Towards the Dynamic Personalized Selection and Creation of Learning Objects

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Abstract: Delivering the most appropriate learning object for a learner's goals, needs and preferences presents an interesting research challenge. [Dagger et al., 03] presents a solution based on the production of and selection between multiple candidate pieces of content. This solution is predicated on appropriate metadata being available that adequately describes those candidates (and more importantly the differences between them). The ability to dynamically create new Learning Objects at runtime to fulfill the learner's needs and based on their preferences is one of the goals of the iClass project [iClass]. This paper describes the LO Generator and its function within the iClass suite of eLearning services. Specifically, it describes the different modes of operation of the LO Generator and how it utilizes different pieces of learning content to deliver the most appropriate Learning Object to the learner.

Introduction

Making learning experiences in all types of settings more effective and efficient for both the learners and the teachers [Koper and Van Es, 04], is the idea behind the implementation of an eLearning system. The system should present the learning content in an attractive way to the learner while all the time making it more accessible. The quality of the content should be one of the main focuses, along with the interactivity available both to the learner within the learning environment and also outside it, i.e. interactions with classmates, discussion sessions, etc. This refers to the idea that learning doesn't come from the simple provision of knowledge; it is the activities undertaken by the learner both within and outside the learning environment that facilitate learning.

As part of the iClass project [iClass] a repository of discrete learning objects (LOs) is maintained. These atomic learning objects are independent pieces of content, which either represent a specific learning goal or learning event, or fulfill a step in a sequence of LOs which together satisfy a learning goal or learning event. The LO Generator is a service within the iClass project, and is the service which looks after the selection and creation of these LOs. Getting information from various other services running within the iClass system influences this selection and creation and builds towards the personalization aspect of the service. Learner information is one of the most important pieces of information that is given to the LO Generator. This allows the service to make an informed decision on the selection or creation of a learning object based on various different preferences or abilities of the learner, e.g. pedagogical preferences, prior knowledge, etc. This service is the one that is described in this paper.

This paper aims to describe the approach undertaken in selecting a relevant LO and the proposed approach to creating a relevant learning object during the automatic creation of a course. This selection or creation will be described in relation to the interactions with other services and modules within the iClass project. This paper will provide a brief state of the art on adaptive hypermedia, followed by an introduction to the European funded iClass project. An architecture of the system (the LO Generator) will be provided, as will the next steps leading to its full implementation.

The Adaptive Personalized eLearning Service (APeLS)

Brusilovsky [Brusilovsky, 96] defines adaptive hypermedia as "By adaptive hypermedia systems we mean all hypertext and hypermedia systems which reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user. In other words, the system should satisfy three criteria: it should be a hypertext or hypermedia system, it should have a user model, and it should be able to adapt the hypermedia using this model."

An Adaptive Hypermedia System (AHS) [De Bra, 01] [Brusilovsky, 96] used in the context of eLearning encompasses the idea that different learners learn at different rates in different ways. A hypermedia system consists of a collection of linked nodes (hyperdocuments), which provide links to enable a learner to traverse to other nodes within the hypermedia space. In these AHSs the learning experience is tailored to the specific capabilities and past history of the individual learner, using techniques such as adaptive navigation structuring, adaptive content selection and adaptive presentation. Studies have shown that users of educational AHSs are faster, more goal-oriented and take fewer steps to complete a course and also prove less likely to repeat the study of content that they have already covered [Conlan, 00].

The Adaptive Personalized eLearning Service (APeLS) [Conlan and Wade, 04], developed in Trinity College, provides a generic model for integrating the learner model (which describes the pertinent learner characteristics), content model (which describes the pedagogical qualities of the content) and the narrative model (which describes a mechanism for combining the content to produce a coherent educational courseware component), to create an adaptive eLearning system. The narrative describes the various sequencing rules and metadata which govern the range and scope of different personalized courses that may be produced by the adaptive engine [Conlan et al., 02].

The adaptive engine provides the facilities for reconciling the content, learner and narrative models in order to produce individualized content. The models need a high level of detail in order to achieve a high level of adaptivity. This detail takes the form of focused pedagogical elements which need to be added to the metadata in the various models. These elements should provide information on how to combine the different models to provide coherent course material to the learner. The system is an adaptive metadata driven engine that employs a multi-tiered AI model to achieve effective adaptation to the learners' requirements, and composes, at runtime, tailored educational experiences across a single content base. Very little semantics are actually embedded in the adaptive engine itself. Using appropriate pedagogic instruments, the learner can control the dynamic building of the course. This approach enables multiple narrative models to be constructed to fulfill different learning goals, while these goals may be achieved from a common repository of content.

The iClass Project and the LO Generator

The European Commission IST FP6 project iClass [iClass] is investigating the roll-out of personalized eLearning in the European K12 market. iClass is an integrated project constituting 22 partners from 11 different countries. It is working to develop an intelligent cognitive-based open learning system and environment, adapted to individual learners' needs at a European level. As part of the project a suite of services is being developed to support the various actors involved in education including the teachers (Teacher's Preferences Tool), the students (Student's Preferences Tool, Profiler and Monitor), school authorities and administration (Reporting Tool) and legacy LMS vendors (Adapter). There are three services which are central in the provision of personalized eLearning experiences in iClass – the Selector, LO Generator and Presenter [Brady et al., 2005].

In iClass a concept domain is described in terms of a concept domain ontology, which in turn describes the concepts that make up the domain as well as the relationships between them. This concept domain ontology would ideally be pedagogically independent, but this is often not possible as the ontology often corresponds to a specific subject matter and curriculum. Curricula contain details of not only what needs to be taught, but also how it should be taught and, therefore, are rarely pedagogically neutral. The use of an ontology in this way speeds up the time taken to develop courseware and also reduces the cost involved as this view of the curriculum can help define the development of learning content.

The importance of separating the pedagogy from the concept domain ontology from the content stems from the need to make maximum reuse of these elements [Dagger et al., 03] and also to provide the ability of replacing them when necessary. Investigations in the iClass project have indicated that this level of reuse of the concept domain ontologies and the strategies that operate across them may not be feasible. The reusability of learning content is, however, a key issue.

A way of enhancing the educational impact of eLearning courses is to facilitate the personalization and repurposing of learning objects across multiple related courses [Conlan et al., 02]. In [Weller et al., 03] a learning object (LO) is defined as embodying "the concept of digital, self-contained 'chunks' of learning capable of reuse in different contexts and drawn together 'on the fly'. When using LOs as part of an eLearning course, the manner in which the learning content is written has to be dramatically altered from the case where the course is presented as an entirety. There are various demands on individual LOs which would not exist in a complex course; demands such as autonomy, independence, format and structure. A LO is seen as the smallest piece of content that can be used independently; if broken down further the content would become incomprehensible. One of the obvious benefits of LOs is reuse. A LO which is independent of a course or a specific pedagogical strategy is a very useful entity. The provision of metadata describing a LO is inherent in its use. If a LO is sufficiently described, it can be easily selected to fulfill a particular learning objective.

In iClass there are two types of learning objects – LOs and iLOs, both of which are composed of atomic assets. The distinction between a LO and an iClass LO (iLO) is important. A LO does not contain any conditional branches or adaptive behavior. An iLO, on the other hand, may include adaptive features. There are a number of possible modes in which LOs (or iLOs) may be produced –

- LO Generator creates a new LO from atomic Learning Assets
- LO Generator creates a new iLO from atomic Learning Assets adding the appropriate Learning Design [IMS LD] or Simple Sequencing [IMS SS] as required
- LO Generator creates an LO, based on an existing iLO, by selecting the most appropriate path specified by the LD or SS of that iLO

The iClass system has a number of repositories that store and monitor various learner and teacher models. Using the Teacher Preference Tool, the teacher specifies the scope of the course to be taught, which details the aspects of the concept domain that the teacher wants the learners to learn while using the course. At this point the teacher has other options available to him/her, including the ability to indicate the desired outcome of the course and also any content that he/she would either want included or not included in the course. The teacher can also specify his/her preferred learning style or pedagogical preferences.

The Selector and LO Generator services are both based on the multi-model approach proposed by APeLS, which is described briefly above. The operation of the LO Generator relies on the behavior of the Selector service [Brady et al., 2005]. When the Selector service is invoked, it parses the relevant learner and teacher models, also taking into account the scope of the course outlined by the teacher, to produce a sub-domain, which is a subset of the original concept domain. The Selector again uses the learner and teacher preferences to select an appropriate pedagogical strategy. This decision is based on the learner's prior knowledge, learning goals and personal preferences, while also taking into account the teaching preferences of the teacher.

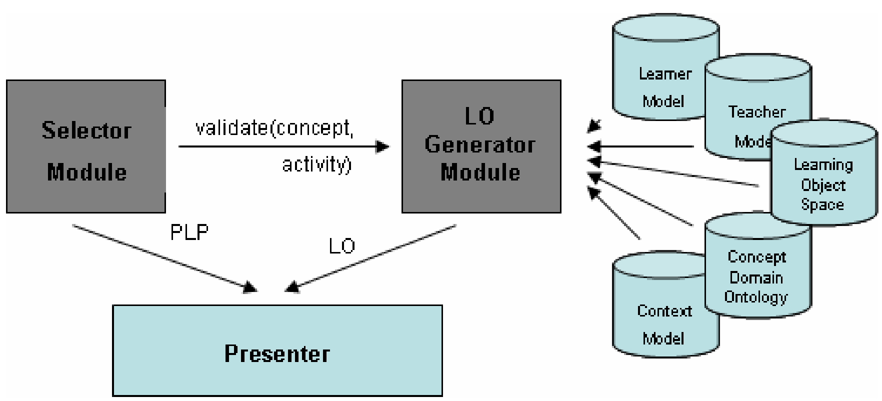

Figure 1: Interactions between the Selector and LO Generator

Using the pedagogical strategy the Selector can choose relevant activities that the learner must undertake in order to fulfill the strategy. The output of the Selector is a Personalized Learning Path (PLP) which contains a structure of concepts to teach the learner, coupled with pedagogical information on how they should be taught. For example, a PLP for a particular learner may describe the teaching of the biology of the human eye in a case based approach – initially the PLP states that the problem of "How do we see?" should be introduced; next several cases of how animals, such as insects, fish, birds and mammals see may be required; finally, the human eye is presented and the learner is asked to figure out how it works and which animals it most closely matches. It is important to note that the PLP does not prescribe which content is used to teach the concepts. The realization of concepts with real learning objects is the role of the LO Generator.

When the Selector has finished selecting appropriate concept(s) and an activity type, it then calls the LO Generator to validate that these concept(s) and activity, while based on a particular pedagogical strategy, may be realized as a concrete learning object. It is then the responsibility of the LO Generator to select the most appropriate learning content from the learning object space which corresponds to these specific concept(s) and activity. The LO Generator must also account for learner and contextual preferences in the selection and generation of learning objects. In this way the Selector guides the overall pedagogical strategy of the learning, but the LO Generator personalizes towards the learner's preferences and current context. When validating these concept(s) and activity, the LO Generator will essentially produce a list of candidate LOs that satisfy these specifications. This list may be further narrowed down by using relevant learner information. If there are no relevant LOs to select that satisfy the conditions, the LO Generator will attempt to generate a relevant LO. This may be done by morphing an existing LO, or by creating a completely new LO.

The produced LO should consist of the appropriate Learning Assets, an XML Manifest and possibly some LD/SS based on the IMS Content Packaging [IMS CP] (in the case of an iLO). Through the manifest a collection of sequenced learning assets, which corresponds to the sequence of learning concepts specified by the PLP may be specified. Where the output is an iLO the sequence of assets may not be known until runtime. In this case it is specified by an IMS LD or SS.

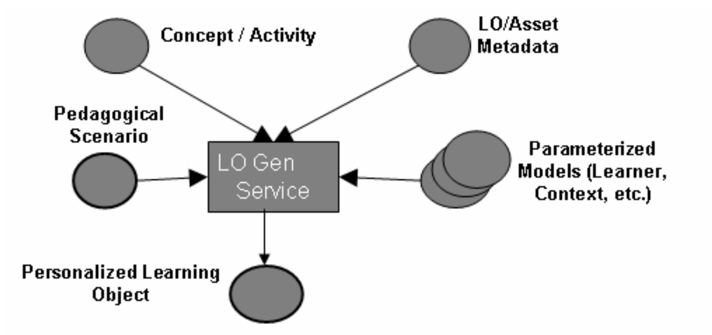

Figure 2: Inputs/Outputs of the LO Generator

The LO Generator uses a number of different models to both select and generate these personalized learning objects. In order to aid the personalized selection process, the LO Generator makes use of the learner model to obtain information about the general preferences and also the pedagogical preferences of the learner. Similar information which may be of use to the service is information about the teacher, including their preferred pedagogical strategy, or specific details they may want to be included in the course. Use will also be made of information obtained from the repository of contextual data, which stores information about the environment, device type, etc. For example, it would be very important to know what type of device the learner will be looking at the course on, because a LO that would be suitable for viewing on a full size screen would be very different to a LO that would be suitable for viewing on a PDA screen. A narrative is also included and executed within the adaptive engine. This narrative provides the storyline or strategy which will be used to enable the selection or creation of the relevant learning objects.

The concept(s) and activity selected by the Selector service is an important input into the LO Generator, and this provides the relevant pedagogical information that the LO Generator will have to satisfy in order to select a relevant learning object. Obviously, the LO Generator also has to communicate with the learning object space, which provides access to the actual content needed for the selection and generation of the learning objects needed for the course. This content is comprised of low level LOs, which may not necessarily make sense individually, but will when combined with other LOs.

Within the scope of iClass, the required information is obtained from various other services which are being developed. The learner information is obtained from the Profiler service, which collects data about the learning style and preferences of the learner, evaluates this data and generates an individual learning style profile for the learner. It utilizes various assessment tools and also models static information about the learner. The Monitoring engine receives information about the learning success of a student's learning activities and assesses their competencies for related skills and knowledge sets. This information is then passed to the LO Generator to assist in the generation of appropriate learning objects. By using the Student Preference Tool, the LO Generator can tailor the LOs to the specific learner's learning preferences. And by using the Teacher Preference Tool, the LO Generator can produce LOs that reflect the teacher's preferences and approach to learning.

Future Work

This section will present the next steps that will be taken in order to bring the implementation of the LO Generator forward.

The LO Generator will need to be extended to facilitate the use of different information models. At present the service does not make direct use of the supplementary models detailed in the architecture section, e.g. a Learner Model. In the case of the learner model, the LO generator receives indirect information about the learner's competencies from the Selector. By looking at additional preferences of the learner, determined from supplementary context models, the most appropriate LO may be identified from the list of candidate LOs. It will be the responsibility of the LO Generator narrative to qualify this selection based on the information obtained from the supplementary context models.

At present, when searching for relevant learning objects, the LO Generator simply searches the metadata of existing LOs using a multiple word search, e.g. *cornea*, *lens*. This ensures that the LO found will have all of these words as keywords. Obviously, it would be beneficial for to allow searching using compound expressions, i.e., using queries with the operators AND, OR and NOT.

Another way of making the search more powerful would be to perhaps allow the client calling the LO Generator to form its own query and pass this to the learning object space in iClass. For this a simple query language, understood by the LO Generator and any client (e.g. the Selector) would have to be utilized. At the moment Simple Query Interface using the Very Simple Query Language [Massart, 05] specification are leading contenders. The LO Generator narrative will then interpret this query in order to retrieve the required information. A benefit of the use of a query in this manner would be that it may allow for more flexible retrieval. In a situation where no results are returned the query may be altered intelligently from within the narrative giving different precedence to different learner parameters to find an approximate result.

The LO Generator may also need a facility to determine whether a selected LO fulfils the requirements laid out by the client, and may need to detail why a particular LO was selected over any other. This may be included in the form of an appropriateness measure which will be a way of indicating the relevancy of a candidate LO. Therefore when the LO Generator gets a list of all of the candidate LOs, it may examines and give each a numerical grading. The LOs will therefore be ranked using this measure and two lists will be presented to the client, a lost of all of the appropriate LOs and a list of all of the inappropriate LOs. Therefore when the client gets back the list of candidate LOs, the appropriateness measure is also included, allowing the client to make a more informed selection.

Another feature that would prove of great benefit would be the provision of more information about the candidate LOs to the client. The aim would be to get a fuller description of each LO and perhaps a written comparison of different LOs and present this information to the client, where the client may be a tool that an end user (possibly an course creator) uses. This information would be more useful than the metadata currently available about the existing LOs. The LO Generator would also be able to provide relative information between several candidates, e.g. how they differ, how they are similar.

Conclusion

An initial version of the LO Generator has been developed for the iClass integration which took place in the autumn of 2005. This version took a simplified approach, and was implemented to get a prototype version of the service up and running. From this prototype it was possible to define the interactions between different services in the iClass framework and put the necessary integration hooks in place. It also provided a way of implementing the basics of any technologies that were used. The initial LO Generator prototype has operated across iLOs in it selection mode to select the most appropriate Learning Design path for the current learner. These iLOs are in the domain of Food and Nutrition.

These iClass learning objects and their relevant metadata were prepared by the iClass content developers and the Learning Design paths are being elaborated at the moment. The learning objects were based on the principles taught when learning about Food and Nutrition. A narrative was written for the LO Generator that searched through the metadata describing existing LDs and provided a list of relevant LDs based on a keyword search. With more detailed LD paths and more descriptive metadata about these paths the LO Generator will be able to make more informed decisions. This initial prototype will be trailed with real users in the winter of 2005. The iClass project has three 18 month release cycles with June 2005 being the end of release one, deemed as the basic functionalities release. The user trials will be used to gauge user acceptance and the effectiveness of the iClass services. It is envisaged that the next release of the LO Generator will examine the issues behind the dynamic creation of Learning Objects from atomic assets, in line with the ideas expressed in this paper.

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