Techniques to Personalized Observation and Improved Learning Experience in Digital Libraries

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Abstract: *The implementation of the idea of improved access and effective usage of digital libraries (DLs) content for different purposes (incl. eLearning) has led to new types of services and ways to personalize access and content observation, and learning experience in DLs. This paper discusses solutions for personalized observation and enhanced learning experience in digital libraries.*

Key words: *digital libraries, personalization, user profiling, learning experience.*

INTRODUCTION

Libraries have been always being an important source of learning resources. The latest tendencies of the development of digital libraries (DLs) are towards transforming their static complex structures to systems with a dynamic federation of functional units. This change resulted from the needs of the market, the emergence of new technologies, and especially from the request for stricter use of the existing resources and adapting DLs content and services to the needs of different user groups. Main challenges for the DL are to provide effective access to content types based on the context of usage and to support "real-time" integration of different content types according the users' needs. The user and respectively its needs, interests, goals, preferences have to be carefully studied and have to become the starting point for DL functionality development.

In this paper we discuss different techniques for customizing and personalizing the user access in DL including user modelling and profiling, tracking user's behaviour and personalizing its stay in the library, enhancing learning experience, as a base for supporting eLearning on top of the digital library.

USER MODELLING AND PROFILING

Most often the personalization techniques in DLs includes the selection and recommendation of information resources, system interfaces and the means of navigation according to the personal characteristics of the user (demographic status, goals, tasks, skills, motivation, achievements, interests/disinterest, preferences, requirements, *etc*.) on one hand, and according to the user's behaviour in the environment on the other - a solution specified as personalization according to a user profile. User modelling can be defined as the process of acquiring knowledge about the user in order to provide services, adaptive and personalized information flow/s following its specific requirements in the DL domain. Closely related to this solution are the personalization techniques adverting the ways of delivery and access the content, content adaptation and transformation, grouping, ordering, and reconstructing.

Main questions asked:

- User interests: What is the user interested in? What needs to be done or accomplished?
- User preferences: How is something done or accomplished?
- User goals and intents: What the user actually wants to achieve?
- User motivation: What is the force that drives the user to be engaged in observation activities?
- User experience: What is the user's previous experience that may have an impact?
- User activities: What the user does in the DL environment, *etc*.

Building a user model for a DL involves defining: the "who", or the degree of specialization in defining who is modelled and what the user history is; the "what", or the cognitive goals, plans, attitudes, capabilities, knowledge, and beliefs of the user; the "how" the model is to be acquired and maintained; and the "why", including whether to elicit information from the user, give assistance, provide feedback, or interpret the user's behaviour.

The DL user model often covers a certain amount of information that can be divided into two main groups [5]:

- General user information, such as actual and historic data (personal information), goals, interests, wishes, cognitive aptitudes, object observation style, measures for motivation state, preferences regarding the object presentation method, etc.,
- Information about user's behaviour in the library such as chosen paths for object observation, chosen objects and collections, overall competence level, difficulties during the understanding of the information, etc.

The DL user model can be formally presented by a user ontology, providing general concept framework, concept (class) relations, individuals, rules, axioms, facts, *etc*.

Specific features of the DL user-learner

When the DL user is a learner, or has learning purposes in the environment, "one size fits all" solutions are not enough to satisfy his/her needs [1]. Different DL users-learners have different learning needs and preferences that (should) affect the learning function outcome. Learners expect from the DL system a "personal facilitator" and not a "classroom" behaviour, where their personality and needs are known and taken into account. There are several benefits of thinking about and trying to understand learning needs and preferences [4]:

- people learn most effectively when the strategies used are closely matched with their preferred learning style
- sometimes we can improve our learning by knowing what our strengths are and then doing more of what we're good at
- often we can improve our learning by knowing what our weakness are and trying to enhance our skills in these areas
- different situations and learning environments require different learning strategies, so it's best to have a large repertoire from which to draw.

There are a number of factors that can influence the extent of learning: learning style; learner goals/objectives; previous knowledge; educational level and difficulty; technical preferences and other preferences (e.g. language *etc*.) [1]. If taken into account and considered as input parameters in personalization processes, the efficiency of learning experiences and the learning outcome can be positively affected. A DL learning experience can be considered as a learning plan with associated material (or in a broader view with services) that a Learner exploits in order to fulfil his/her learning goals. Ideally, both the construction of the learning plan and its association with appropriate learning materials should be affected by the Learners' learning needs and preferences.

The representation of the user model can follow developed standards and specifications (e.g. IEEE Personal and Private Information (PAPI) and IMS Learner Information Package), maximizing its reusability and portability.

TOWARDS PERSONALIZED DL CONTENT OBSERVATION

The development of architecture for personalized/adaptive content observation in a digital library requires the consideration of a model for realization of personalized and

adaptive logic for accessing the knowledge [6]. This model traces the activities realizable by the users and the respective replies of the system (figure 1).

We specified a personalized functional module with services for: 1) managing user profiles; 2) creation/delivery of personalized and adaptive information flow according to the user profile and pre-formulated rules for linking DL digital objects with corresponding user profile; 3) tracing the user's behaviour in the DL environment. The service concerns the adaptation and personalization of the content flow using different characteristics of the user profile. They are accomplished by displaying different level of detail in presentation of the digital objects according to the preliminary knowledge level of the user in the DL domain. This level determines the ways of displaying the DL objects i.e. user observation styles. This functionality assists the object observation by generating new objects containing parts of the originals. This activity can be determined as a process of modification of the information materials according to individual requirements, preferences and knowledge level. User cognitive goals and interests are categories that also give information to the system on why the user chooses it and what he/she wants to find out. The solution tracks these rubrics in the profile and delivering on-demand objects for observation. Another possibility is that the system delivers objects to the users according their object grouping style, preferred language, behaviour in the environment, *etc*.

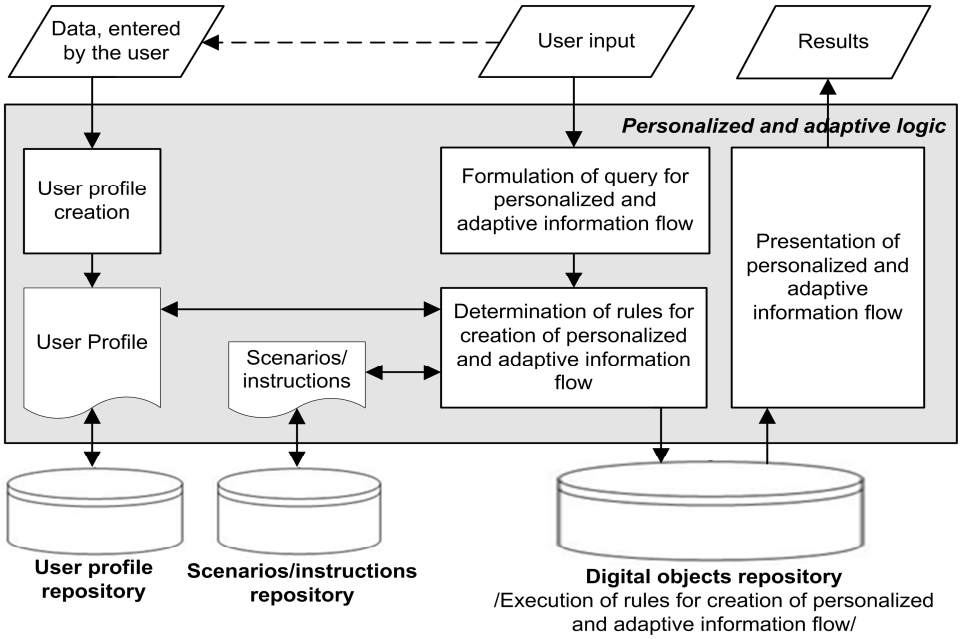

Fig. 1 Abstract model for realization of personalized and adaptive logic in DL

SUPPORTING ELEARNING APPLICATIONS ON TOP OF DIGITAL LIBRARIES

Supporting eLearning applications on top of DLs is a complex and multilevel problem [9]. A lack of effective support of DL applications for learning purposes is observed. Applications are well known to be long living, and typically they have longer life than systems, so they tend to create their own standards, and support infrastructures based on those standards. "Transforming" content residing in DLs to learning objects and then to learning experiences is not a one-to-one mapping process but requires a sophisticated repurposing architecture and tools. Moreover, different Learners have different learning characteristics, needs and preferences and this should affect how the final learning experiences and underlying content are organized and presented. We present a generic interoperability/repurposing framework and a service-oriented architecture developed to address those problems, and incorporating personalization mechanisms to allow the dynamic creation of adaptive learning experiences taking into account learners' profiles and pedagogical templates [9]. Figure 2 illustrates the architecture components, which are described in the following paragraphs.

Repositories provide services for the storage and management of various types of objects: *Audiovisual Digital Objects (AVOs*) created on top of *Media Objects* that correspond to content assets or parts of them annotated and indexed with administrative and semantic metadata; *Learning Objects (LOs)* built on top of *Audiovisual Digital Objects* and enriched with educational metadata (LOM). A LO is a collection of Digital Objects that are assembled to teach a single learning objective; *Assessment Objects (AOs)* that are used to assess the satisfaction of certain learning objectives. AOs can be simple questions (Assessment Items) or complex questionnaires consisting of Assessment Items (Assessment Tests), described with IMS QTI. AOs are also described with educational metadata (LOM); *Learning Components (LCs)* corresponding to learning experiences utilizing the underlying LOs and AOs that can be delivered using different delivery devices. They are hierarchies of activities supported with LOs or AOs and they are described with educational metadata (LOM) and possibly sequencing and navigation metadata.

In order to support the gradual development of learning components, the Metadata Encoding and Transmission Standard (METS) is used for the representation of the above objects [2], since it allows for: 1) Integrated description of objects at each level using several appropriate (metadata) schemes to represent the different aspects of objects, and 2) References to objects residing at lower levels without repeating their information at the current level. Generally, objects residing at a certain level should be able to reference objects at the level underneath. This way reusability of objects at lower levels is supported from the upper levels. Moreover, this flexible representation of objects allows for appropriate adaptation/transformation of objects at run-time in order to support cross-media delivery of learning experiences.

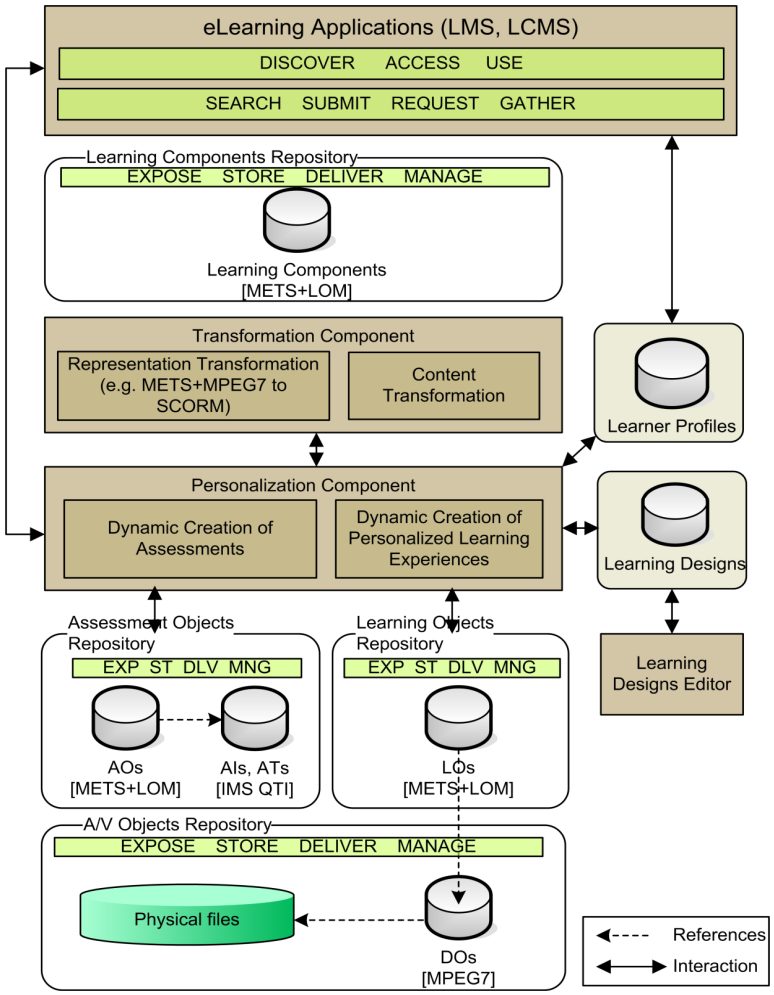

Fig. 2 Architecture for supporting eLearning applications on top of DLs

eLearning Applications discover, access and use the content of the A/V content of the digital library through appropriate services (resource utilizers), including authoring tools (e.g. Learning Content Management Systems - LCMS) for the authoring of the above types of objects, as well as Learning Management System (LMS) for the delivery of learning experiences to Learners. In this framework it is assumed that the LMS includes components encapsulating functionality to track user's progress and update the user related information represented in Learner Profiles.

The *Personalization Component* is used for the *Dynamic Creation of Personalized Learning Experiences* according to specific learning needs expressed in Learner Profiles and using a set of abstract training scenarios (*Learning Designs*) constructed with a tool named Learning Design Editor [1]. This service can be exploited both by Learners (pers. learning experiences), and courseware authors, providing them a semi-automatic way for the creation of courseware. Before transforming the resulted learning experience to a SCORM package, it is stored as a Learning Component being ready and available in an interoperable way for later requests. The Personalization Component encapsulates functionality for the *Dynamic Creation of Assessments* from Assessment Objects in order to "measure" the previous knowledge of the Learner and update his/her Learner Profile.

The *Transformation Component* is responsible for the transformation of the objects' METS-based descriptions to SCORM Packages. The type of the underlying physical files is taken into account (from A/V descriptions, e.g. MPEG-7), and the requirements of the delivery channel and, if needed, intermediate html pages are constructed with links to these files (e.g. for video files), and appropriate content transformations are performed.

The framework and the architecture presented were in the basis of two European Projects architectures and their implementation: 1) Implemented in FP6 Project: LOGOS "Knowledge-on-Demand for Ubiquitous Learning" (IST-4-027451) (common project of the Laboratory of Distributed Multimedia Information Systems and Applications/ Technical University of Crete (MUSIC/TUC) with the Institute of Mathematics and Informatics/ Bulgarian Academy of Sciences (IMI-BAS), 2006–2008) [2], and 2) Applied in FP7 ICT-PSP Natural Europe "Natural History & Environmental Cultural Heritage in European Digital Libraries for Education" (2010-2013) [3]

DL PERSONAL WORK SPACE

The use of user profiling techniques has several advantages as well disadvantages. As already mentioned, good features are the possibility to get to know the users themselves and their personality, to fit the system using rules to user's desirable content and recommend similar content. But, these good features could also be irritating and intrusive for some users and could become unacceptable with time. Moreover, existing systems have difficulty to specify the difference between temporary and permanent user characteristics/requirements or they don't have them in mind. They also use preliminary established templates for personalization, content adaptation and content delivery avoiding some serious problems such as incompatibility and incorrectness of their usage.

The DL personal work space includes services for personalized content marking, commenting and analyzing that doesn't require a strict user profile, but aims at adjusting the user's individual needs. The solution is borrowed from real work and studying of traditional written content sources (incl. books, manuals), where the user mainly performs activities such as underlining the important parts of the content, writing notes and inferences, selecting and marking zones of their interest in pictures, *etc*. The DL personal work space could be organized as an interactive and smart corner, saving the "marked user's content" or could be integrated in the DL content and collections by "user's working tools". Some libraries provide recommendation panels, content-on-demand services or content analysis allowing different ways for the user to experience DLs objects in more creative settings. In the Bulgarian Iconographical Digital Library [8] a personal work space [7] is now in a process of implementation. It includes functionalities for: 1) raw digital

object/ Iconographical object or their metadata sharing, ranking, enclosing, tagging, linking, underlining, outlining, commenting, reviewing, bookmarks, etc. 2) Content analysis and synthesizing.

CONCLUSIONS

We presented several techniques for customizing and personalizing the user access in DL as a base for supporting personalized observation and improved knowledge perception. Moreover, we presented solutions to support eLearning applications on top of Digital Libraries in order to be able for eLearning applications to effectively exploit the wealth of content residing in Digital Libraries. Towards this end, we presented a generic interoperability/repurposing framework and a service-oriented architecture where learning experiences are dynamically constructed taking into account user profiles and pedagogical templates. Finally, a different approach, without strict user profiling, focusing on personalized content marking, commenting and analyzing has been presented, which is now in a process of implementation in the Bulgarian Iconographical Digital Library.

REFERENCES

[1] P. Arapi, N. Moumoutzis, M. Mylonakis, G. Theodorakis, and S. Christodoulakis. "A Pedagogy-driven Personalization Framework to Support Automatic Construction of Adaptive Learning Experiences," *In Proc. ICWL,* 2007, pp. 55-65.

[2] P. Arapi, N. Moumoutzis, M. Mylonakis, G. Theodorakis, and G. Stylianakis. "Supporting Personalized Learning Experiences within the LOGOS Cross-Media Learning Platform," *In Proc. LADL (in conj. with ECDL)*, 2007, pp. 5-18.

[3] Natural Europe Project. [Online]. Available from: http://www.natural-europe.eu/

[4] Learning Skills Services Student Development Centre. "Learning Styles & Preferences." Internet: www.sdc.uwo.ca/learning/selfhelp/skill_building_handouts/, [Jul. 14, 2016]

[5] D. Paneva. "Ontology-based Student Modeling," *In Proc. Fourth CHIRON Open Workshop "Ubiquitous Learning Challenges: Design, Experiments and Context Aware Ubiquitous Learning"*, 2006, pp. 17–21.

[6] D. Paneva-Marinova. "A Semantic-Oriented Architecture of a Functional Module for Personalized and Adaptive Access to the Knowledge in a Multimedia Digital Library." *International Journal "Serdica Journal of Computing"*, vol. 2, pp. 403-424, 2008.

[7] D. Paneva-Marinova. "Personal Work Space and Content Analysis Functionality in a Cultural Heritage Digital Library," *In Proc. DiPP*, 2012, pp. 78–84.

[8] L. Pavlova-Draganova, D. Paneva-Marinova, R. Pavlov, and M. Goynov, "On the Wider Accessibility of the Valuable Phenomena of Orthodox Iconography through Digital Library," *In Proc. 3rd International Conference dedicated on Digital Heritage, EuroMed,* 2010, pp. 173–178.

[9] R. Yoshinov, P. Arapi, S. Christodoulakis, and M. Kotseva, "Supporting Personalized Learning Experiences on top of Multimedia Digital Libraries." *International Journal of Education and Information Technologies*, vol. 10, pp. 152-158, 2016.

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