AUGMENTING E-LEARNING STANDARDS WITH ADAPTATION

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

ABSTRACT
Collaborative learning, in the context of Learning Management Systems (LMSs), is becoming an important factor in the e-Learning process. LMSs such as Blackboard, Sakai, allow various forms of collaboration between students. Moreover, LMSs allow a high degree of reuse by relying on e-Learning standards. Nevertheless, LMSs lack adaptation and personalization facilities. Adaptive Hypermedia environments allow for adaptation, but do not usually allow for collaboration, and only seldom use standards. In this paper, we present our work towards *combining adaptation, standards, and typical LMSs*, to achieve personalization in collaborative environments. In particular, we use MOT (My Online Teacher), an authoring system for adaptive hypermedia, IMS Question and Test Interoperability (IMS QTI) and IMS Content Packaging (IMS CP), and the Sakai LMS. In We demonstrate how e-Learning materials based on standards can be augmented; in order to achieve personalization, and adaptive collaborative support, using collaborative adaptive strategies. Thus, this work describes a significant step towards the little explored avenue of adaptive collaborative systems, based on extant learning standards and popular LMS.

KEY WORDS
Adaptive authoring, e-learning standards, collaborative learning, MOT, SAKAI, LMS

1. Introduction

E-Learning standards are considered the skeleton of Learning Management Systems (LMS), as they provide reusability of learning objects, as well as interoperability between different LMSs. Moreover, LMSs provide support for collaborative learning amongst students. Learners can engage in common tasks, in which each individual depends on, and is accountable to each other. On the other hand, Brusilovsky [4] reports the significance of adaptivity for e-Learning, as the students differ in their learning goals, backgrounds and knowledge, etc. Hauger and Kock in [16], reporting on the state of the art of adaptivity in e-Learning platforms, show that most LMSs do not yet benefit from adaptivity.

This paper presents work within the Adaptive Learning Spaces (ALS) EU Project[1], which focuses on delivering adaptive hypermedia [12] to groups/teams of learners by integrating adaptive tools such as: AHA![11] (for adaptive delivery); MOT [7] (for adaptation authoring); and PILS (for adaptive communication) into popular LMSs, such as Sakai. The overall research questions that the ALS project is attempting to answer are: 1) how to best combine personalization to the individual learner, with personalization to a group of learners; 2) how to best demonstrate the solutions envisioned with popular LMSs and, to the extent possible, standards-based approaches.

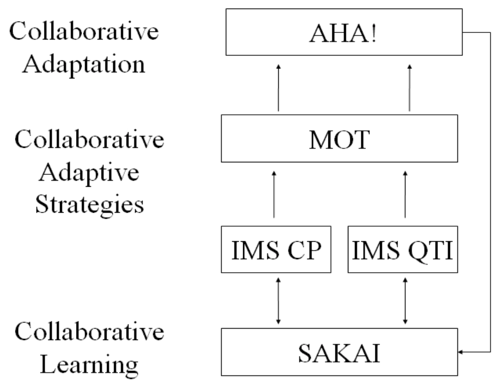

Figure 1. Adapting e-Learning standards

Thus, this work presents a step towards adaptive collaborative support based on standards, by firstly focussing on applying adaptation to material represented via e-Learning standards, in particular, IMS Question and Test Interoperability[2] (IMS QTI) and IMS Content Packaging[3] (IMS CP), and secondly, by extending the classical personalization strategies to adaptive collaboration strategies. The methodology is based on importing these standards into MOT (My Online Teacher), an authoring system for adaptive hypermedia [7], applying an adapting authoring process on the content, and delivering the result via the AHA! adaptation

[1] http://www.als-project.org/index.php
[2] http://www.imsglobal.org/question/
[3] http://www.imsglobal.org/content/packaging/

engine [11] which can run integrated in Sakai[4]. Figure 1 illustrates the process of applying adaptivity to collaborative learning environments (or LMS).

1.1 Sakai and E-Learning Standards

Sakai is a popular LMS, supporting collaborative learning amongst students, as well as e-Learning standards. In this research we use two of its built-in tools: *Melete* (a lesson builder, which allows creating modules) and *Samigo* (an online assessment tool). These tools support IMS CP and IMS QTI, respectively. Thus, in order to add adaptation to these e-Learning standards, we had to import them into the authoring environment, MOT – either via internal database representations, or via the Common Adaptation Format (CAF) [10]. We chose the conversion to the CAF format for the following reasons: 1). *Independency and reusability*: CAF is already being used by other adaptive systems (e.g., AHA! [11]) therefore the result of the conversion can be easily imported to any platform that supports CAF. 2).*Consistency*: On a technical level, CAF, IMS CP, and IMS QTI are all XML-based, thus, the mapping process is straightforward.

1.2 The Authoring System MOT and the CAF Format

In order to have a better understanding of the conversions, we shortly sketch main composing elements of the authoring system, MOT, and of the intermediate format, CAF. *MOT* (My Online Teacher) [7] is an authoring system for adaptive hypermedia based on the LAOS Adaptive Hypermedia authoring framework [8], which we simplify by mapping it onto three modules [9] as below: 1). *domain (content) model*: consisting of a hierarchy of domain concepts, each with domain attributes; this level also allows for other relatedness relations between concepts; 2). *lesson model*: (called goal map to conform to the LAOS framework) filtering contents at attribute level or above and allowing thus course material to be re-structured according to the author's/ teacher's desire; and 3). *Adaptation to student and presentation*; this represents the actual adaptation specification. Please note that the original version of the authoring system provides for personalization, however not for adaptation of the collaborative processes. This is conforming to the typical adaptive hypermedia systems that are focussed on personalization, and not on interaction between learners.

The *CAF* [10] structure reflects the actual course structure for adaptive delivery, minus the adaptation strategy. CAF uses XML representation, suitable for web conversions. CAF thus instantiates a representation [10] for two of the static modules of the description (1) and (2) from above: domain model (one or more), describing the actual content and e-learning resources; and goal model, filtering, reordering and restructuring the information in the domain model according to the lesson goals. Concepts in the goal map have two attributes: weight and label, which are used to determine the adaptation requirements via adaptation strategies (e.g., show concepts labelled 'beginner' to beginner users, and concepts labelled 'advanced' to advanced users). These structures allow for flexible recombination of all elements (concepts), in order to achieve personalization for the learner, and deliver to each learner the material customized for him/her.

[4] http://sakaiproject.org/

2. Adapting IMS QTI and IMS CP

Next, we show how e-Learning standards content can be used in the authoring system, MOT. This represents a novel step towards applying adaptivity to e-Learning standards, and at same time, it is the reverse work of extending MOT to support e-Learning standards, which presented in [14]. The conversion procedure is a two step process. First we convert both IMS CP and IMS QTI to CAF. In this way, we ensure the independency from the currently used authoring system, as well as the reusability as mentioned in section 1.1. Then, we adapt the imported content by defining adaptive variables, and adaptive strategies. Optional steps could be to deliver the adapted content into AHA!, which can run in the Sakai LMS. In the following, we will discuss the technical decisions made in the implementation phase, as well as justify them.

2.1 The Conversion and its Underlying Technology

To tackle the various requirements and constraints for the conversions, we used the Java Architecture for XML Binding[5] (JAXB), due to the fact that CAF, IMS QTI and IMS CP are defined via XML files. JAXB handles most of the problems raised by traditional mechanisms (e.g., SAX - Simple API for XML; DOM - Document Object Model) of parsing XML files, as it provides flexible API functions to generate Java classes that match the DTD (Document Type Definition) of CAF and XSD (XML Schema) of QTI and CP, in a transparent manner for the user. Thus, JAXB is preferable to XSLT[6] (XSL transformations), or other, home-built processing mechanisms. The (internal) conversion steps are as follows (Figure 2). First we generate Java classes for CAF.dtd, QTI.xsd and CP.xsd. Secondly we parse (a process called unmarshalling) the IMS CP and IMS QTI files to generate Java objects. Thirdly we map the results onto IMS QTI and IMS CP classes accordingly. Finally we generate (marshalling) CAF files.
Whilst this process may sound overly technical, in reality, it works transparently for the author, and, due to the advantages as mentioned above, it is useful for the implementer as well.

[5] https://jaxb.dev.java.net/
[6] http://www.w3.org/TR/xslt

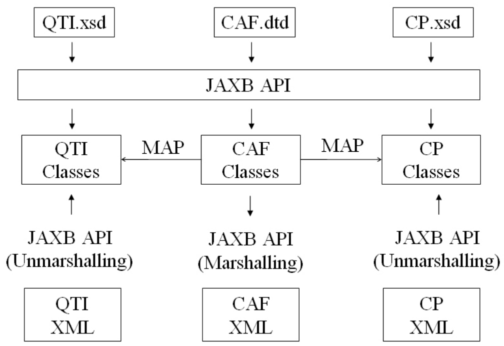

Figure. 2. JAXB Utilization

Next we shall describe creating the goal model, domain model, concepts, and attributes for each of the two standards.

2.2 Adapting IMS QTI

IMS QTI is a data model and de facto standard for the representation of questionnaires and quizzes for e-Learning. The structures represented by IMS QTI are: 1). *Item*: the smallest data unit in QTI, containing the 'question', the configurations, the feedback (if any), and the metadata that describe the item. 2). *Section*: QTI may contain one or more sections, and a section may have item(s) and/or other section(s). 3). *Assessment*: QTI contains only one assessment, which contains at least one section. Assessments cannot contain item(s) directly.
Compared to the structure of CAF, we map the main assessment of IMS QTI onto one domain model; each question in IMS QTI is mapped to one item concept in the domain model; each concept contains three attributes (question, answer and the score). This conforms to the use of concepts in MOT and the use of items in the standard. After creating the domain model, we create the goal model automatically based on the domain model structure[7]. Decisions are based on the analysis of common practice use of the elements of the two representations.

2.3 Applying Adaptive Strategies for IMS QTI

The next step is to define adaptive strategies [20] for the imported IMS QTI content. Please note that the authors who are using the authoring environment MOT, can use the same or other strategies for different scenarios. One possible simple strategy, for illustration, is the 'Type'-based strategy. This strategy shows concepts based on their type (the name of the respective attribute, as shown in Figure 3).

Here, if the learner is ready to see questions, his current user preferred type will be 'question', and thus concepts of type 'question' will be shown. When he is ready to see answers, his current type will be updated accordingly (code not shown here). Finally, when he should see his scores, his current type variable will be updated to 'score'. The main adaptation program snippet that matches concept types to the current type of the user is the following:

```
if GM.Concept.type == UM.GM.currenttype
   ( PM.GM.Concept.show = true )
```

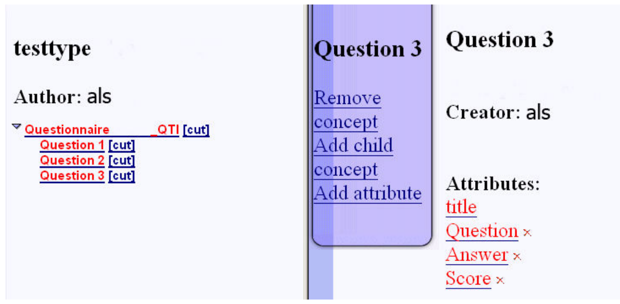

Figure 3. Applying adaptive parameters on IMS QTI

Furthermore, more complex adaptation and personalization scenarios can be created, even for the same content. The labels and meta-data allow for various type of personalization, according to the author's intent.
An author that has imported his IMS QTI content to the authoring system for adaptation doesn't need, however, to know the intricacies of using the adaptation programming language, if he is content with using strategies created by others (and documented respectively). In fact, prior tests show that authoring for adaptation without knowledge of programming is possible [18].

2.4 Adapting IMS Content Packaging

The IMS Content Packaging (IMS CP) is a de facto standard that describes data structures that are used to provide interoperability for the contents of Learning Management Systems (LMS). The structure of IMS CP (content packaging) consists mainly of:
1) *Manifest XML file*: describing the contents' hierarchy, and pointers to the actual contents (physical files), and
2) *The actual physical files* (resources). Thus, a manifest consists of a set of items and a set of matched resources.
IMS CP has more flexibility than IMS QTI, amongst which, the fact that it also supports hierarchical structures (same as CAF). Moreover, the aim of both IMS CP and CAF is to store courses (only the latter however stores adaptive courses). After carefully analysing the structure, it was decided that each item in IMS CP without sub-items, is mapped to an attribute in the domain model of the CAF file; and each item containing sub-item(s) then is mapped to a concept in the generated CAF file[8]. Due to lack of space, we do not show screenshots of the imported IMS CP (before applying adaptive parameters). The

[7] The URL of IMS QTI to CAF converter is http://als.dcs.warwick.ac.uk/mot/qti2caf.jsp

[8] The URL of IMS CP to CAF converter is http://als.dcs.warwick.ac.uk/mot/cp2caf.jsp

screen is similar to the one shown in Figure 3; only it contains course content, and not questionnaires.

2.5 Applying Adaptive Strategies for IMS CP

The next scenario shows how to apply the simple, classical Beginner/Intermediate/Advanced strategy on the imported IMS CP (which could also be applied on the imported IMS QTI). This strategy shows material to students only when they are ready for it (i.e., beginner students see only material for beginners, etc). This adaptation strategy is based on the following: if a concept is labelled in the same way as the current knowledge level of the student, that concept should be made visible, as it is ready to be displayed:

```
if (GM.Concept.label == UM.GM.knowlvl) then
(      PM.GM.Concept.show = true     )
```

To use this strategy, after importing IMS CP into MOT, a teacher needs to define adaptation parameters (meta-data), as illustrated in Figure 4. A teacher labels material and decides the difficulty level of individual pieces of course (e.g., the ‘Module Introduction’ is for beginners, etc.).

Figure. 4. Defining Adaptation Parameters for CP

A strategy such as Beginner/Intermediate/Advanced is aimed at individual students. However, LMSs (e.g., Sakai) offer collaborative learning environments. Thus, if the adapted IMS CP course runs in AHA!, which can run in Sakai, students with ‘beg’, ‘int’, ‘adv’[9] knowledge level can collaborate via Sakai collaboration tools (such as blogs, chat tool, forums tool, etc.), as is illustrated in Figure 5. In such a way, a simple solution of combining collaboration and personalization is achieved. The following scenario goes one step further, and demonstrates how to apply an adaptive collaborative strategy for adaptive collaboration support. As previously mentioned, MOT, with the use of adaptive strategies, can generate adaptive courses. A snippet of an adaptive collaborative strategy is shown below:

```
IF UM.GM.Concept.access == true
THEN FOREACH GM.User DO
  IF GM.User.GM.Concept.knowledge > 80 THEN
GM.User.show = true
```

The above strategy does the following: once a concept is accessed, all students of expert level (knowledge over 80) are listed. Another, largely similar collaborative adaptation strategy would be as follows. The beginner users in the previous strategy could be directed to experts (instead of to their peers) for more information, moving from student-system or student-student interaction to student-expert collaborative interaction. In combination with communication tools that allow for tracking users’ interactions, more complex strategies of collaboration and cooperation can be designed. Generally speaking, a variety of collaborative adaptation strategies can be based on the formula ‘FOREACH User DO Something’. For authors, a simple way exists to influence even the most complicated adaptation strategies: via setting of weights and labels in the authoring environment (as depicted in Figure. 4). Thus, the overall scenarios for authors are as follows:

Scenario 1: *adding adaptation to e-learning standards content.*

1. Create (or use) material based on e-learning standards.
2. Import this into an adaptation authoring environment (e.g., MOT).
3. Add new weights and labels (i.e., adaptation variables, or meta-data) according to the desired personalization. For instance, labels of ‘beg’, ‘int’ and ‘adv’ need to be added to content in order to use it in conjunction with the beginner-intermediate-advanced strategy.
4. Optional: modify the strategy; or even create a new strategy, if so desired.
5. Export the enriched content to a platform that can display it adaptively (e.g., AHA!)

Scenario 2: *exporting content created for adaptation to e-learning standards.*

1. create (or use) material generated via an authoring system for adaptation (e.g., MOT)
2. export this material to e-learning standards (e.g., IMS LD or IMS QTI); please note that some intermediary steps are needed here, but as they are not essential for the logical process, they are skipped. Thus, material created for adaptation can be used in delivery platforms that support standards and/or collaboration (e.g., Sakai). Similarly, it can be enriched by tools that allow authoring of content based directly on e-learning standards (that may not provide adaptation).
3. Optional: modified content can be re-imported into an adaptation authoring environment (e.g., MOT) and enriched with adaptation, as in Scenario 1.

The overall components and responsible entities in the two scenarios are depicted in Figure 5.

[9] ‘beg’: beginner; ‘int’: intermediate; ‘adv’: advanced.

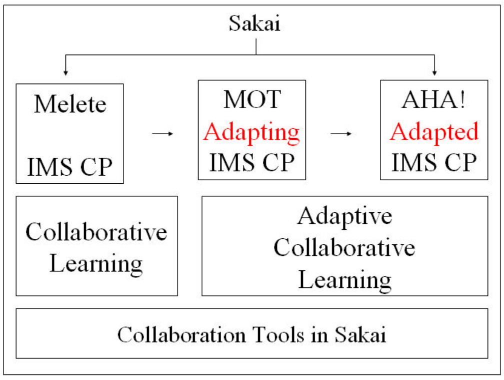

Figure. 5. Adaptivity on Sakai

3. Discussion

Converting learning materials from IMS QTI and IMS CP into MOT allows applying adaptivity to LMSs. LMSs support collaborative learning via multiple collaboration tools, which help the students to communication and share their experiences. Thus, in this paper we combine features from adaptive hypermedia and LMS, adaptation and collaboration & standards, respectively. Furthermore, creating adaptive content is considered costly and time-consuming [6]. Therefore, reusing already created content is valuable, particularly when this content follows standards, which makes the adapting process identical, regardless of the type of LMSs. Thus, existent standard materials can be introduced into an authoring system for adaptive hypermedia, like MOT, where additions towards adaptation specification are possible. In this way, enriching standard-based static material from rich repositories with adaptation becomes easier.

4. Related Work

Previous studies report that adaptive systems do not support standards in general [23], and e-Learning standards in particular [21]. However, LMSs rely heavily on standards. As a result, it is fundamental to provide a connection from AH to e-Learning standards [14], based on analyses of e-Learning standards that are applicable in adaptive systems [13][19]. Pioneers in such work exist. E.g, [5][15] focus on creating an assessment framework for adaptive educational systems via the use of LOM (Learning Object Metadata [17]) and IMS QTI. Hence, the issue of connecting adaptivity and standards is still open, and there is a pressing need to offer new viable solutions. On the other hand, the research looking into combining adaptation and collaboration is relatively scarce. The ALS Minerva project embarks in addressing this niche. Adaptive collaborative tasks support is addressed in WebDL [3]. The system however 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. Another research [22] promotes collaborative adaptation based on scripts of interactions of pairs of students. Prompts about contacting the peers and explaining, talking about consensus, etc. are being 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. However, additionally to this, our research blends the learning process and the collaboration process. Other researches take an AI-driven approach, and describe processes of adaptive collaboration in peer-to-peer systems [1] in terms of players (or agents) with shared or exclusive goals, thus cooperating or competing against each other. Minimization of cost in the process of reaching the goal of the current agent is sought. The overall goal of such research is quite different from the current one in this paper. Our aim is to express with as simple as possible rules adaptation processes that can currently be applied in extant LMS. This will serve as a framework for future, more complex developments, via a robust and constructive approach. Thus, processes are representing social protocols. Adaptation here however means negotiation, in order to adapt these protocols. Compared to our research, this would be at the level of meta-strategies [23], which help in choosing the appropriate strategy. However, the current paper does not elaborate on this direction, focussing on the combination of adaptation, standards and collaboration. Concluding, our research addresses this particular combination of desirable features, in a realistic manner, which is easy to deploy. We opt for a simple, quick solution, instead of an all-encompassing approach. We also argue that this quick solution presents the ideal basis for future extensions of various kinds.

5. Conclusion and Future Work

Most adaptive learning systems focus on personalizing the delivery of course materials to individual learners. However, not enough work has been performed on applying adaptivity in regular collaborative learning systems, such as popular LMSs. Adaptation based on e-Learning standards can supply a dynamic learning process which is compatible with all systems that support these standards. In this paper we present our work of converting IMS QTI and IMS CP to MOT, in which the e-Learning standards content can be adapted in MOT by using adaptive variables, as well as adaptive strategies. We also present some simple, illustrative learning scenarios on how to apply adaptive collaborative strategies on the adapted e-Learning standards contents. Finally, adapting e-Learning content is time-saving, as the process of applying adaptivity for collaborative learning requires only applying adaptive parameters, without the need of re-creating this content from scratch. For the next steps, work has already commenced towards full integration of the other components of the ALS project's collaborative, adaptive learning space.

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