the name of a particular type attribute, and val is the value (contents) of the type attribute.

Example: The type of a physical device attribute can be “resolution”. The PDA resolution is 240×160, and the computer screen resolution is 1280×1024. Please note that when more users are collaborating, the common denominator of the different devices used by the different users is the one that is selected, e.g., the minimum resolution at which all collaborating partners can view the item.

Definition 32: A **user device link** ul ∈ **PDL** is a tuple <id_{uc}, pm> where id_{uc} is an **identifier** for user uc, and pm is the presentation media.

Example: A user, say “Jonny”, can use different devices, say “PDA”, “Desktop”, “Group device”, etc. The latter is used in connection with the last example in definition 33.

Adaptation Model

Definition 33: The **social adaptation model AM** is formed by the set of all **adaptation maps** (**AM** ⊆ **CM**), containing all information (resources and links between them) of the adaptation (dynamic changes) performed in a social adaptive system, based on all other *static* models in the framework (*Social Resource Model*, *Social Domain Model*, *Social Goal and Constraints Model*, *Social User Model*, *Environment Model* - here: *Physical Device Model, Presentation Model)*.

Example: The adaptation model is thus the only dynamic model in the framework, and it uses the other models as ‘ingredients’, to form the overall ‘recipe’ for social adaptivity. This model in itself can have many components. An example is the LAG model (Cristea & Verschoor, 2004), which can be extended towards collaborative adaptation. This is not further pursued in the current chapter, due to lack of space.

Definition 34: An **adaptation map** AM ∈ **AM** (or an **adaptation strategy**) of the social adaptive system (SAS) is a collection of mapping functions f:{i(**IM**)*, i(**DM**)*, i(**GM**), i(**UM**)*, i(**EM**)*, i(**PM**)*} -> {i(**PM**)*, i(**UM**)*}, where i(X) is an instance of X, and **EM** represents the generic environment model (as illustrated by the physical device model, **PDM**, above).

Example: This type of definition is very generic, and allows for the actual implementation to be done either by traditional rule-based systems, or by actual mathematical formulas, or by Bayesian networks, etc. An example is a group-based adaptation support via recommendations techniques, such as *recommended learning content* (which is rated high using Definition 4) based on the learner’s profile (which is represented in Social User Model). This can be implemented with a function based on the content (from the i(IM)) and the rating (from the same model), and a personal threshold for a given student for accepted rating, stored in the i(UM). This will influence which items will be shown: i(PM). This represents content adaptation as in scenario 1 (item or module), scenario 3,5 (module) and Figures 4 (adaptive reading) and 6 (adaptive authoring). Another example is that of *recommended expert learners* based on the learner’s profile, as in the second part of scenario 1, as well as in the recommendationof a group member in scenarios 2 and 4. This maps i(UM) to i(UM), and it actually means adding a temporary link between the current user and the recommended person in the user’s user model.

In the context of MOT 2.0, the learner’s knowledge (experience level) is the main factor in the recommendation process, as it reflects who is expert in the selected domain. We recognize two steps — the recommendation step and the communication step. MOT 2.0 as presented in this chapter focuses on recommendation, but not on the communication between learners (which is left to further research and implementation). Further work on the communication step has already started. Also various recommendations based on cosine similarity between elements have been added.

Presentation Model

The presentation model in Figure 2 has the role to decide what, where and how something is being shown to the user.

Definition 35: The presentation model **PM** is formed by the set of all **presentation maps** (**PM** ⊆ **CM**), containing all information (resources and links between them) of the content, type, place, etc. about the presentation performed: the **set of all presentation concepts PC ⊆ C**, the **set of all presentation links PL ⊆ L,** and the **set of all attributes describing presentation PA ⊆ A**.

Example: Types of presentation can be as simple as deciding if a specific content is to be shown or not, or if the name of a peer student is to be shown or not. Alternatively, it can be complex, such as in deciding how the screen is to be used for the specific presentation, what is to appear where on the screen, etc.

Definition 36: A **presentation concept** p ∈ **PC** is defined defined by the tuple <P_{pc}, i_{pc}, PA_{pc}, PL_{pc}> where P_{gc} ∈ **PM** is the presentation map the presentation concept belongs to, i_{pc} is a overlay concept identifier (item, domain map concept goal model concept, etc., PA_{pc} ∈ **PA** is a set of presentation model concept attributes; and PL_{pc} ⊆ **PL** is a set of presentation model links the presentation model concept is participating in.

Example: An overlay over a goal model concept is for instance the Boolean 'show' set to True for the goal model concept 'Financial crisis' (see Figure 4). This would mean that a student can have reading rights to this concept, such as John in Scenario 3.

Further definitions of link, attribute etc. for this model follow the Social Goal and Constraints model example and are not further detailed here.

IMPLEMENTING ADAPTIVE E-LEARNING 2.0

In the following, we illustrate the definitions of the Social Layer for a specific new system developed at the University of Warwick - the MOT 2.0 system, an adaptive Web 2.0 authoring and delivery system for adaptive hypermedia, first mentioned in (Ghali *et al*., 2008a). MOT 2.0 is loosely based on the MOT 1.0 authoring system for adaptive hypermedia (Cristea & De Mooij, 2003), 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 delivery system.

Figure 3 illustrates the fact that the social user model (as defined in definitions 19-28) captures the results of all actions the users made using MOT 2.0; these action results including which groups the user has already subscribed to, what modules the user has created/edited, and what tags the user has already used and for which module. In a future version, MOT 2.0 will capture more information, such as a user's subscribers, a user's own subscriptions, user's own ratings, etc. Group affiliation as shown in Figure 3 is used in scenario 2, where Mary, Jane and Bob eventually belong to the same group working on a common project, and in scenario 4, where Mario moves between two groups, finally reaching one that is better matched to him.

Figure 4 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). This is also in view, to some extent, of scenario 1, which requires that adaptation of items and modules should be supported, and scenario 3, which requires only recommendation of other modules. The content is based on an overall social goal and constraints model, with a hierarchical structure, directly reflecting, in this simplified version, a similarly social structured domain model and social item model underneath. In the

Figure 3. MOT 2.0: User model 2.0

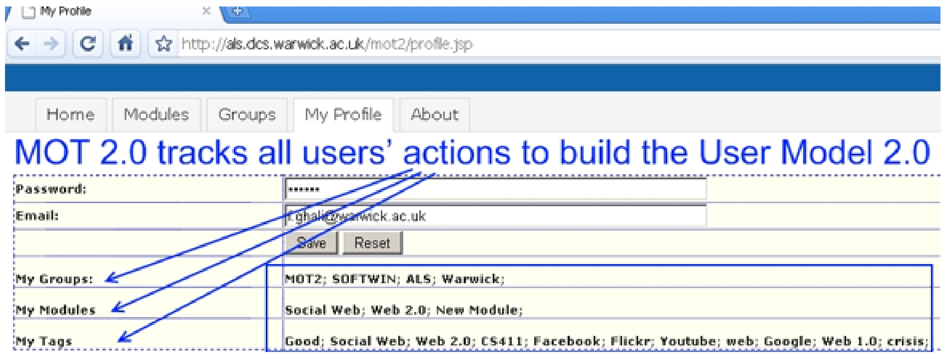
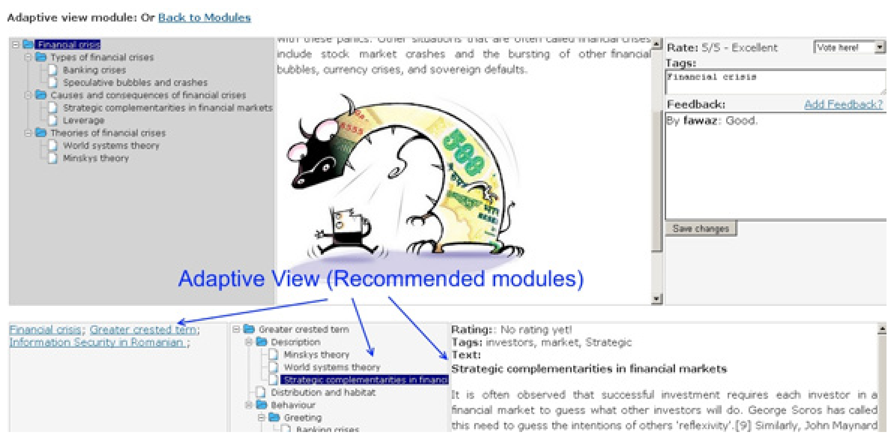


Figure 4. MOT 2.0: Adaptive reading



following implementation round, we plan to both extend the implementation to more fully reflect the flexibility allowed by these content-based layers, as well as apply other adaptive strategies, as the specification of the strategy will be external and exchangeable, according to the LAG model (Cristea & Verschoor, 2004).

Figure 5 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 (such as defined by definition 3). They 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, or on who recommends it (trusted users versus unknown users). This also is used in scenario 1 for recommended content, as well as in scenario 2 on grouping the work for students.

Figure 6 shows how the *adaptive authoring* works, by displaying other related recommended courses which can be used in creating the course. Scenario 5, with Helen putting together a course based on system recommendations, is directly reflected here. Whether or not something is presented or is based on the pedagogical adaptation strategy, which influences the presentation model (e.g., a Boolean value overlaid over an item that is to be shown is commuted to True). In

Figure 5. MOT 2.0: Social and Web 2.0 annotation

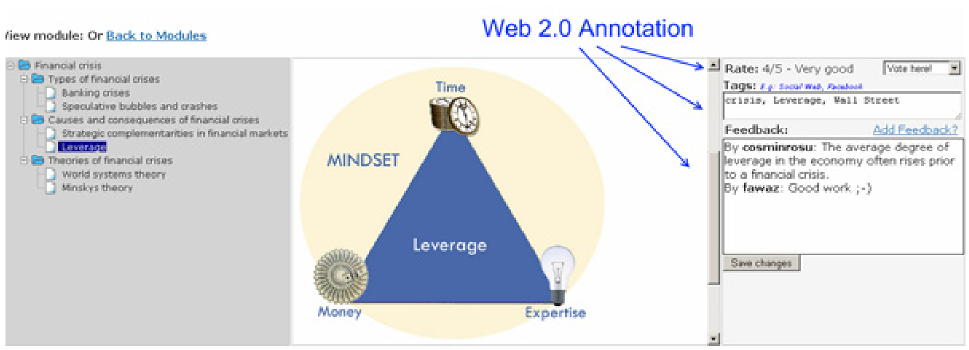
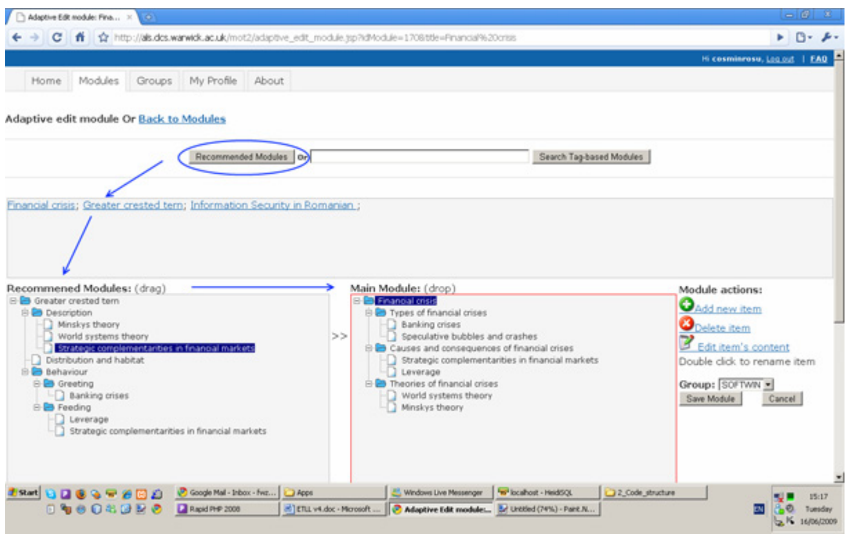


Figure 6. MOT 2.0: Adaptive authoring



a future version, the authoring process can use different adaptive strategies as defined by the LAG model.

Figure 7 is about *merging the authoring and the delivering* view and processes, as the users may still change the content of the course during or after the delivery, or they may annotate it during its creation. This explains why adaptive strategies can be applied not only for the delivery process, but also for the authoring process. The view shows both goal and constraints maps in viewable ('view') and editable ('edit') form, as well as the result of overlaying two different adaptation strategies over each of these maps (in this case, the editing adaptation strategy, for authors, and the viewing adaptation strategy, for the student role).

Figure 8 shows the *group-based authoring* concept, where users can create groups and have different privileges for different groups (as in scenarios 2 and 4). This setup allows the definition of advanced levels of the relation between tutors and learners based on the latter's user model. In future versions, MOT 2.0 will update the privileges automatically and semi-automatically, based on the user model. For example, when the learner is a beginner, they can have fewer privileges within a specific group, but during the learning

Figure 7. MOT 2.0: Authoring versus delivering

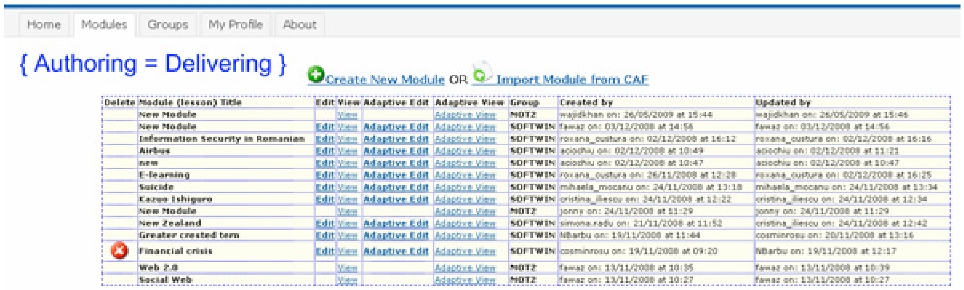
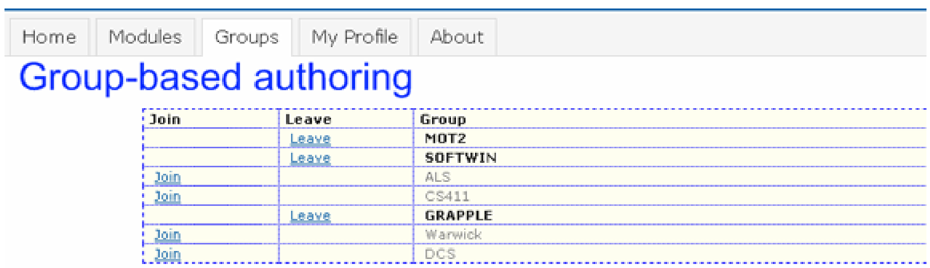


Figure 8. MOT 2.0: Group based authoring



process, their knowledge might be increased, as well as their 'good behaviour' in the system (contributions, tagging, etc.). This can result in increased privileges. The screenshot only shows the functionality of joining/leaving the group, but the system can allow creating groups as well, and defining different types of privileges on different groups.

CASE STUDY EVALUATION OF E-LEARNING 2.0

The new *social layer* and MOT 2.0 as presented above have been evaluated with the help of (i) a group of eight *course designers* from Softwin, an e-learning company in Bucharest, Romania, in addition to (ii) a group of seven *students* studying 'Dynamic Web-based systems', a 4th year undergraduate module at the Department of Computer Science at the University of Warwick, UK. The two evaluations happened at different intervals in time (January – March 2009 and October – December 2008 respectively) and took place in two different countries, Romania and the UK. The common features of the two evaluations are as follows. The course designers and the students were separately introduced to the system after they had had a few lectures on adaptive hypermedia, user modelling, the semantic web and the 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 they analysed MOT 1.0, the prior authoring-only environment for adaptive hypermedia engineering based on LAOS, versus MOT 2.0 which is based on the Social LAOS and 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 users. 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, and each consisting of participants following five scenarios within the authoring system for adaptive hypermedia MOT 1.0 (Cristea & De Mooij, 2003). Similarly, the second stage involved two experiments, also carried out by the course designers and the students respectively, this time using MOT 2.0. The results of stage one were collected before the start of the second stage in both cases. 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 also 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.).

After performing each experiment, participants in all experiments were asked to respond to specially neutralized questions (i.e., questions starting with 'what do you think of …?' instead of 'Do you like..?') as shown in Figures 9-12. 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. Figures 9-12 also show the mean values of their responses on a scale of 1-5 (1: not at all useful, 5: very useful), as well as the variance of the results. The scale was kept numerical for further interval processing.

These questions are: *What do you think about…:*

Visualisation:

- Q1. *browsing other authors' domain maps / modules?*
- Q2. *browsing other authors' lessons?*

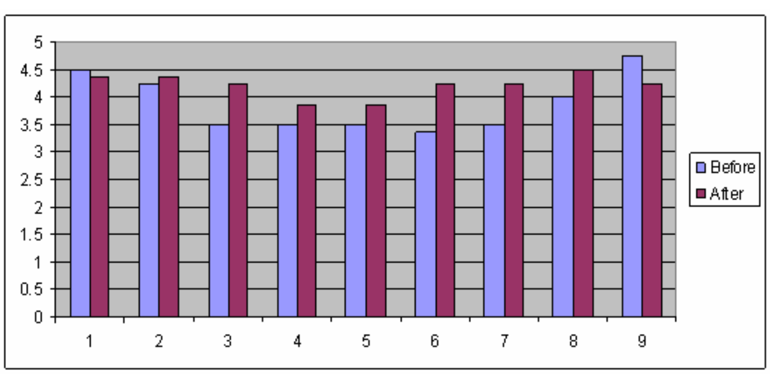
Manual collaborative authoring:

- Q3. *keyword-based access for other authors' content?*
- Q4. *copying a domain concept / items across domain map(s) / modules?*
- Q5. *linking to concepts from someone else's domain map(s)?*

Semi-automatic collaborative authoring:

- Q6. *creating a lesson based on someone else's domain map(s)?*

Figure 9. The means before (MOT 1.0) and after (MOT 2.0) by the authors



Q7. *creating a lesson based on lessons created by other authors?*

New issues:

Q8. *adding collaborative authoring (i.e. tagging, rating, commenting on content)?*

Q9. *adding authoring for collaboration (i.e. defining groups of authors, subscribing to other authors)?*

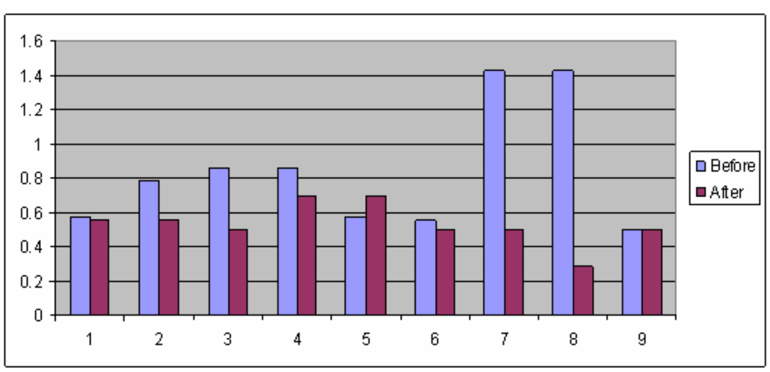
Note that questions 1-7 are general functionality questions. This functionality was present in both systems, but there were changes (we were trying to find out if they were improvements) in MOT 2.0. Questions 8 and 9 address collaboration functionality – MOT 2.0 had this functionality implemented, whereas MOT 1.0 did not have it. Thus, the question was kept generic, in order to refer to future extensions, in the case of MOT 1.0, and to actual implemented features, in MOT 2.0.

Figure 9 shows the mean response of the authors (the Softwin designers) for the two systems, whilst Figure 10 shows the variance. Due to the small number of designers used in this study, we cannot speak directly about statistical significance. Instead, we can observe the general preferences. Overall, both systems scored above the expected average of 2.5 (in fact, they scored above 3).

There is a slight preference for the functionality of the new system in all aspects (lesson browsing, keyword access, copying, linking of concepts, lesson creation and reuse, and collaborative authoring). Moreover, the variance for most of these questions is less for the new system, showing a higher level of agreement between testers. The mean is very slightly higher for the first question for the first system. Looking at the qualitative comments, the only criticism is about the domain maps not being in alphabetical order. In the follow-up implementations, we have already introduced various ways of ordering the domain maps beside the default ones (which are based on the order of creation).

More worrisome for the MOT 2.0 implementation is the fact that Q9 on authoring for collaboration was scored lower, suggesting that at least some of the expectations of the designers had not been fulfilled. One designer who had given it a score of 3 was complaining about the rights related to these groups and the exact procedure for forming them. In the version we had given them to test, groups were pre-formed and joining and leaving groups was open to all. An administrator role is necessary for allowing for group formation, since people could otherwise be inviting others into their own groups, as well as restricting unwanted persons from joining their groups. Such functionality is clearly desirable and has been taken into consideration in the follow-up developments.

Figure 10. The variance before (MOT 1.0) and after (MOT 2.0) by the authors



Our other set of testers were the students (Figures 11 and 12) who, according to the overall philosophy presented here, are treated like authors but possess a subset of normal authors' rights. In fact, the students who performed the evaluation had identical rights to the designers – they just used another version of the system at a different time. In the initial experiment all users (learners and course designers) had same rights (i.e., full rights), for the purpose of the evaluation only, for ease of experimentation.

What can be seen from Figure 11, which shows the mean estimation of student satisfaction with the system, is that they also score both systems above 3. For Q9 on authoring for collaboration, the score is slightly lower for MOT 2.0 in comparison with MOT 1.0. However, as both scores are very high (> 4.5), the students do not seem to share the designers' concern about the group formation issue. The students also do not seem to share the concerns about browsing (Q1), however, they seem to slightly prefer copying a domain concept (or item) (Q4), as well as creating a lesson based on someone else's domain maps (Q6) in MOT 1.0.

For Q4, on *copying domain concepts within one's own domain*, one student was worried about "what … you do if their item doesn't fit exactly in to your module … Can I edit their work …?" He further realizes editing is possible, but then raises the issue of copyright. This is a fair point and is something that was not addressed, on purpose, in the first version of the system: group members had full rights over the content, in order to allow

Figure 11. The means before (MOT 1.0) and after (MOT 2.0) by the students

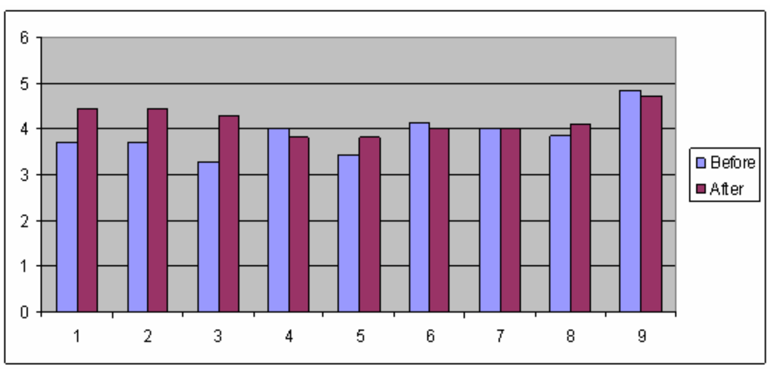
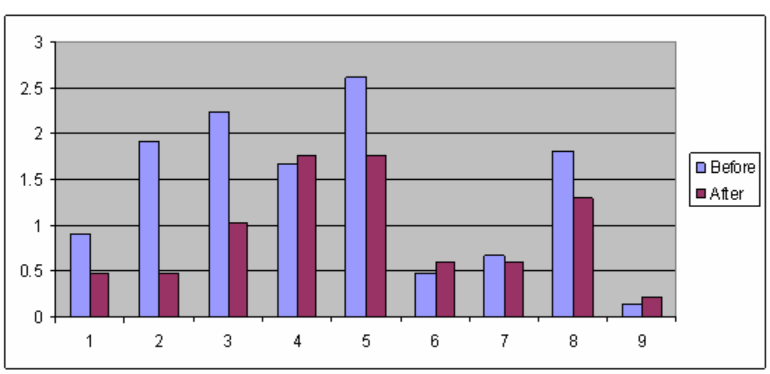


Figure 12. The variance before (MOT 1.0) and after (MOT 2.0) by the students



them to test the various functionalities. Another issue is that the question referred in MOT 1.0 to an author's own items, whilst in MOT 2.0, items belonged to a group. The next version will set various rights within a group, having members only allowed to edit, or to read (and this implies link without change), or copy and change the item. Also individual rights on items and modules will be enabled. Another student commented on the possible redundancy of information – "repetitive lessons". This student however did not understand that the two concepts pointed to the same information item, in order to avoid exactly this type of redundancy. The issue here is however to differentiate between linking to content and copying and re-editing content. This will be taken into consideration in the next version of the system. For Q6 on *creating a lesson based on someone else's domain map(s)*, students who gave lesser marks were commenting on the speed being "a bit lazy". However, another student commented that the speed was "quick". Disregarding the discrepancies in opinions, the speed issue needs to be checked in the next version of the system.

DISCUSSION

Moving personalization for lifelong learning into the realm of Web 2.0 raises interesting issues. Personalized environments have in the past been centred on a single user. In the new type of environment, users interact and collaborate, and this can lead to the adaptation to one user influencing the adaptation process for another. For instance, the same user, Mary (in scenario 1) could be recommended Jane, if she finishes her reading on the "Banking crisis" on a Monday, or another student, Mark, if she finishes on Wednesday. Similarly, a student studying about "Speculative bubbles and crashes" on a Tuesday could be recommended "Strategic complementarities in finance", because they are both tagged "Financial crisis" (see Figure 4), but that student might be recommended "Leverage" on Thursday, just because a colleague has added a tag to that item, or because the rating of the item has increased. Other issues that have been picked up by our experiments and evaluations are the issues regarding copyright and rights of use in general — when we refer to one user only, there is no problem in allowing that user to edit, change, move or link their own material. However, when there is a cooperative effort, the issues of ownership appear. Editing rights have to be carefully granted, in order not to allow destruction (removal, or permanent change and damage) of content created by others. Even in an ideal, cooperative world, there needs to be a clear differentiation between linking to an item created by others, and editing it. As items are reused in different contexts, changing an item for one context may render it unusable for another context. This is in contradiction to Web 2.0 techniques, such as in Wikipedia, where the content is permanently changing, stopping only when it represents a common denominator. In adaptive, personalized systems, the permanent change is useful, but the representation cannot be a common denominator. Personalization also means addressing the outliers, creating versions of content for various types of users, usage and context. Thus, in such a case, if changes are desired for a particular type of context, a user would have to make a copy of the original item, and edit this copy, instead of the original. Only in the case in which no changes are necessary could a user link to the original item. This however brings with itself the same issue as linking to Internet pages: the owner might change the content, thus changing the relevance to the source of the link, or even remove the concept, in which case empty links could appear.

Another issue that is inherent in Web 2.0 applications, and which personalized, adaptive lifelong learning enhancing Web 2.0 applications share, is that of quality of content. In this chapter, we have shown how this issue can be solved by a progressive increase in contribution rights (be they tagging, rating, commenting, or even editing of new items), dependant on the overall quality of an individual's (e.g., student's) contribution. Thus, poor contributors would lose their contributing rights, and may at some point only be allowed to read content, whereas high quality contributors would be possibly achieving similar rights to authors, or even teachers.

We have focused on personalization and adaptation as a key strategy to support lifelong learning, but we should not lose sight of the other technologies and pedagogic developments which will be important in the future. For example, the use of Learning Management Systems in institutions and beyond is pervasive, and effective delivery of educational tools typically takes place through such systems. However, the effective incorporation of educationally rich tools and frameworks (such as those presented in this chapter) within such systems is mainly unresolved (Rößling *et al*., 2008). The integration between "mainstream learning platforms" and "advanced- (often AI-based) solutions" is beyond the scope of this chapter, but is the main scope of research such as targeted by us and the partnership in the EU projects such as ALS and GRAPPLE.

Web 2.0, as a representative of the information society, can provide more information and knowledge to a broader audience and the audience does not have to be in a classroom. This makes Web 2.0 an optimal candidate for lifelong learning, where we do not have to depend only on schools, libraries and experts to gain deeper understanding. However, e-learning is not a means to an end, and schools, libraries and experts are still very important. The two approaches will work together more in the future. For instance, in the context of Web 2.0, experts play an important role as part of the Web 2.0 e-learning system as well – they can help students, interact with them, etc. The added benefit is that of bypassing distance issues, on one hand, and allowing software systems to more easily (automatically, adaptively) pair needs with offers (between learners and experts), to perform scheduling functions, etc.

Web 2.0 could be said to be a means of creating equal opportunities for different learners from different backgrounds and conditions. Also, specifically in the context of lifelong learning, it creates opportunities for people who have no time to participate in the formal learning settings. Finally, the specific features of lifelong learning — such as allowing people to communicate via various information channels — support a broader, information and people-richer access to such classic learning paradigms as the Socratic dialogue.

From a broader social web perspective, the user model as built in MOT 2.0 can be extended towards a distributed user model, able to track users' activities not only within one system (MOT 2.0), but also on the broader Social Web (e.g., the groups a user is member of on *LinkedIn*, the tags they used on del.icio.us, the (educational) videos they watched on *YouTube*, etc.). These types of mash-ups would harness the power of not only one social web system, but several. From a modelling point of view, the Social LAOS framework is perfectly compatible with such an extension — it would only mean that user model variables may be set by calls to external sites, instead of locally — which are implementation details and do not interfere with the framework.

RELATED RESEARCH

Related research into supporting adaptation and personalization in collaborative learning environments is relatively limited. Adaptive collaborative tasks support is addressed, for instance, in WebDL (Boticario *et al.,* 2000). The system allows annotations and tagging, and then selects information based on these tags for personal student needs. No specific rules that guide the collaboration process in an adaptive way are envisioned.

Work by Tsovaltzi *et al.* (2008) promotes collaborative adaptation based on scripts of interactions of pairs of students. Prompts about contacting the peers and explaining, talking about consensus, etc., are used. Interestingly, the paper reports that, whilst the students might have perceived the adaptive comments as intrusions, the overall result (in terms of learning) was positive. Our approach is closer to this study, as the collaborative adaptation process aims at guiding students towards useful interactions with each other, and with their teachers (recommended learners), as well as guiding students towards useful recommended learning content based on their profiles. However, our research also blends not only the learning process and the collaboration process, but also the learning and authoring processes.

Awerbuch *et al.* (2005) have taken an AI-driven approach, and describe processes of adaptive collaboration in peer-to-peer systems in terms of players (or agents) with shared or exclusive goals, thus cooperating or competing against each other. Their system is not directly aimed at learning, and its focus in on how to minimize the cost for an agent in a world of threats (e.g., from dishonest 'players'). Whilst this work may be useful for collaborative and competitive systems in general, it is less applicable in the context of learning, where learners might try to 'beat the system', but would usually gain little from being dishonest to each other. Our aim is to define a new social personalized adaptation model that can currently be applied in extant learning management systems (LMS), in which learners and teachers can engage in a multi-role, personalized, adaptive learning environment to enhance the learning and authoring processes.

In the context of lifelong learning, the APOSDLE (Advanced Process-Oriented Self-Directed Learning environment) project (Lindstaedt & Mayer, 2006) introduced new ways to support informal learning activities (work, learn, collaborate) for the workers in their working environments, which gives *learners support*, by providing the learners with support for self-directed searching and learning within the working environment; *experts support*, by allowing social interaction between learners, and making the results of this interaction available to other learners in their own learning environments; and *worker support*, in which the learning process happens within the working context, and the learners access the learning content without the need to change the working environment. Our approach is slightly similar as it supports recommendations techniques, such as *recommended learning content* based on the learner's profile and *recommended expert* learners also based on the learner's profile. The differences appear in the target — we target not just workers, but lifelong learners, as well as students in formal education.

The Ensemble (Semantic Technologies for the Enhancement of Case Based Learning) project (Carmichael *et al.,* 2009) is a relatively new project, which explores the benefits of the Semantic Web to support learners and teachers in a case-based learning approach. The goal of this work is to explore both the nature and role of the learning cases between learners and teachers, using the emerging semantic technologies. This work is very interesting, but is still in progress. Our approach does not rely heavily on semantic web techniques currently, although import from RDF, for instance, is possible. The result of the Ensemble project could be extended in the near future, based on the framework we are proposing.

In the ALS project[4], the adaptation to collaboration approach is similar to our approach; however our approach extends the collaboration by using the Social Web techniques (such as rating, tagging, etc.).

Telme (Sumi & Nishida, 2001) is a communication tool that acts as a moderator between people with different levels of knowledge. The personalizationin Telme occurs by presenting information from a knowledge base customized according to the user's profile. The system is effective when the user cannot question others directly by concluding the context of the conversation from predefined conceptual spaces.

The personalization in the work of Pinheiro *et al.* (2008) is based on the mobile user's profile, where the context-aware profiles permit mobile users to state their personal preferences for particular situations when using web-based systems. The preferences vary based on the current context. Then a filtering process is applied to the user's current context and the user's preferences for this context. The process selects the context-aware profiles that match the user's current context, and then it filters the available informational content based on the selected profiles.

Barkhuus and Dey (2003) argue that context-aware applications are preferred over personalized ones, where personalization in the sense of adaptability is used. Thus, the application allows the user to specify their settings for how the application should behave in a given situation.

The learning environment described by Yang (2006) consists of three systems: (1) peer-to-peer content access and adaptation system; (2) personalized annotation management system; and (3) multimedia real-time group discussion system. It uses the ubiquitous learning paradigm, with features such as identifying the right collaborators, contents and services in the right place at the right time, based on a learner's surrounding context such as where and when the learners are (time and space), what the learning resources and services available for the learners are, and who the learning collaborators are that match the learners' needs (Yang, 2006). Our approach does not rely on the context of the learner, but it uses user profiles to provide recommended learning contents and recommended users. On the other hand, the context aware ubiquitous learning environment has neither recommended learning materials nor recommended collaborators.

The system described by Perscha *et al.* (2004) provides context information in a presentation-independent format that can be used for mobile learning teams for synchronous and asynchronous communication means. In our approach, we are currently adding a communication facility which can be used by the recommended (expert) learners to help other learners by answering their questions.

LearnWeb 2.0 (Marenzi *et al.*, 2008) is a platform for sharing and discussing as well as creating knowledge resources, which allows for integration of social networks, such as Facebook and Flickr. The integrated infrastructure in LearnWeb 2.0 relies on external Web 2.0 applications. Therefore, one of the platform's main challenges is determining which Web 2.0 tool should be used, as not all Web 2.0 applications are open source, and not all of them actually provide APIs to connect to LearnWeb 2.0. In MOT 2.0, we use the concepts of Web 2.0 (rating, tagging, feedback) applied within the system, and not by integrating external ones.

Calvani *et al.* (2008) argue that each model of lifelong learning should take into account the following main factors.

1. The complexity and the variety of the types of knowledge involved. In MOT 2.0, we have covered the variety of the types of knowledge, as the privileges in each group are based on the knowledge level (i.e., the higher the knowledge level the more privileges the user has).
2. The dimension of self-directed learning. This dimension is also covered in MOT 2.0, as the system can track all actions of the user, and uses these actions in the recommendation process (i.e., recommend learning content rated 4/5 or higher, recommend users who are experts).
3. The dimension of informal learning. In MOT 2.0, both formal and informal learning are supported. In the case of informal learning, the Web 2.0 features in MOT 2.0 facilitate the learning process, during the work, the study, or any other activities.
4. Multiple dimensions of the technological solutions. This factor is a challenging one — currently MOT 2.0 is a Web 2.0 application, which can be integrated with any LMS, or any other web applications that support Java and Tomcat.

StudyNet (Glover & Oliver, 2008) moves away from lecturers to harness the power of connections of the social networks, as it provides the learning materials in a social network environment. StudyNet allows connections not only between staff and students, but also with university alumni. However, due to licence restrictions, StudyNet is only available to enrolled students and academic staff at University of Hertfordshire. In contrast to this, MOT 2.0, can be used by anybody, as it is open to public with no restrictions. Moreover, StudyNet provides neither recommended learning content nor recommended experts. In other words, StudyNet does not support personalizationor adaptation.

Bilge *et al.* (2009) investigated the possibility of attacking social networks to gain access to personal information. While the work proved that it is easy to forge user profiles and create a cross-site cloning profile, it did not provide a solution to this issue. The paper advises us to raise the awareness among users of social networks about privacy and security risks. In MOT 2.0, the privacy and security risks are minimised, as the platform does not support sharing of personal information.

The work of Mislove *et al.* (2008) describes the detailed growth of data in Flickr, by crawling the Flickr sites to find out how the links are constructed, in order to predict how new links will be created. The study concludes that users tend to respond to incoming links by creating links back to the source, and that users link to other users who are already close within the network. Such work shows the popularity of Web 2.0 applications, and the fact that it is timely to invest in researching the potential such applications bring, including for the important area of lifelong learning.

CONCLUSION

The emergence of the Social Web is changing the way in which people communicate with each other, as well as the methods of creating and sharing knowledge. In particular, learners in higher education institutions are using social tools in their everyday life to support their learning needs. Moreover, mature people engaged in lifelong learning are gradually beginning to use social networks and applications in their work and daily activities. Therefore, the Social Web has a potential to support both learners in higher education as well as in lifelong learners. However, research on personalizing and adapting social lifelong learning has not yet been extensively researched.

In this chapter we aim to close this gap with this ongoing study on personalized adaptive social lifelong learning. We have extended the LAOS adaptive hypermedia framework by integrating a social layer, and by blending the authoring and delivering phases (i.e., removing the barrier between tutors, learners and authors, all of whom become authors with different sets of privileges). Our approach allows students to contribute to the authoring phase with different sets of privileges, and distinguishes between collaborative authoring (editing the content of other users, describing the content using tags, rating the content, commenting on the content, etc.), and authoring for collaboration (e.g., adding authors activities, such as defining groups of authors, subscribing to other authors, communicating with other authors).

In the future, we expect many systems to take over such a blended approach to adaptive, personalized and customized education in social environments, both as a research topic, as well for commercial systems.

Encouraged by the first set of experiments, we have already started adding more adaptation functionality into MOT 2.0 via recommended learning content and recommended experts based on the user profile. Another new feature is that the users within same group can have different sets of privileges. Moreover, a new communication tool has been added to the system in order to facilitate the collaboration among learners via discussion support. The chat tool recommends expert users who can help in answering questions and giving feedback. Moreover, the system can now track the reading activity of the learners, which can be used to update the user profile. Finally, the feature of goal visualization was introduced in order for students to be able to recognize easier (a) the fact that members of a group have a common goal, and (b) that they need to work together in order to achieve it. Other types of adaptation for recommending users, apart from their knowledge level, can be applied in the future, borrowed from social recommender systems, such as social proximity or presence in online learning environments, as has previously been covered elsewhere in the ALS project.

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ENDNOTES

1 Document Type Definition

2 'Experts' here is used to denote persons with a higher degree of knowledge than the current student on a given item. This definition can be changed depending on the roles existing in a system, and the overall goal of the system.

3 The elements of these models were also integrated in LAOS, but in SLAOS we specify them more clearly.

4 www.als-project.org