Enhancement of SCORM to support adaptive E-Learning within the Scope of the Research Project AdeLE

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Abstract: With regards to a more effective knowledge transfer through adaptation and personalisation, adaptivity is one of the hot spots in the field of e-learning. As one particular and interesting detail of *AdeLE (Adaptive e-Learning with Eye Tracking)*, a research project with the aim to develop and implement a solution framework for personalised adaptive e-learning based on real-time user behaviour, this paper examines theoretical principles and the possible realisations of adaptivity in terms of technology-based learning and teaching. According to these basics, requirements on an e-learning standard are established. Finally, one well-established collection of specifications and standards, *SCORM*, is inspected referring to these requirements, and exemplary enhancements to support adaptive e-learning are suggested.

Introduction

E-learning turns out to be an important aspect for the educational area, e.g. as shown in (Lennon et al. 2003), as well as for companies as part of a holistic knowledge management approach (see Hasebrook 2001). E-learning paradigms and implementations have brought many advantages to technology-based distance education as pointed out in (ADL 2001). Since e-learning on its own is accompanied by a lot of disadvantages, it is recommended that technology-based learning should be combined with conventional courses (see Garcia et al. 2004). Besides, e-learning has to consider didactical theories in terms of behaviourism, cognitivism and constructivism (see Dietinger 2003) as well as psychological aspects like cognitive styles, learning strategies, etc. (see Blöchl et al. 2003). Furthermore, we believe that adaptation and personalisation will improve the learning process. A paradigm shift from consumption of static learning contents to well tailored, highly personalised learning sessions is needed (see Garcia et al. 2004). Therefore, an e-learning environment has to provide methods to adapt to the learner as well as to the teacher.

Due to the necessity of high-quality content, interoperability issues like transferability and reusability of content as well as the usage of learning object repositories have to be considered (see also Qu et al. 2002). In particular, standards for describing and exchanging e-learning content should be supported by an e-learning environment. In fact, the standardisation process in the field of e-learning is still in progress and only a few specifications are standardised by an international organisation like the ANSI (see Dietinger 2003). Hence, a lot of aspects of e-learning content can only be described with proprietary specifications, which, additionally, do not fully support learner-centred adaptivity as shown in (Mödritscher et al. 2004).

AdeLE, a two-year research project carried out by the Department of Information Design at the University of Applied Sciences (FH JOANNEUM) and the Institute for Information Systems and Computer Media (IICM) at the Graz University of Technology, Austria, aims to research on adaptivity in the field of e-learning and to develop an

innovative framework for personalised adaptive e-learning. The *AdeLE* framework itself will not be treated closer here, but in context of the research project the reminder of this paper discusses adaptive e-learning theoretically, points out requirements on a standard to support adaptivity and shows exemplarily, how a wide-spread standard, *SCORM*, can be extended to fulfil the needs for the research project *AdeLE*.

The basic Idea of adaptive E-Learning

To explain our view on adaptive e-learning more closely, we first have to define the terms "adaptation" and "e-learning" and point out the underlying concepts of these areas. On the one side, we see an adaptation system as a system, which comprises a set of features of adaptivity and adaptability. According to (Oppermann et al. 1997) systems that allow the user to change certain system parameters and adapt their behaviour accordingly are called *adaptable*, while systems that adapt to the users automatically based on the system's assumptions about user needs are called *adaptive*. Furthermore, there are several graduations between adaptivity and adaptability depending on who – the user or the system – has more control of the system's behaviour. Over the last decades various forms of adaptation systems can be identified, like Intelligent Learning System (ILS), Adaptive Hypermedia System (AHS), Computer Assisted Instruction (CAI), etc.

On the other side, (DerekStockley 2004) defines e-learning as *"the delivery of a learning, training or education program by electronic means. Elearning involves the use of a computer or electronic device, e.g. a mobile phone, in some way to provide training, educational or learning material."* According to (Jain et al. 2002), e-learning is asymmetric and covers two important processes:

- First there is the **teaching process** that describes how the teacher intends to deliver the content to the learners. Therefore, the teacher has to consider the following questions (see Specht 1997): Which contents should be delivered and what overall goals should be reached? Who are the recipients of the learning content? What is the best way – in terms of didactical models and content types – to convey the contents to the learners?
- Secondly, the **learning process** describes how the learner assimilates the e-learning content. Depending on the learner's characteristics, which can be classified into domain-specific and background knowledge, cognitive and affective abilities, constitutional attributes, preferences as well as interests and learning targets (see Brusilovsky 1996), the learning process itself can be variably efficient.

Combining the above depicted definitions about adaptivity and e-learning, we come to the conclusion that adaptive e-learning consists of two adaptation circles. On the one side an adaptive e-learning environment may adapt to the learner with regards to his characteristics as described in (Mödritscher et al. 2004). On the other side the system can adapt towards the teaching process, which can be described for example with the preferred teaching styles of a teacher (see Moallem 2001). These aspects concern the e-learning content, the possibilities for teachers to interfere in the learning process as well as tools for collaborating with the learners. In order to provide adaptation features to e-learning environments, the system itself has to provide adaptive methods for the learning and teaching process, mechanisms to allow the teacher to override system decisions (dynamic adaptability) and collaboration software like discussion group, chat-rooms, etc.

Adaptation in respect of the learning and the teaching process can be realised in an ideal e-learning system by the following four elements:

- **Adaptive content aggregation**: Depending on the learning and teaching style the system could offer different types of content beginning with static information units to fully interactive elements like simulations, games or questionnaires as described in (Specht 1997). Besides, the content can be assembled with regard to different background domains, levels of detail or multimedia formats.
- **Adaptive presentation**: According to (Han 2001) the presentation of the content can be enhanced with additional, prerequisite, comparative explanations and all possible variants of these methods as well as sorting content units towards criteria like relevance to background knowledge, knowledge level, and the like. These techniques can be realised using techniques like conditional text, stretch-text, page variants, fragment variants and frame-based methods.
- **Adaptive navigation**: Navigation can be adapted in terms of global or local guidance and global or local orientation. Therefore, an e-learning environment could offer direct guidance as well as sorting, hiding and annotating links (see Brusilovsky 1996).

- **Adaptive collaboration support**: This kind of technique, which can be offered by a network-based educational system uses the system's knowledge about learners to form a collaborating group and offers or suggests communication within these learners using collaboration software (see Hoppe 1995).

Regarding the teaching process, two important aspects have to be mentioned here: On the one side, e-learning content has to be linked to knowledge domains or concepts, which can be extracted from the lecture's conceptual scope (see also Han 2001). Thus, the e-learning system should provide mechanisms to the teachers to assign concepts to lecture units or undertake the correlation automatically by means of e.g. an existent knowledge base. Furthermore, it must be also defined on which level of detail a domain or concept is covered with one lecture. This mapping is especially important for tracking the learning progress. On the other side, the content also has to be linked to the context in which the user should learn it. Depending on the context, which could be represented by different learning or teaching goals, the system can provide adaptive methods like varying the kind of task or the level of detail. The consequences for the e-learning environment can be reduced to the four elements stated above. Furthermore, these two aspects can be used to generate a more detailed user profiling information, which allows the system to record on which level and in which context the user acquired knowledge through e-learning.

Requirements on a Standard for adaptive E-Learning

Derived from the theoretical reflections in the previous section, adaptivity in relation to the learning and teaching process has an effect on an e-learning standard on the following levels: Firstly, a standard has to support adaptive e-learning in terms of *content aggregation* and *content presentation*, which influences learning objects as well as assets as described later on. Secondly, the aspects about adaptive navigation require special preconditions for the *sequencing* specification for learning objects. Thirdly, the standard has to support an enhanced *user profiling* for learners and teachers. Furthermore, it has to be possible to link the learning objects and courses to *domain knowledge* and the *context* of e-learning. Finally, *technical requirements* on e-learning standards can be identified, too. These aspects of standards for adaptive e-learning will be discussed more precisely in the following subsections outlining the main categories of requirements on content, sequencing, user profiling and miscellaneous.

Requirements on Content

E-learning content can be divided in assets – atomic elements like a picture, a paragraph, etc. – and learning objects which defines a digital resource – an asset or an aggregated object – that is used to support learning (see DLNET 2001). In regard to adaptive e-learning, the following requirements have to be supported by the standard:

(A1) Defining different types of assets (e.g. text, picture, audio, video, a hyperlink or even a link to a knowledge domain or concept)
(A2) Supporting different types of learning objects (e.g. content, exercises, examination, etc. and any combination of these types)
(A3) Providing different levels of detail for a learning object (e.g. novice, average and expert user)
(A4) Mapping a learning object to a learner's characteristics (e.g. language, accessibility, learning style, multiple intelligence, etc.)
(A5) Mapping a learning object to a domain or concept (e.g. learning content from the domain mathematics consisting of the concepts integral and differential calculus)
(A6) Mapping a learning object to a context or task (e.g. giving an overview about a domain, practicing a concept intensively, etc.)

Requirements on Sequencing

As already mentioned, sequencing has an effect on navigational elements and, furthermore, on didactical principles of e-learning, so this aspect is particularly important for a standard. Therefore, a specification covering the sequences of the learning objects has to fulfil these requirements:

(B1) Providing different sequencing types to combine the learning objects (e.g. linear, divergent, convergent, etc.)
(B2) Defining different prerequisites for learning objects (e.g. conditions according to a learner's characteristic, a context, a certain domain or concept)

(B3) Mapping a sequence to a learner's characteristics (as described above)
(B4) Mapping a sequence to a domain or concept (as described above)
(B5) Mapping a sequence to a context or task (as described above)

Requirements on User Profiling

According to section 2, an outstanding aspect for adaptive e-learning is the user profiling. A specification has to fulfil the following requirements:

(C1) Defining static and dynamic information attributes about a learner or teacher (see Mödritscher et al. 2004)
(C2) Providing management (like storage, deletion or update) of attributes in real-time, e.g. the actual constitution
(C3) Supporting an enhanced learner tracking (e.g. observing the learning process, the paths through the courses, all learning objects and assets viewed or the learner's constitution)

Miscellaneous

Finally, three requirements, which are derived from technical aspects and considerations about knowledge domains and the learning context, have to be manifested:

(D1) Modelling knowledge domains and their concepts including overlapping domains or concepts
(D2) Modelling contexts and their tasks including overlapping contexts and tasks
(D3) Offering different presentations for learning objects (e.g. for a certain device, browser or bandwidth)
(D4) Separating content and presentation

According to these requirements, we enhance e-learning specifications of ADL's *SCORM* to satisfy the particular needs for the AdeLE research project, as discussed in the following section.

Enhanced E-Learning Specification for AdeLE based on SCORM

The *Advanced Distributed Learning Initiative* (see ADL 2004) was established by the *US Department of Defense (DoD)* in 1997 in order to develop a strategy for using information technologies to modernise education and training and to promote cooperation between government, industry and academia to develop e-learning standardisation. Currently, the standard specifications are summarised within the *Sharable Content Object Reference Model*, abbreviated as *SCORM*. *SCORM* is a collection of specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of web-based learning content. Because the actual version of the standard, *SCORM 2004*, is still part of the development process of the standard, there are some aspects towards learner-centred adaptivity missing.

SCORM supports a detailed description of assets and content objects using the *IEEE LTSC* metadata specification *Learning Object Metadata (LOM)* with *IMS* metadata elements. Using this specification, *SCORM* allows defining assets and learning objects for different aggregation levels and formats, languages and language levels, operating systems and platforms, interactivity types, semantic densities, intended end user roles, typical age ranges, difficulties, relations, and so forth. In spite of all these attributes, knowledge domains cannot be modelled with *SCORM* at all, so the system cannot cross reference to similar domains.

Referring to learning instructions and sequencing, *SCORM* includes the *IMS Simple Sequencing* specification (see IMS 2004), which allows the definition of dependencies between content objects as well as more complex structures of the content. Although questionnaire is implemented in a very prototypical way within the exemplary runtime environment of *ADL*, there exist no specifications for assessment objects, user profiles or knowledge domains - these areas are evaluated at the moment or will be treated in the near future. Thus, our requirements on *SCORM* towards user profiling and learning instructions are not or only partially fulfilled. In contrary to the KOD project (see KOD 2002), which defines adaptation rules within the content package, we suggest – as depicted in the following subsections – enhancements of *SCORM* to support adaptive e-learning. Finally, other aspects not covered by *SCORM* are analysed.

Enhancements on learning objects and sequencing

As mark **[a]** in figure 1 shows, the structure of a course, the so-called "Organization", can be defined in a hierarchical way using items, sub-items, etc. The mapping to the learning objects, mark **[b]**, is unique and should not be changed from the logical point of view. Mark **[c]** shows the first extension we suggest: Instead of a unique mapping from one SCO to other assets and SCOs, a learning object should be able to contain several aggregations of SCOs and assets with a different number of elements which can even be arranged in arbitrary order. Such a mechanism may fulfil the requirements (A2) to (A4). Sequencing the learning objects as described with requirements (B1) and (B2) is covered with the *IMS Simple Sequencing* (see mark **[d]**).

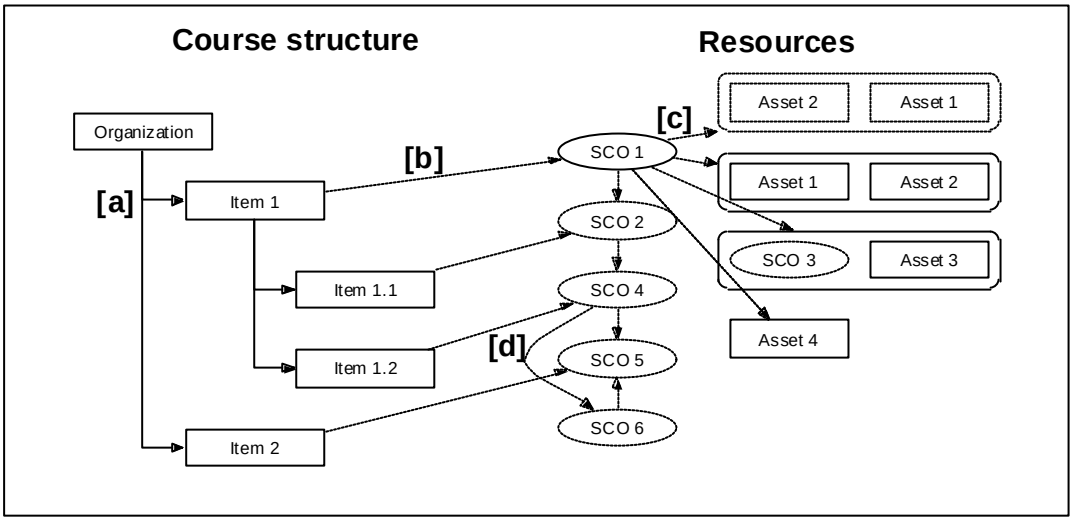

Figure 1: Enhancing SCORM's Organization and Content

Enhancements on assets

To fulfil the requirements (A1), (D3) and (D4) we suggest an extension of the assets as pointed out in figure 2. On the one side, an asset should be able to include more resources at once (see mark **[a]**). These coexisting resources could be assigned to certain attributes, e.g. to the learner's characteristics. On the other side, there should also be the possibility to combine several resources from one asset (see mark **[b]**). This enhancement would allow to aggregate different resources to one asset or to store a textual fragment within a *XML* file and to specify several *XSLT* files for different kind of content presentations. As a result of this last suggestion, the e-learning environment would have to implement this *XML* transformation on the level of an asset.

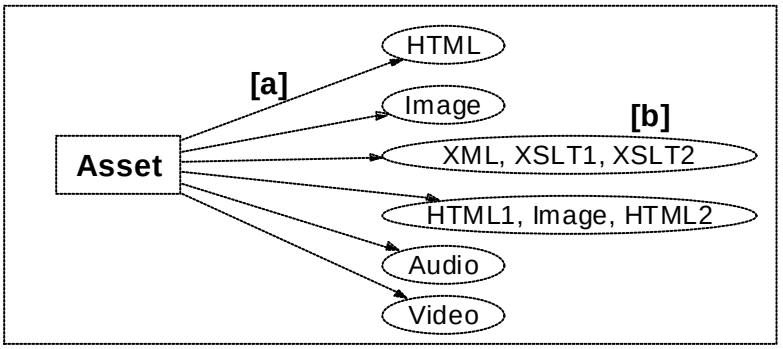

Figure 2: Enhancing SCORM's Asset

Other aspects

As *SCORM* does not support user profiling, it is necessary to adopt an existing *XML*-based specification like *PAPI* (see PAPI 2000) or *GESTALT* (see GESTALT 1999). According to the requirements on user profiling, it is necessary that the chosen standard considers domain-specific information like domain knowledge, records of learning behaviour, records of evaluation and assessment (see Brusilovsky 1994) plus domain-independent information like cognitive attitudes, motivational states, background knowledge, multiple intelligences, learning styles, etc. (see Lane 2000). Furthermore, it is important that this specification is well-performed to allow real-time user tracking.

To fulfil the requirements (D1) and (D2), the standard needs to support modelling of knowledge domains and defining the contexts for e-learning. Therefore, we suggest to adopt other existing specifications like the *IMS Reusable Definition of Competency or Educational Objective* (see IMS 2004) to describe knowledge domains and concepts. Furthermore, it is necessary, that the specifications for learning content and sequencing ought to be extended to be able to link to the learner's characteristics, knowledge domains and concepts as well as contexts and tasks as pointed out in requirements (A4) to (A6) and requirements (B3) to (B5).

Due to using *XML*-based specifications, the extensions described in this subsection can be easily made by modifying the mark-up definition. Concerning the specifications to adopt, we do not want to give any recommendation this far, because detail expenses within the *AdeLE* project have to be evaluated on criteria like performance, flexibility, etc.

Conclusions and Future Work

To sum up this paper, we have to point out that adaptivity can be useful and necessary in the field of e-learning. The most outstanding chance for adaptive e-learning is the possibility to enhance the learning as well as the teaching processes in terms of efficiency. Nevertheless, an adaptive e-learning environment also has to consider financial aspects like the transferability and reusability of e-learning content. On basis of these reflections, this paper explained possible adaptive approaches, the consequences for an e-learning standard as well as an exemplary enhancement of the *SCORM* standard. Regarding to the last section, adaptivity as well as adaptability aims at extending the design of learning objects and assets. Although *SCORM* partially fulfils the requirements for adaptive e-learning, it has to be extended by other specifications covering the missing aspects of adaptive e-learning. Concerning enhancements of existing e-learning specifications, we have to mention that it is important to consider downward compatibility to guarantee that the e-learning content still is usable in other systems.

Regarding the research project *AdeLE*, we can conclude that we apply *SCORM* as pointed out in this paper and design the architecture of the system on basis of the extended specifications. Due to necessary features like the *XML* transformation for assets or alternative assets for one *SCO*, it is obvious that the system's architecture has to be very flexible to be able to adapt to changing specifications in a fast and easy way. Therefore, we are developing an own framework, the so-called *Service-Based Framework (SBF)*, which still is in an early designing stage and cannot be explained closer now. Regarding the question about which specification we have to adopt in addition to *SCORM*, at this time we are focused on *PAPI* and the *IMS Reusable Definition of Competency or Educational Objective* extended in terms of modelling e-learning contexts and tasks.

For future work we will generate exemplary e-learning content based on the enhanced *SCORM* standard and adopt missing specifications as well as adapt the resulting standard in terms of new insights or new recommendations of ADL, IMS or any other organisation. Nevertheless, this kind of developing process for the well-tailored e-learning specifications for *AdeLE* is very evolutionary and can last a long period. Therefore, we plan to implement a prototypical environment on basis of the *Service-Based Framework* at the same time. The framework should be that flexible that minor changes of the e-learning standard can be implemented for the system very quickly.

References

ADL (2001) Advanced Distributed Learning: *Sharable Content Object Reference Model Version 1.2: The SCORM Overview*, 2001. Last visit: 2004-01-29, URL: http://www.adlnet.org/index.cfm?fuseaction=DownFile&libid=40&bc=false

ADL (2004) Advanced Distributed Learning: *SCORM*, 2004. Last visit: 2004-03-26, URL: http://www.adlnet.org/index.cfm?fuseaction=scormabt

Blöchl et al. (2003) Blöchl, M.; Rumetshofer, H.; Wöß, W.: Individualized E-Learning Systems Enabled by a Semantically Determined Adaptation of Learning Fragments. In proceedings of *DEXA 2003*, 2003.

Brusilovsky (1994) Brusilovsky, P.: The construction and application of student models in intelligent tutoring systems. In journal *Journal of Computer and System Sciences International*, vol. 31, pp. 70-89, 1994.

Brusilovsky (1996) Brusilovsky, P.: Methods and techniques of adaptive hypermedia. In journal *User Modelling and User-Adapted Interaction*, vol. 6, pp. 87-129, 1996.

DerekStockley (2004) DerekStockley: E-learning Definition and Explanation (Elearning, Online Training, Online Learning), 2004. Last visit: 2004-04-29, URL: http://derekstockley.com.au/elearning-definition.html

Dietinger (2003) Dietinger, T.: *Aspects of E-Learning Environments*. Graz University of Technology, Dissertation, 2003.

DLNET (2001) DLNET: *Brief Introduction to Learning Objects in DLNET*, 2001. Last visit: 2004-04-29, URL: http://www.dlnet.vt.edu/Resources/reports/ARI_LO_Def.pdf

Garcia et al. (2004) Garcia Barrios, V.M.; Gütl, Ch.; Preis, A.M.; Andrews, K.; Pivec, M.; Mödritscher, F.; Trummer, Ch.: AdeLE: A Framework for Adaptive E-Learning through Eye Tracking. In proceedings of *I-Know'04*, 2004.

GESTALT (1999) *GESTALT: Getting Educational Systems Talking Across Learning-Edge Technologies*. Work Package 3, D0301 Design and Specification of the RDS (Resource Discovery Service), 1999.

Han (2001) Han, B.: Student Modelling and Adaptivity in web-based Learning Systems. Massey University New Zealand, 2001.

Hasebrook (2001) Hasebrook, J.P.: Learning in the Learning Organisation. In journal *J.UCS*, vol. 7, pp. 472-487, 2001.

Hoppe (1995) Hoppe, U.: Use of multiple student modelling to parametrize group learning. In proceedings of *AI-ED'95*, 1995.

Jain et al. (2002) Jain, L. C., Howlett, R. J., Ischalkaranje, N. S., Tonfoni, G.: Virtual Environments for Teaching & Learning. In book *Series of Innovative Intelligence*, vol. 1, World Scientific Publishing Co. Pte. Ltd.; 2002.

IMS (2004) IMS Global Learning Consortium: Overview of Specifications. 2004. Last visit: 2004-02-04, URL: http://www.imsglobal.org/overview.cfm

KOD (2002) KOD: *Knowledge On Demand*. Informatics and Telematics Institute, 2002. Last visit: 2004-03-26, URL: http://kod.iti.gr/

Lane (2000) Lane, C.: Learning styles and multiple intelligences in distributed learning/IMS projects. In *The Education Coalition (TEC)*, 2000. Last visit: 2004-04-29, URL: http://www.tecweb.org/

Lennon et al. (2003) Lennon, J., Maurer, H.: Why it is Difficult to Introduce e-Learning into Schools And Some New Solutions. In journal *J.UCS*, vol. 9, pp. 1244-1257, 2003.

Moallem (2001) Moallem, M.: The implications of the research literature on learning styles for the design and development of a Web-based course. In proceedings of *AECT 2001*, 2001.

Mödritscher et al. (2004) Mödritscher, F.; Gütl, Ch.; Garcia Barrios, V.M.; Maurer, H.: Why do Standards in the Field of E-Learning not fully support Learner-centred Aspects of Adaptivity? In proceedings of *ED-MEDIA 2004*, 2004.

Oppermann (1994) Oppermann, R.: *Adaptive User Support: Ergonomic Design of Manually and Automatically Adaptable Software*. Hillsdale, 1994.

Qu et al. (2002) Qu, C.; Nejdl, W.: Towards Interoperability and Reusability of Learning Resources: a SCORM-conformant Courseware for Computer Science Education. In proceedings of *IEEE ICALT*, 2002.

PAPI (2000) IEEE: *Public and Private Information (PAPI) for Learner*, IEEE 2000, Draft Standard for Learning Technology, IEEE P1484,2/D6, 2000.

Specht (1997) Specht, M.: *Adaptive Methoden in computerbasierten Lehr/Lernsystemen*. Universität Trier, Dissertation, 1997.

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