A Computer Support Collaborative Authoring Model for Authoring Adaptive Educational Hypermedia Systems

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ABSTRACT
Adaptive Educational Hypermedia (AEH) systems require massive and complex knowledge spaces in order to provide adaptation and personalisation in learning. Hence, it is difficult for a single person or a small group of people to develop them effectively. Former studies addressed the problem by developing collaborative authoring systems. However, the systems tended to support object reusability rather than enabling authors to collaboratively work in the same workspace. Potential ways to address these issues come from recent developments in social semantic web technologies that have successfully shifted authoring to a community based development. The application of such technologies together with Computer Support Collaborative Work (CSCW) could enhance collaborative authoring on documents and ontologies. This paper presents a Computer Support Collaborative Adaptation Authoring (CSCAA) model for AEH systems. The novelty of the model lies in the use of Semantic Mediawiki and the application of CSCW principles. The model aims at improving authoring for AEH systems by allowing more people to participate and enhancing authors’ interaction. We have established requirements for the model and evaluated it by drawing a comparison with other existing collaborative authoring models made for developing documents, simple knowledge, and ontology. The result shows that such tools can be complementary for CSCAA, and CSCAA has a novelty by applying the CSCW aspects for authoring adaptation.

Keywords
Adaptive Educational Hypermedia, Computer Support collaborative Work (CSCW), Computer Support Collaborative Adaptation Authoring (CSCAA), semantic wikis, asynchronous distributed collaboration.

1. INTRODUCTION
Developing and maintaining learning resources is a big problem in adaptive – personalised computer support learning systems like Adaptive Educational Hypermedia (AEH) systems. Learning resources, called knowledge space in AEH systems, consists of domain-related knowledge, content, and pedagogy-related knowledge including adaptation support [1, 2]. The larger knowledge space is maintained, the better adaptation and personalisation will be offered. However, developing knowledge space is not simple and it is time consuming as it consists of three types of activity including authoring knowledge, developing content, and then structuring knowledge and linking knowledge to content[1, 3].

On the other hand, recent developments in social web with Web 2.0 have changed the way that experts are building documents and knowledge. First, documents and knowledge are now products of collaborative work. A survey of professionals in business and industry who spent their time in writing showed that most of them did their work cooperatively. In addition, most of the work in academia and business was completed by groups of people (Ede and Lunsford as cited in [4]). Second, domain experts engage in online communities of practice. With the complexity of knowledge and content developed, authoring does not remain technical tasks carried out by administrators or content developers. It has shifted to the development of collective intelligence in which domain experts give their contribution. With information technology support, they perform online communities of practice. Third, authored knowledge and documents are not static objects, but always dynamic and constantly updated. We call them evolving objects.

The most phenomenal Web 2.0 systems are wikis that have successfully provided an asynchronous distributed collaborative authoring in which online communities can participate. One example of wikis is Wikipedia which promotes document authoring and encourages people to participate. There are past studies which utilised Wikis. Ras [5] for example, used a Wiki to develop courseware by extracting learning elements from Wiki pages and then organising them in a SWEBOOK (Software Engineering Body of Knowledge) based learning space. Combined with semantic web technology, wikis are enhanced into semantic wikis which allow people to add knowledge in wiki documents.

Other studies in the area of Computer Support Collaborative Work (CSCW) concerns the way to enhance collaborative work [4, 6]. There have been a number of proofs on how the implementation of CSCW principles in an academic environment can improve collaborative authoring; for example, in developing hypermedia documents [7] and courseware [8]. In terms of courseware development, collaborative authoring can give an advantage in time efficiency and the opportunity to keep learning resources continuously updated, thus keeping it relevant to students’ need [9, 10]. Considering that courseware development is a complex endeavor and to enhance the quality of the authored objects, people with various concerns should be encouraged to participate. For example, a research study on authoring adaptive learning system resources [11] involved developers’ team and teachers as authors. The former has responsibility for establishing authoring environments covering core educational content, whereas the latter do create the majority of educational content such as explanations, examples, and problems. Other authoring systems which define content for Adaptive Educational Hypermedia such as AHA! [12, 13] and MOT [8, 14] also proposed collaborative features.

This paper presents our ongoing research in developing an enhanced model of collaborative authoring for adaptive
educational hypermedia, named Computer Support Collaborative Adaptation Authoring (CSCAA), by taking advantage of semantic wikis and CSCW. This paper focuses on CSCW aspects required in CSCAA.

The paper is structured as follows. First, problems in authoring AEH and the potential of semantic wikis and CSCW principles to solve problems in authoring for AEH systems are described in Section 2. Afterwards, a description and a set of requirements for authoring adaptive educational hypermedia collaboratively are presented in Section 3. We then describe the design of the proposed collaborative authoring system in Section 4 and the comparison with former research in Section 5. Finally, we present conclusions and areas for future work in this research.

2. PROBLEMS AND POTENTIAL IMPROVEMENTS IN AUTHORING FOR ADAPTIVE EDUCATIONAL HYPERMEDIA

We analysed that there are four problems in authoring for AEH system; these are usability, interoperability, authoring tools, and collaboration.

**Usability.** To keep learning materials updated, suitable authoring systems are required. In fact, the availability of such systems is still a challenge. Authoring systems needed are those with user friendly features for domain experts, not technical tools which only administrators can use. In addition, considering the fact that instructional designers or course designers always work collaboratively, authoring systems should provide features for collaborative work. Until recently, there have been many authoring systems for AEH which address such problems, for example AHA!, MOT, and GRAPPLE [8, 12, 15-17]. They enable an author to reuse other authors’ work.

**Interoperability.** Authored objects are often not transferrable or reusable. Since each AEH system is unique, authoring systems generally just produce courseware that can be delivered by a particular AEH system. Not only is it the authored objects that cannot be reused, but also authors’ effort. It means that authors need to learn new skills or knowledge every time they intend to contribute in the authoring process. MOT with the motto “authoring once, delivery many” and GRAPPLE produce generic output that can be delivered in other AEH systems. Until recently generic and reusable output has remained a big issue in authoring for AEH systems.

**Authoring tools.** Considering that authoring is a complex process and learning resources that will be established are wide ranging, the use of existing authoring tools will make the authoring process efficient. With the popularity of Web 2.0 and the capability of semantic web technology for managing knowledge, Semantic Wikis is a good alternative to develop domain knowledge. Then, collaborative authoring can focus on the enrichment of semantic wikis’ output by adding pedagogy information and adaptation rules. Some past research utilised Wikis and Semantic Wikis for courseware authoring, for example se(ma)2wi and SWIM [18, 19]; both concern mathematical knowledge management.

**Collaboration.** Current authoring systems for AEH do not support collaborative work. They support object reuse and annotation but do not provide functions to enable interaction among authors. The systems do not translate the collaboration environment in which instructional designers or course designers do their work. To enhance authoring, communication and coordination as two main characteristics of collaborative work need to be implemented.

3. REQUIREMENTS FOR COMPUTER SUPPORT COLLABORATIVE ADAPTATION AUTHORING

To solve such authoring problems mentioned in Section 2, we are developing a Computer Support Collaborative Adaptation Authoring (CSCAA) model for authoring adaptation of AEH systems. We propose the implementation of CSCW to address usability and collaboration issues, the enhancement of semantic wikis to address the authoring tools issue, and the use of generic knowledge representation to address interoperability issue.

This paper is focused on CSCW aspects. We have defined the requirements of the system from CSCSW perspectives as follow.

**Asynchronous distributed.** The type of CSCW system that will be developed is the fundamental decision that the developer must make in the first instance. We design a collaborative authoring system by applying the asynchronous distributed model. The model enables groups of people to work collaboratively towards a common goal from different places at different times [20]. Although authors do not need to work interactively at the same time, the system anticipates the occurrence of authors for sometimes working concurrently. There are two reasons to motivate the use of the model. First, a way to improve collaborative authoring for AEH systems is by enabling people from different concerns, domain experts and instructional designers for examples, to participate. Second, former research on instructional design [21, 22] found that instructional designers generally work collaboratively. They select instructional strategies by discussing and brainstorming with other instructional designers. Interaction with other practitioners has more influence on decision making than instructional design theories. They undertake discussion, brainstorming, coordination, and meetings to define the same vision in designing and conducting learning.

The integration of authored objects with discussions and annotations. In the manual authoring system, face-to-face meeting is the most common way of communication that authors use. Hence, it is important to implement communication and coordination mechanisms in CSCW systems that can replace the face-to-face meeting. A research study [23] concluded that communication and coordination functions in CSCW systems can replace the face-to-face meeting; both ascribe similar values to collaboration. Another study shows that CSCW-based group learning presents a better subjective learning outcome than manual group learning with face-to-face meetings [24]. CSCAA is designed to implement annotations and discussions via shared pages/notes linked to the authored objects. It is inspired by talk page in Wikipedia [25-27].

**Implicit planning and Coordination.** In CSCW, essentially, there are two kinds of coordination. One is explicit coordination through which authors discuss and brainstorm through explicit communication to create a plan and coordinate among themselves. The other one is implicit coordination in which early authors play the role of leaders who structure and direct authoring tasks in a particular way [25, 28]. Novice members can understand all information about the authoring process from a script explaining process structure [29]. CSCAA combines implicit and explicit coordination. Early members can structure
the targeted knowledge. There is no explicit task allocation to members. All members can modify the structure, update objects, or do rollback to return an object into its previous status. Explicit coordination is provided in the form of shared notes or pages on which authors can write anything about authoring tasks or authored objects.

*Future work and authoring history information.* A to-do list [6] and authoring history information are provided to give a view about what a contributor has done and will do. Moreover, they describe what has been and will be done to an object. They are anchored to knowledge space or to each knowledge object, and can be deleted automatically or manually by an author if (s)he thinks it is not relevant anymore. Progress tracking and provenance information can help novice users to know what has been done and to what objects, and also to understand how the authoring process is progressing.

*Members control membership.* It is common that courses and learning are carried out by a small group of instructional or course designers whose members know each other. With the popularity of the social web, people connect, develop something collaboratively, and engage in online communities of practice. This research takes advantage of the social web by enabling instructional designers to perform a group to develop learning resources collaboratively. As only instructional designers can participate in authoring, they form a small homogenous community of practice that work on topics that are relevant to members [30]. Membership is fluid; it means that communities can evolve as they open up to everyone to subscribe to. As this system is designed as a collective system in which all members have same responsibility, an membership applicant can participate in the authoring process if at least one member of the community gives approval to his/her subscription.

4. DESIGN OF COMPUTER SUPPORT COLLABORATIVE AUTHORING

Considering the complexity and the massive volume of the knowledge space of AEH systems, the use of existing authoring tools could be helpful. We use semantic wikis for the authoring domain model and general pedagogic knowledge. The proposed system, CSCAA, focuses on the development of adaptation rules.

Users are grouped based on their roles and priviliges into Domain Experts, General Public, and Instructional Designers. Domain Experts and General Public can be large groups with many people contributing. The former work to develop domain knowledge, while the latter participate in content development. On the other hand, Instructional Designers are responsible for the development of pedagogic knowledge including adaptation rules.

Figure 1 describes the general architecture of the proposed model. Output consists of:

1. **Domain knowledge.** It contains all information about courses and their properties including goal, overview, course introduction, a set of concepts, and links to supporting learning materials. Goals refer to course objectives based on the perspective of domain experts.
2. **Content.** It contains learning materials represented in wiki documents.
3. **General pedagogic knowledge.** It represents any information needed to support learning. It includes lessons representing units of learning that will be delivered to students, learning paths as sequences of lessons, and general rules; for example a minimum grade that students must achieve.

4. **Adaptation rules.** It is part of pedagogic knowledge which supports adaptation in learning. It consists of rules considering learners’ performance to determine the next materials, lessons, or concepts to be learned.

![Figure 1: The General Architecture of Collaborative Authoring for Adaptive Educational Hypermedia System Focusing on the Computer Support Collaborative Authoring for Adaptation Rules](image-url)

**Semantic Mediawiki based authoring system.** We propose Semantic Mediawiki regarding its expressivity as it supports the OWL Lite format. In addition, Semantic Mediawiki has a high usability factor, so that people who are familiar with computer applications without having any programming and modeling skills can use it [31]. The contributors of this sub system are Domain Experts and General Public. The former is a community of practice whose members are experts in related authored topics but probably not instructional designers or teachers. They are mainly responsible for developing domain knowledge. All those knowledge items are maintained in an ontology represented in RDF/OWL. Learning content, on the other hand, will be generated by General Public.

**Collaborative ontology development system.** The output of the Semantic Mediawiki based authoring sub system is enriched by Instructional Designers, a small community of practice whose members are teachers, instructional designers, or course designers. They can refine domain knowledge or enrich it with general pedagogic knowledge.
**Learner Model.** It is an external sub system that is not the focus of this research. It is represented in the most generic model: overlay.

**Computer Support Collaborative Adaptation Authoring (CSCAA)** for adaptation rules and Inference engine. These sub systems are the main sub systems in the whole collaborative authoring model for AEH systems. Input of CSCAA is the ontology of domain and general pedagogic knowledge. In these sub systems, enrichment will be achieved by adding adaptation rules anchored to the lessons. There is a different format between domain/general pedagogic knowledge and adaptation rules. The former is part of RDF/OWL knowledge ontology; hence it can be manipulated by any collaborative ontology development tool - Protégé 3.4.x for example. The latter is represented in rule languages or formatted text. All this knowledge with learner models are then processed by an inference engine, which resulted in adapted knowledge which is suitable for a particular learner and laid out in generic format. Tasks and activities in CSCAA are described in Figure 2.

**Transformation Engine and Existing AEH System.** Adapted knowledge as output of CSCAA and the inference engine is needed to be transformed into the required format according to an existing AEH system that will deliver it. Until recently, there have been many research studies on establishing AEH systems; AHA! for example and also GRAPPLE which is under development [12, 17].

**Figure 2. Authoring Tasks in CSCAA**

5. **ANALYSIS OF THE DESIGN AND EXISTING TOOLS**

This section presents a comparison of three authoring tools with requirements presented in Section 2. The tools and the objectives of the comparisons are listed below:

1. Comparison with MOT (My Online Teacher) [14, 32, 33]. MOT is a collaborative authoring tool for AEH systems. Its output is to be delivered in other AEH systems; AHA! for example. The comparison with MOT aims at presenting the novelty of the proposed research.

2. Comparisons with Semantic Mediawiki (SMW) [34, 35] and Collaborative Protégé [36, 37]. The former enables authoring documents and semantic annotations by a large online community, whereas the latter is used to author ontology collaboratively. These comparisons aim at presenting the potential of utilising such existing tools because those tools can fulfill some of the requirements of the proposed system.

We classified the analysis points into authoring functions and CSCW features. In the former, we separate authoring ontology from authoring domain and pedagogic knowledge. Sign √ in the table means that the tool in the corresponding column is possible to be used for the function mentioned in the corresponding row. On the other hand, we also compared CSCW features provided by the tools with the requirements listed in Section 3. CSCW features represent environments to support authoring functions.

| Table 1 Comparison between CSCAA requirements and existing authoring tools |
|--------------------------|---------|-------|
| Authoring Functions | MOT | SMW | PROTEGE |
| Authoring ontology | | | √ |
| Authoring domain knowledge | √ | √ | √ |
| Authoring learning materials | √ | √ | |
| Authoring general pedagogic knowledge | √ | √ | √ |
| Authoring rules in generic formatted text | | | √ |
| CSCW Features | | | |
| Asynchronous distributed | √ | √ | √ |
| Discussion | | | √ |
| Annotation | | | √ |
| Planning and coordination | | | √ |
| Future work information (a to-do list) | | | |
| Provenance information. | | | |
| Members control membership | | | √ |

The table presents how MOT implements a distributed asynchronous environment enabling authors to develop or reuse learning resources. MOT has all the required authoring functions for developing AEH systems but does not implement any CSCW features. On the other hand Semantic Mediawiki (SMW) can be used for developing knowledge and content but not for adaptation rules. However, although SMW supports knowledge development by semantic annotations on wiki pages, it is not sufficient for developing ontology. It is contrary to collaborative Protégé that provides functions to build ontology; hence it can be used to develop ontology-based domain and pedagogic knowledge, but not to establish learning content and adaptation.
rules. Both SMW and collaborative Protége enable annotations and support communication among authors via page talk in SMW and notes in Protége. In addition, they maintain provenance information. Progress tracking in the form of a to-do list, however, is not explicitly provided in both but authors can use page talk/notes for that.

6. CONCLUSIONS AND FUTURE WORK

The analysis, design, and evaluation that have been carried out point to several issues. First, with the success of CSCW in improving collaborative authoring for documents, CSCW could be able to improve collaborative authoring for pedagogic knowledge including adaptation rules. The natures of all collaborative developments are the same in that the people who participate need to communicate and coordinate among them. Second, authoring will be more effective for instructional designers or teachers. Since people with different concerns including Domain Experts and General Public participate in developing domain and general pedagogic knowledge and content, teachers or instructional designers can focus on adaptation matters. Third, Semantic Mediawiki can be utilized for authoring resources for AEH systems. Fourth, the novelty of CSCAA compare to former research is on the application of CSCW and the enrichment of semantic wiki’s output.

We continue to develop the CSCAA. Currently we are working in developing technical artifacts including a case study in a semantic wiki and a prototype of CSCAA. The future plan covers implementation and evaluation work to answer higher level questions on collaboration policies, for example what should be done if Instructional Designers can not achieve agreement about a pedagogic matter.

7. REFERENCE


