PERSONALIZED AND ADAPTIVE eLEARNING - APPROACHES AND SOLUTIONS

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Abstract

This paper presents personalized and adaptive eLearning approaches and solutions, which are implemented in some contemporary eLearning systems. Section 1 discusses basic concepts and different types of personalization. In the section 2 of the paper is described a solution for role- and competency-based learning customization that uses Web Services approach. A method for development and design of adaptive learning content is represented in section 3. The provision of personalized access to learning objects requires a profile to be modelled and stored for each learner and for each group of learners. Student modelling is discussed in section 4. A key requirement of learning management systems (LMSs) is 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 5. The last part presents how personalization techniques are implemented in Learning Grid-driven applications.

Keywords

Adaptive Learning Content, Customized learning, Personalization, Learning Grid, Learning Management Systems, Web Services.

1. INTRODUCTION

A key requirement of the contemporary eLearning systems is the personalization that is a function able to adapt the eLearning content or services to the user profile. The personalization include how to find and filter the learning information that fits the user 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. Analytical study of the main characteristics (adaptability, personalization, access, modality, etc.) for the contemporary Learning Management Systems and how they improve conventional education has been done in [1].
The authors define three types of personalization:

- 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.

Personalization in current LMSs 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 (learners, teacher and administrators) are able to edit their own profile; to maintain their personal calendar (monthly and weekly) 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. [8]

For instance, WebCT can provide personalised learning paths for users, as access to objects can be conditioned on a wide range of personal data. There would seem to be a lot more scope for individual personalization than this, as the WebCT system records quite a lot of information on the behaviour of the users (which documents they visit, how long they spend viewing them, test results and grades). At present this information seems to be used solely for the production of reports, but could be used towards providing a truly personalised educational experience without the need for large investments of course designers' time. [14]

Xtensis claims to be "a revolution in the management and delivery of e-learning" as it is specifically designed to handle LOs and their (IMS and SCORM-compliant) metadata. It is usable 'out of the box' as a learning management system, but can be configured to reflect the structure of an organisation and is more an architecture than a single product. Xtensis keeps a very detailed student record that allows for much personalization. As well as user interface preferences (graphics, colours, text size and font) and personal bookmarks the system stores a complete history of the LOs accessed by the user. This history, combined with LO metadata can be used by the system to make 'intelligent suggestions' about which LOs are the best ones to present to the learner next. The factors considered by the system include:

- the language of the LO (compared with the preferred primary and secondary language of the student);
- the platform being used at the time;
- the difficulty of the LO;
- the intended age range of the LO;
- prerequisites of a LO;
- nearness in a taxonomy of subjects (i.e. LOs dealing with the same, or similar topics);
- the preferred learning style.

So far there has been little use of Xtensis as an LMS to deliver content directly to learners, so the personalization and intelligent suggestion features are yet to be extensively used. The base functionality of classifying users and LOs and making suggestions based on a mapping between them has been used to automatically select versions of content based on users' learning difficulties or physical disabilities.
Areas that are specifically indicated as work for the future are the extension of personalised suggestion mechanisms to include factors additional to those mentioned above, and the further development and implementation of digital rights protection. [15]

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open source software package for producing internet-based courses and web sites. Depending on the difficulty level of the learning content and the general level of knowledge and skills of the learners, learning process can be realized dynamically. The exemplary scenario is the following. The students read the learning content and answers several questions. Based on the answers the student gave, the system determines the next screen piece of the content. In this way the navigation through the learning units will be system-guided and personalized.
The capacity for personalization of the environment is subject to be improved further in the next main release of the product. [16]

The possibility for adaptation of the learning content accordingly to the learner's performance and progress is a key issue for the learning process. 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. A method for development and design of adaptive learning content is represented in section 3. On the other hand, 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). In section 2 we present a web services-based methodology for customization by profile, specifically one of eliminating LOs from a course offered by William Blackmon and Daniel Rehak. Moreover, construction of an effective user model and tracking of its continuous changes are a real challenge in contemporary LMS with respect to providing adaptive learning content and personalized instructional flow/s. However, the process of development and accurate representation of the learner's information, knowledge, and behaviour, as well as the mechanisms for tracking the continuous changes in the learner's characteristics, is made more difficult in contemporary eLearning systems. The quality and expressive power of the user model is crucial in respect to the implementation of intelligent support for different adaptive teaching strategies and their switching during the personalization [2][3][4]. User modelling is a complex and sophisticated one. We discuss user modelling solutions in section 4. We suggest that the application of the semantic web approach to representing student model based on multiple student data with respect to the most important and well-developed learner model standards will help and decrease the difficulty of the process.

2. 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 offer a web services-based methodology for customization by profile, specifically one of eliminating LOs from a course [7] because either:

a. Learner's current role does not require the learning objective taught by the LO, or
b. 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 [17] [18].

Content and learning activity customization uses six sets of data elements (with data representations taken from current learning technology standards):

- *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]:

- *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.).

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

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 [6]. 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.

3. 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 [10], SCORM [11] 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. [10]

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. [12] [10]

4. STUDENT MODELLING

The student model enables the system to provide individualised course contents and study guidance, to suggest optimal learning objectives, to determine students' profiles and the actual knowledge they have acquired, to dynamically assemble courses based on individual training needs and learning styles, and to join teachers able to provide support in terms of guidance and motivation and therefore to help the students with different backgrounds and knowledge levels to achieve their learning goals effectively on the Web.

The software developers face a number of challenges and difficulties when trying to model student profile and activities on real eLearning systems. The process of collecting student modelling data is time-consuming and requires the development of complex data structures to represent student's personal information, knowledge and behaviour in the learning domain. Once student data is collected, it must be converted into a format compatible with knowledge representation and reasoning systems to function as the input for the adaptive systems. Faced

with these requirements, student modelling data is often stored in proprietary, hard-to-access formats that don't encourage reuse or distribution. In addition, in most cases the student models can only be used with the learning application, which it was developed for and when the application is changed or replaced they will be useless.
The student model needs to cover a certain amount of information that can be divided into two main groups:

– general student information such as learning goals, cognitive aptitudes, measures for motivation state, preferences about the presentation method, factual and historic data (personal information), etc.,
– information about student's behaviour in the learning domain such as overall competence level for the course, module competence level, concept competence level, module study time, test solving status, etc.

Naturally, student models "do not have to fully account for all aspects of student behaviour. In fact, we are interested in computational utility rather than in cognitive fidelity" [13].

Learner model standards

The interpretations of the student model do not have to be considered isolated from the developed standards and specifications in this area because the goal is to maximize the reusability and portability of the designed student model. Two of the most important and well-developed of these are the IEEE LTSC's Personal and Private Information (PAPI) Standard [23] and the IMS Learner Information Package (LIP) [18]. Both standards deal with several categories for information about a learner.

PAPI specifies the syntax and semantics of a "learner model", which characterizes a learner and his or her knowledge/abilities. This standard includes elements for recording knowledge acquisition, skills, abilities, learning styles, records, and personal information. This standard allows these elements to be represented in multiple levels of granularity, from a coarse overview, down to the smallest conceivable sub-element.
The purpose of this standard is:

- To enable learners (students or knowledge workers) of any age, background, location, means, or school/work situation to create and build a personal learner model, based on standards, which they can utilize throughout their education, learning experiences, and work life.
- To enable courseware developers to develop materials that will provide more personalized and effective instruction.
- To provide educational researchers with a standardized and growing source of data.
- To provide a foundation for the development of additional educational standards, and to do so from a student-centred learning focus.
- To provide architectural guidance to education system designers.

PAPI distinguishes personal, relations, security, preference, performance, and portfolio information. The personal category contains information about names, contacts and addresses of a learner. Relations serve as a category for relationships of a specific learner to other persons (e.g. *classmate*, *teacherIs*, *teacherOf*, *instructorIs*, *instructorOf*, *belongsTo*, *belongsWith*). Security aims to provide slots for credentials and access rights. Preference indicates the types of devices and objects, which the learner is able to recognize. Performance is for storing information about measured performance of a learner through learning material (i.e. what does a learner knows). Portfolio is for accessing previous experience of a user. Each category can be extended.

IMS Learner Information Package is based on a data model that describes those characteristics of a learner needed for the general purposes of:

- Recording and managing learning-related history, goals, and accomplishments;
- Engaging a learner in a learning experience;
- Discovering learning opportunities for learners.

The specification supports the exchange of learner information among learning management systems, human resource systems, student information systems, enterprise e-learning systems, knowledge management systems, resume repositories, and other systems used in the learning process [29].
The IMS-LIP standard contains several categories for data about a user. The identification category represents demographic and biographic data about a learner. The goal category represents learning, career and other objectives of a learner. The QCL category is used for identification of qualifications, certifications, and licenses from recognized authorities. The activity category can contain any learning related activity in any state of completion. The interest category can be any information describing hobbies and recreational activities. The relationship category aims for relationships between core data elements. The competency category serves as slot for skills, experience and knowledge acquired. The accessibility category aims for general accessibility to learner information by means of language capabilities, disabilities, eligibility, and learning preferences. The transcript category represents institutionally-based summary of academic achievements. The affiliation category represents information records about membership in professional organizations. The security key is for setting passwords and keys assigned to a learner [29].

IMS-LIP improves on PAPI slightly by providing a string field for learning goals. Moreover, the IMS LIP work incorporated the IEEE PAPI specification. Figure 1 describes such the relationship [30].

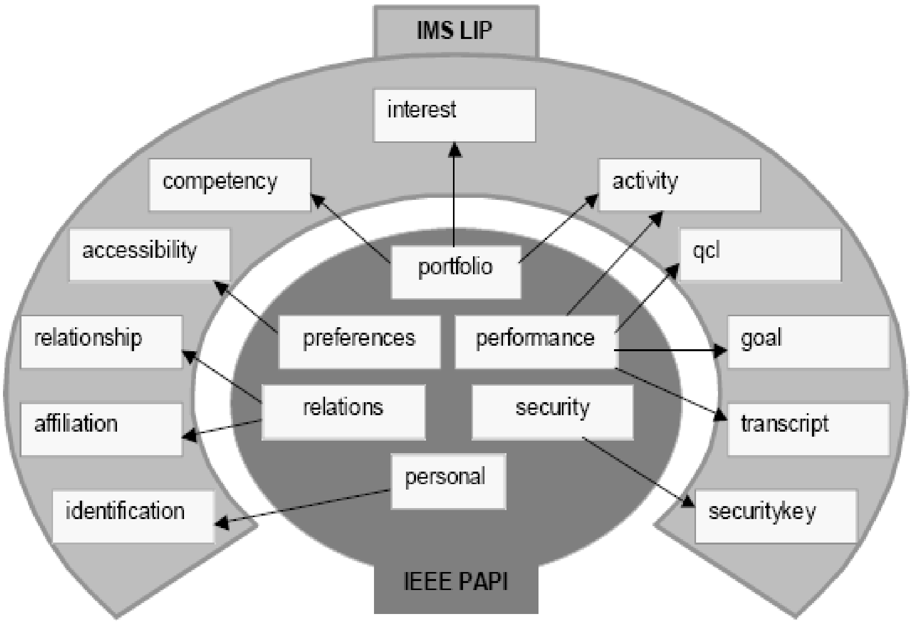

Figure 1: Incorporation between IMS LIP and IEEE PAPI

Lip and PAPI are competing specifications aimed in "learner information" description. PAPI Learner specifications use a registry-based approach for long-term maintenance of the "value domains" and their "permissible values" (often called "vocabularies"). Form the other hand, LIP uses XML while the PAPI Learner and its related standards use ISO/IEC 11179 and ISO/IEC 20944 for a complete suite of harmonized bindings. LIP organizes data according to "purposes" while PAPI Learner does not. This is a useful characteristic in those application contexts where data needs to be organized in customized ways. The previous considerations make LIP a better candidate than PAPI Learner.

Semantic web modelling languages like the Resource Description Format (RDF) [31] or RDF schema (RDFS) [32] provide us with interesting possibilities. RDF models are used to describe learning resources but they can be used for learner description as well. The use of RDF to encode the profile data (so called learner data description) allows us to pick elements from multiple schemas, for instance, PAPI and IMS-LIP, and remain interoperable with other RDF-enabled systems. With the plethora of specifications available and the lack of even a de facto standard, we see the use of RDF to select from multiple existing schemas in order to create customised, application-specific data models as being the dominant trend in user modelling in the future.

Learner modelling implementations

Recently, student modelling researchers have begun to adopt technologies, applications and standards from the Semantic Web to solve the problems mentioned above. The first ideas of using ontologies for learner modelling have been reported by Chen&Mizoguchi [19]. Kay also argues about the use of ontologies for reusable and "scrutable" student models [20]. More recently the idea of using sharable data structures containing user's features and preferences was proposed in order to enable personalized interactions with different devices for the benefit of the users. For this purpose, a user modelling mark-up language for ubiquitous computing built on XML technology has been proposed as a platform for communication [21].
In the ELENA project [22] there is a very rich and detailed learner model developed. It is distributed and reflects features taken from several standards for a learner modelling and in particular, IEEE LTSC's Personal and Private Information (PAPI) standard [23] and IMS Learner Information Package (LIP) [18]. Its features can be combined according to the requirements of specific personalization techniques, which are provided as personalization services in a P2P learning network RDF and RDFS as key tools of the semantic web, which are used to handle such situations [24]. However, this model cannot cope with the user inputs at different levels of detail, precision and completeness according its authors.

5. TAILORING LEARNING MATERIALS TO THE 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 LOs 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. We will track down one clear approach for personalization realization implemented in Self e-Learning Networks (SeLeNes) project [28]. Personalization will have an effect on search results returned from a keyword-based query at three different levels:

- *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).

6. PERSONALISATION AND LEARNING CONTENT ADAPTATION IN LEARNING GRIDS

The philosophy and the approach behind Grid technologies [9] 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.

The SeLeNe (Self eLearning Networks) [26] project was funded as an EU FP5 Accompanying Measure (IST-2001-39045) running from 1st November 2002 to 31st January 2004. This project 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.

ELeGI (European Learning Grid Infrastructure) [27] is an EU-funded Integrated Project that aims at facilitating the emergence of a European GRID infrastructure for eLearning and stimulating research of technologies to enhance and promote effective human learning. The project is supported by the European Community under the Innovation Society Technologies (IST) programme of the 6th Framework Programme for RTD - project ELeGI, contract IST-002205.

ELeGI promotes and supports a learning paradigm shift focused on knowledge construction using experientials based and collaborative learning approaches in a contextualized, personalized and ubiquitous way. This new paradigm is based on a learner centred approach, to replace the classical, content centred approach to learning. The learner plays an active and central role in the learning process. Rather than stressing the memorization of information, learning activities are aimed at aiding the learner in the construction of an autonomous, functional base of knowledge and skills. In keeping the learner at the centre of the learning process, personalisation/individualisation (creating and adapting learning paths according to learner's previous knowledge, preferences, skills, preferred learning style), and collaboration (with other students, teachers, tutors, or experts) become relevant aspects to be supported by technologies through the creation of the appropriate context. Considering humans at the centre, learning is clearly a social, constructive phenomenon. It occurs as a side effect of realistic simulations, interactions, conversations, collaborations and enhanced presence in dynamic Virtual Communities.

Project DILIGENT (Digital Library Infrastructure on Grid Enable Technology) [5] is an integrated project funded in part by the European Commission FP6 IST Programme [25]. DILIGENT is aimed at the creation of virtual digital libraries on the basis of grid-based infrastructure so that the integration of metadata, personalization services, semantic annotation, and on-demand availability of information collection and extraction to be supported. Such new decentralized and service-oriented architecture for digital library assures a better and adaptive tailoring of the content and service offer to the needs of the relevant community as well as to the current service and content offer, and a more systematic exploration of existing resources.

7. CONCLUSIONS

To sum up, the main goal of the eLearning systems 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. 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 eLearning system.

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