DIFFERENT MODELS FOR PERSONALIZATION REALIZATION IN CONTEMPORARY ELEARNING SYSTEM

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***Abstract**:* In recent years the use of the Web has increased exponentially. Now Web has become mainstream medium for communication and information dissemination. This paper presents approaches and methods for adaptive learning implementation, which are used in some contemporary web-interfaced Learning Management Systems (LMSs). The problem is not how to create electronic learning materials, but how to locate and utilize the available information in personalized way. Different attitudes to personalization are briefly described in section 1. A personalization of learners' access to learning objects by providing results tailored to the individual or group of learners as the response to search queries. Some aspects of personalization can also take place even before a query is submitted for evaluation. These issues are included in section 2. A method for development and design of adaptive learning content in terms of learning strategy system support is represented in section 3. In section 4 is described a model for role- and competency-based learning customization that uses Web Services approach. The last part presents how personalization techniques are implemented in Learning Grid-driven applications. In the end of the paper a summary is represented.

***Keywords**: Adaptive Learning Content, Customized learning, Grid technologies, Learning Management Systems, Personalization, Simple Sequencing, Web Services.*

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INTRODUCTION

Personalisation, which became one of the key concepts in current education, reacts to the fact that students come to school with different knowledge and skill bases as well as varying learning preferences, interests, and aptitudes. Personalised learning presupposes high quality teaching that is adaptive to the different ways students achieve their knowledge and skills. Therefore, the teaching courses, curricula, and school organisations have to be designed in a way to reach as many students as possible with diverse needs and experiences for as much of the time as possible. Personalised courses actively engage the learners by providing teaching strategies and materials that appeal to the learners' knowledge and preferences etc. Since it would be costly and unfeasible for teachers to produce personalised courses that meet all of these requirements, the LMSs are of prime importance for education. Such systems allow for delivering information outside the traditional bound of a classroom situation, where learners are taught by a static one-fits-all approach. An educational system that responds to individual needs by creating a personal learning path enables individual students to experience excellence in his or her learning. Analytical study of key functional LMSs requirements such as adaptability, personalization, modality, possibility for record-keeping on student's performance, and usage statistics for the system as a whole has been done in [Pavlov et al.'04].

The personalization includes how to find and filter the learning information that fits the user's preferences and needs, how to represent it and how to give the user tools to reconfiguration the systems, in consequence, reconfiguration system could be part of personalized environment in some systems. The user modelling is the process of constructing (often computer-based) users models, background knowledge and users behaviour representation, while the user model means all the information collected about a user that logs to a web site, in order to take into account her needs, wishes, and interests. Every LMS has its techniques to modelling his users so as to construct the user model or profile.

In general the personalization might be examined in the following aspects [Zheleva'05, Graziano et al.'03, Gibson et al.'02]:

- Personalization of the learning content, based on learner's preferences, educational background and experience, learning content tailored to individual learning style of the user;
- Personalization of the representation manner and the form of the learning content (for example, learning content in the form of the adaptive learning sequences of learning objects).
- Full personalization, which is a combination of the previous two types.

The following approaches can be used to apply the learning personalization:

- Personalization, controlled by the learner – It requires direct input of the learner's needs and preferences by filling question forms or by choosing options and alternatives.
- Personalization, based upon an existing user profile and meta-descriptions of the information content - In this case, the learners' preferences are stored in their profile.
- Personalization via searching for a correlation between the learners - Correlation is through the values of the attributes, describing the learner's profile. If there is a strong correlation, there is a possibility that the content for a given profile is suitable for applying to its close (adjacent) profiles.

Personalization in current Learning Management Systems tends to be concerned with remembering which courses the user is allowed to view and how they like their pages to be presented. In some cases users are able to edit their own profile; to maintain their personal calendar which keeps track of their event transactions; to subscribe to forums, etc. Observing the educational process as a whole, learners are very rarely allowed to get access to learning objects which are conditioned on a wide range of personal data including achievement, date/time and class code. In [Paneva'05] the author gives an overview of several methods for implementing personalization, which are exploited in several widely used LMSs in the recent years.

Tailoring to individual learning styles

In the contemporary learning environments personalization techniques of learners' access to learning objects have to provide results tailored to the individual or group of learners and their learning styles as the response to search queries. When users search for learning objects (LOs), i.e. the collection of content and learning resources maintained in a content repository, the results returned to them will depend on who they are as well as their query, since different LOs may be more appropriate for different learners. Personalization will have an effect on search results returned from a keyword-based query at three different levels [Paneva'05]:

- Filtering of the returned LOs - excluding those LOs deemed unsuitable for the learner, even though they satisfied the original query;
- Ranking of the returned LOs - the 'best' LO for one user may be different from the 'best' LO for another, but personalized ranking means that they can both have the most suitable LO for them returned at the top of their search results;

- Presentation of results - users will have different preferences for the display of their search results (e.g. display results as trails or as a simple list, display 10 results per page or 50 results per page).

Some aspects of personalization can also take place even before a query is submitted for evaluation: personalized queries can be constructed using information stored in the profile, by re-formulating or annotating the user's original query to reflect elements of their profile. The user profile has to contain information about preferences, aims, and educational history that can be used by the system. This is the first stage of filtering.

Keyword-based query is not the only way that users can locate LOs – the schema of the LO descriptions can also be browsed to find relevant LOs, providing facilities such as 'browse by author' and 'browse by subject'. Personalization of the browsing process can occur at two levels:

- Allowing users to restrict the information they see to only those attributes of interest to them, organised in their preferred manner.
- LMS can use knowledge of a user's preferences (either those explicitly supplied by the user or those learned by the system itself) to recommend individual LOs or categories of LOs to the user as they are browsing.

Filtering and ranking search results

The query service will return a set of LO descriptions - all those LOs that satisfy the user's query. The user wants to be able to find exactly the right LO quickly, without having to browse too many of the results, so rather than present the results exactly as they are returned by the query service some processing is done first.

If a profile of the user is not available (or the user has personalization turned off) then all that can be done at this stage is some rudimentary ranking of the result set, possibly using standard ranking techniques from information retrieval and web search.

However, we anticipate that usually some minimal profile will be available to the system, as users should supply at least some minimum information into their profile when first registering. In this case the ranking of LOs will involve personalization. This means that the system can attempt to show the user only those results likely to be most relevant to them personally, as well as relevant to the query in general.

The first step in this processing is to filter the results - remove all those LOs that we are certain will be of no use to the user. At this stage, for example, any LOs in languages that the user does not understand can be eliminated, as can those not meeting accessibility requirements, those at a far too high or low level of difficulty and possibly those covering only material that the learner is already completely familiar with.

Next, the remaining set of LO descriptions must be ranked in order of relevance to the user. Whereas filtering can be done with just the user profile, ranking a set of results should take the original query into consideration too (i.e. relevance must be judged against the combination of user profile and query, not just the profile).

The best algorithm to use for this ranking is still an open question, but it will take into consideration:

- Relevance of the LO to the query;
- How well the LO caters for the user's accessibility requirements;
- Whether the user has the prerequisite knowledge and experience;
- Matching between the user's goals and the learning objectives of the LO;
- If the user's learning styles are those catered for by the LO;
- If the user is likely to prefer it for other reasons (it is by a preferred author, say);
- The user's most recent activity.

The clear individual semantics of each section of the user profile allows focussed matching against relevant sections of the LO descriptions. For a LO to be a „good" LO for the user, the greatest possible number of different elements will match to some degree. Clearly, though, some factors are more important than others to the user and a good algorithm for combining them will reflect this. For example:

- If LO X caters for one of the user's learning styles but is not very relevant to the original query then other, more relevant LOs should be ranked higher even if their descriptions don't list one of the user's learning styles;
- If LO Y has a learning outcome that matches one of the user's goals but is far too difficult for the user to tackle (they have none of the prerequisite knowledge, say) then again other LOs (closer to the user's level) should be ranked higher.

With so many factors to take into consideration, discovery of which algorithms work better or worse for which groups of users requires much further work and testing, and is beyond the scope of this project. It may be that the ranking algorithm itself needs to adapt to the individual, and will differ from user to user (an additional section could be added to the user profile to store information about parameters used by the ranking algorithm).

Support for browsing as a trail

As the user is browsing LOs the trails and adaptation service can actively recommend the next LO to look at, effectively generating trails of length two (i.e. a trail consisting of the current LO and a suggestion for the next one) at every stage of the user's browsing, based on the user profile.

The recommendations can be derived in several ways:

- from the semantic relationships between the current LO and other LOs in the LMS repository;
- from the user's profile plus LO metadata - perhaps suggesting LOs that cover more advanced material on the same topic, and also suit the user's preferences (learning style, accessibility, etc.);
- through a process of collaborative filtering, suggesting as the next step a LO that other similar users browsed after seeing the current LO (where similar users can be identified by having similar preferences or similar histories of LO access).

Methodology for development and design of adaptive learning content

The term "adaptive learning" means the capability to modify any individual student's learning experience as a function of information obtained through their performance on situated tasks or assessments. With the integration of the IMS Simple Sequencing Specification [IMS SS'03], SCORM [SCORM] allows the learning strategies to be translated into sequencing rules and actions, which are associated with the activities a learning experience consists of. The sequencing rules are based on learner's progress and performance and affect the availability of the learner is allowed to experience.

All learning activities can be associated with sequencing information defined by the content author. In run time, each activity experienced by the learner is associated with tracking status data, which may affect the overall sequencing process. This means that learners with difficulties in satisfying the learning objective should be able to experience additional activities (or repeat some of the activities) to improve their knowledge level and skills. Some restrictions concerning number of attempts and/or period of time for any activity could be set by the content author.

The process of defining a specific sequence of learning activities begins with the creation of a learning strategy for the achievement of the determined pedagogical aim/s. Learning strategy specifies types of learning activities and their logical organization (the activity tree) as well as the prerequisites and expected results for each activity. The rules for managing the instructional flow are the other important part of the strategy. Describing the rules by

means of IMS SS elements and attributes the content author transforms the sequencing strategy into strategy for the activity tree traversal management. The author establishes an aggregation of learning objects associating leafs of the activity tree with appropriate Sharable Content Objects (SCOs). The outcome of this process is a content package. The imsmanifest.xml file of the package describes SCOs organization and their sequencing. The implementation of adaptive learning in given eLearning environment could be promoted and facilitated by providing of sequencing templates for the development and design of instructional flows.

The sequencing template describes the conceptual organization of the learning content as a sequence of template pages and provides the learning strategy implementation translating it into sequencing strategy. Such sequencing template can be used in different knowledge domains from different instructors who want to follow the described in the package content organization and the implemented learning strategy. In this case, instructor is responsible only to identify (or create) and then to incorporate the relevant multimedia content in each of the template pages accordingly the subject matter of the course taking into consideration the concrete learning objectives and context.

The main advantage of the Simple Sequencing approach is that the sequencing rules are described outside the learning objects' content. In this way, the instructional designer can change the rules (i.e. the learning strategy) without any changes in the content or its organization. Nesting manifests of the developed sample packages the content author can developed more complex strategies and content structures. The main disadvantage of the methodology is that selected strategy cannot be changed dynamically in time of learning.

Customized learning and Web Services Approach

Customized learning, presenting just the right material to the learner on demand, can be described using data representations from learning technology standards (learner profiles, competency definitions, sequencing rules, learning objects). William Blackmon and Daniel Rehak [Blacmon et al.'03] offer a web services-based methodology for customization by profile, specifically one of eliminating LOs from a course because either:

- Learner's current role does not require the learning objective taught by the LO, or
- Learner's profile indicates the learner has already achieved the objective taught by a LO.

The learning content and data used in customization are represented in a set of standards-based data models. These are used in a content authoring and delivery process that customizes the activities delivered to the learner based on the learner's role and competencies [IMS Competency Definition, IMS LIP].

For content and learning activity customization are used six sets of data elements:

- Learning Objects - the collection of content and learning resources maintained in a content repository.
- Content Structure - the organization of learning objects in a tree or hierarchical structure.
- Roles - definitions of the job roles of a learner.
- Competency Definitions - definitions of the skills and knowledge acquired by a learner.
- Learner Information Package - the collection of stored profile information about a learner.
- Sequencing -- rules used to select content and sequence the learner through a content structure.

The major steps for a customized course preparation and delivering are[1]:

[1] Assuming there is a globally defined set of learner job roles and competency definitions

- Create Course and Content Description -- describe the course (content structure and set of LOs) and behaviour rules used to express the progression of the learner through the content:
    - Associate role and competency definitions with each learning object by mapping a sequencing objective id (used to label the objective) to a competency definition id or to a role id.
    - Specify the conditional rules used to customize the course by eliminating learning objects from the activity sequence.
- Establish Learner Profiles -- specify the role of the learner (which in turn may yield a set of competencies required to perform the role), and contain data on the learner's record relative to each of the specified competencies.
- Register Learners -- register the learner for the course.
- Deliver Course -- deliver the course, matching the course description to the learner's profile to select content. As the learner completes instruction, the profile may be updated to include mastery of subject matter. Delivery and customization continues until all required activities have been completed.

The customization process has been implemented through a set of web services. Rather than building large, closed systems, the focus is on flexible architectures that provide interoperability of components and learning content, and that rely on open standards for information exchange and component integration. The overall web services architecture for learning is divided into layered services. The layers from top to bottom in this services stack are:

- User Agents -- provide interfaces between users (both end user applications and program agents) and the learning services. Agents provide the major elements of learning technology systems: authoring of content, management of learning, and actual delivery of instruction to learners.
- Learning Services -- collection of (many small, simple) data models and independent behaviours. Service components are characterized as providing a single function that implements a particular behaviour. Each service is identifiable, discoverable, (de)referenceable, and interoperable. They include built-in security and rights management, and assume an unreliable underlying network. Services are grouped into logical collections, where upper-level services rely on the support from the lower-level services:
    - Tool Layer - Tools provide high-level, integrated server applications. Accessed via known, published interfaces, they provide the public interface to the learning tools (tutors, simulators, assessment engines, collaboration tools, registration tools, etc.). User agents and end user applications are built using collections of tool services.
    - Common Applications Layer - These are services that provide the commonly used learning functions and application support behaviours used by tools and agents (sequencing, managing learner profiles, learner tracking, content management, competency management, etc.).
    - Basic Services Layer - Basic services provide core features and functionality that are not necessarily specific to learning, but which may need to be adapted for learning (storage management, workflow, rights management, authentication, query/data interfaces, etc.).

All services are built on and use a common infrastructure model. The infrastructure layer relies on basic Internet technologies (e.g., HTTP, TCP/IP) to connect service components over the network. The services themselves are implemented using web services bindings. Messaging is done with SOAP; service descriptions are catalogued with UDDI, and described in WSDL - all are XML representations [Samtani et al.'02]. Overall service coordination is expressed in a workflow or choreography language. These standard technologies permit the upper-level services to be implemented in a platform-neutral manner, and provide interoperability across different implementations of the actual learning services.

Personalization techniques in Learning Grid-driven applications

The philosophy and approach behind Grid technologies [Hsing-Chuan et al.'04] show the right characteristics for achieving an effective learning. Indeed, they allow to access and integrate the different technologies, resources and contents that are required in order to realise new paradigms in eLearning. They are the most promising approach to realise an infrastructure that will allow learning process actors to collaborate, to take part in realistic simulations, to use and share personaliselly high quality learning data and to innovate solutions of learning and training. Grid will be able to support learning processes allowing each learner to use, in a transparent and collaborative manner, the resources already existing on-line, by facilitating and managing dynamic conversations with other human and artificial actors available on the grid, etc.

A high quality example of personalization techniques implementation, based on grids is demonstrated in SeLeNe (Self eLearning Networks). This project was funded as an EU FP5 Accompanying Measure (IST-2001-39045) running from 1st November 2002 to 31st January 2004. SeLeNe was part of action line V.1.9 CPA9 of the IST 2002 Work Programme, contributing to the objectives of Information and Knowledge Grids by allowing access to widespread information and knowledge, with eLearning as the test-bed application. The developers conducted a feasibility study into using Semantic Web technology for syndicating knowledge-intensive resources (such as learning objects) and for creating personalized views over such a Knowledge Grid.

A self e-learning network consists of web-based learning LOs that have been made available to the network by its users, along with metadata descriptions of these learning objects and of the network's users. The architecture of the network is distributed and service-oriented. The personalization facilities include: querying learning object descriptions to return results tailored towards users' individual goals and preferences; the ability to define views over the learning object metadata; facilities for defining new composite learning objects; and facilities for subscribing to personalised event and change notification services.

Summary

To sum up, the main goal is the possibility for learning adaptation to be assured for each learner in respect to her/his necessities, preferences, needs, performance, and progress. The achievement of interoperability and content reusability in the existing diversity of software and hardware platforms is a real challenge. One big limitation of the web-based interaction is the smaller communication bandwidth than traditional face-to-face interaction. The term bandwidth represents the amount of information that can be transferred in a unit of time through any means possible. In the face-to-face communication mode, if a verbal instruction is not understood, the clue can be available to the counterpart through gestures, group dynamics and other such means, but the clues in the web-based mode are not always so clear and in many cases not available at all. Therefore, tailoring the information to the right-level for the receiver to understand and integration of different appropriate methods for learning adaptation are crucial factors for the success of any LMS.

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