Digital Rights Management for Distributed Multimedia E-Learning Content

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Abstract:

Nowadays a steadily increasing amount of multimedia content is generated and requires storage in digital libraries. Current research focuses on identifying user needs to make relevant information available through semantically enhanced retrieval techniques. In this context the already complex task of retrieving multimedia content on a semantic level is further complicated by right management and security issues which are evolving into fundamental topics in the area of digital libraries. Previous research conducted by our group concentrated on topics like extraction of metadata from multimedia content, indexing of metadata and application of indexed metadata for storage, search and retrieval tasks. Our research activities resulted in a semantic technology framework for metadata based multimedia retrieval. Based on these results we have selected promising and emerging technologies to extend our framework according to the application domain E-Learning with special focus on digital rights management in context of distributed multimedia learning content management systems.

1 Introduction

The system presented in this paper is called ELARM, which stands for E-Learning And Rights Managements. It allows a teacher or lecturer to define a set of dynamic or static resources and organize them in a hierarchical folder system. The access to resources is simplified through a software layer, which allows the access to different heterogeneous databases. In addition the framework allows ontology based querying and execution of digital rights. For import and export of digital rights definitions from different sources a transformation from MPEG-21 (see e.g. [4], [5], [6]) to an internal digital rights ontology was created.
The client, which is shown in Figure 1, is called *Handapparat*[1] and allows the creation of learning resource collections by lecturers. Lecturers publish the collections for students, enrolled to specific courses. Students, enrolled to the courses, are allowed to access and browse the published collections. Furthermore students can query and browse different heterogeneous databases for gathering additional information. The ELARM prototype supports following data sources:

- The MPEG-7 multimedia database of the former prototype IMB (see [8])

[1] *Handapparat* which is a German word describing a collection of books and resources prepared and offered from a lecturer for his students for further reading on a specific lecture.

- The images of the Brockhaus Multimedial Encyclopedia[2] including their captions
- The Amazon.com[3] online book store
- Google Internet search[4]

This collection allows a capability demonstration of the system for providing a single point of access to very different information sources in the context of E-Learning and digital libraries.

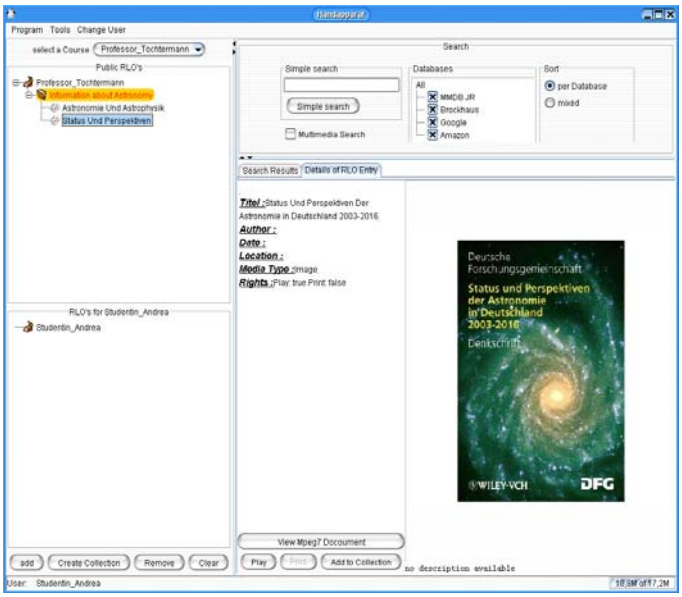

Figure 1: The user interface of ELARM showing a search result.

The paper is organized as follows: In the following section an overview on Digital Rights Management in the context of E-Learning is provided. Afterwards, the concept and design of our distributed system is outlined. After describing implementation details a summary concludes our work.

2 Digital Rights Management in the Context of E-Learning

The domain of E-Learning has recently received increased attention and has acquired an appropriate market share with large companies and educational institutions constituting the customer group. Today E-Learning content is usually consumed via web portals, which provide additional context specific functionalities like resource management and web folders. Common E-Learning suites consist of a learning management system (LMS), a learning content management system (LCMS) and a web portal. Main idea of an LMS is to provide course and user management. Three roles are required to achieve this: The *learner* consumes courses and accumulates new knowledge, the *trainer* creates courses and provides support for learners and the *administrator* assigns courses and learners to virtual classrooms. An LCMS, on the other hand, stores learning content entities that are used by trainers to create courses. Because of the separation of content provider and content producers commonly found in the E-Learning domain, several standards have been established to provide interoperability. LMS standards are required to depict course invocation and management of user profiles. For LCMS, many E-Learning suites provide support for the Shareable Content Object Reference

[2] URL: http://www.brockhaus.de/

[3] URL: http://www.amazon.com

[4] URL: http://www.google.com

Model[5] (SCORM) standard, an XML-based wrapper standard, which incorporates several domain specific specifications. One example is the LOM[6] (Learning Object Metadata) standard describing course content using various high-level metadata attributes. LOM resembles Dublin Core[7], but is specific to E-Learning content, for instance by providing attributes for course difficulty, learning time, typical age range and vocabulary.
LCMS systems face increasing requirements in storage, maintenance and management of multimedia learning content to support trainers in assembling new and in adapting existing courses. A lot of research is currently underway on standardisation of LCMS objects in the form of so-called Reusable Learning Objects (RLO's). An RLO is a learning entity that covers a specific topic and can be reused in a different context [9]. The SCORM standard already reflects the trend towards unified RLO specification, providing the IMS metadata specification[8] as a specialized subset, which describes RLO-based content consisting of Reusable Information Objects (RIO's). These RIO's are typically images, text paragraphs or presentation slides. To avoid confusion RLO's are often called lessons and RIO's sections. In this context, MPEG-7's standardized descriptors can be used to provide media content description for use of RIO's in search engines [1]. MPEG-7, called the *Multimedia Content Description Interface*, is, unlike MPEG-1, 2 and 4, no video or audio coding standard but a XML based standardized way to store annotations for multimedia documents (see e.g. [6]). MPEG-7 documents are built from descriptors, which are organized in descriptor schemes. Descriptors or groups of descriptors (e.g. descriptor schemes) describe a certain aspect of the multimedia content. A description can be for instance about the temporal segments of a video or presentation or the semantics of a multimedia document.
The management of RIO's and RLO's as multimedia content, whereas RLO's can be assembled using different content repositories with different access rights, raises the need for powerful rights management mechanisms. Traditional rights management of physical materials benefits from the fact, that the "physicality" of the resource provides natural barriers to unauthorized exploitation of content. In contrast, the distribution of digital content nowadays is much more challenging, because of the ease with which digital files can be copied and transmitted. For a detailed investigation and comparison of state-of-the-art DRM-systems consult [11].

2.1 MPEG-21

Several DRM standards have been analysed for usage in E-Learning contexts. MPEG-21 has been chosen to be the most feasible standard. The MPEG-21 multimedia framework contains architectural elements that are needed to support the multimedia delivery chain, and is in the process of defining the relationships between and the operations supported by them. The Moving Pictures Expert Group (MPEG) will elaborate the elements by defining syntax and semantics of their characteristics, for instance interfaces to the elements. MPEG-21 will also address the necessary framework functionality, such as the protocols associated with the interfaces, and mechanisms to provide a repository, composition, conformance etc.
MPEG has a long history in dealing with DRM issues. Gradually, MPEG is moving from defining hooks to proprietary systems (MPEG-2, MPEG-4 Version 1) to more encompassing standardization in Intellectual Property Management and Protection (IPMP). MPEG feels that this is necessary to achieve MPEG's most important goal, which is interoperability. Within the MPEG-21 standard it is dealt with digital rights management in three parts: (i) Part 4 de-

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[5] URL: http://www.adlnet.org/scorm/

[6] URL: http://ltsc.ieee.org/wg12/

[7] Dublin Core is a popular set of standardized metadata elements. URL: http://dublincore.org/

[8] URL: http://www.imsglobal.org/metadata/

fines a framework for Intellectual Property Management and Protection (IPMP), (ii) Part 5 - MPEG REL (Rights Expression Language) offers a language for describing rights and (iii) Part 6 - RDD (Rights Data Dictionary) defines the terms for the REL. The requirements and the call for proposals for the MPEG-21 IPMP have been issued recently. For further reading please refer to [4] and [5] as well as the MPEG homepage [10].
A working group at JTC1 (Information Technology for Learning, Education, and Training) is currently reviewing possibilities to adopt MPEG-REL for E-Learning applications. A draft from December 2003 is the latest document available [2]. In this document several techniques are described that can be employed to customize the MPEG-21 REL to a particular domain such as E-Learning. One technique is to create a simple profile of the MPEG-21 REL specification.
This profile is essentially a proper subset of the MPEG-21 REL specification with additional constraints on syntax and semantics of the language. One advantage of this technique is that only a small subset of already defined elements is used to meet the needs of a particular domain. No new elements are introduced. Another option is to extend the MPEG-21 REL specification by adding more rights, conditions, or principals as needed by a particular domain. The ability to extend the language is part of the architecture of the MPEG-21 REL specification and can be done without affecting the underlying structure of the language. The extension becomes part of the E-Learning domain and can be combined with other extensions to satisfy the desired needs. One advantage of this technique is that you can add elements specific to certain domains not defined in the MPEG-21 REL specification.

3 Concept and Design

The development of the ELARM framework and application was based on results of previous research, a multimedia database named IMB. In Figure 2 the architecture of the ELARM system is shown.
In general, the client sends out a query to the broker, which distributes the query further to the single data repositories. Each data repository is capable of performing a search and returning results. Each result item contains the content and associated metadata as well as digital rights information. According to their relevance, results are merged within the result merge component. More details on this general procedure are given in [3].
In order to perform distributed digital rights management the *DRM+* component was added. It filters and adopts all requests and responses according to the specified user rights and maps the rights management system of the specific content repositories to an internal ontology and MPEG-21. The result merging component and the query distribution component handle requests to and responses from different content repositories. An interface for data base access modules was defined to be able to plug in new content repositories.
To assure that only contents the user is allowed to access are shown via the user interface the client application communicates the user profile describing his rights to the DRM+ module. After query formulation the search request is distributed to content repositories the user is allowed to query, which is checked before the distribution. The data base access modules send the results to the DRM+ module, where the results are filtered. Only content, for which the user has the proper access rights, is sent to the result merger. The results are combined into a single result list by the result merger; the presentation of results is done by the user interface. Figure 3 shows a sequence diagram of this procedure.

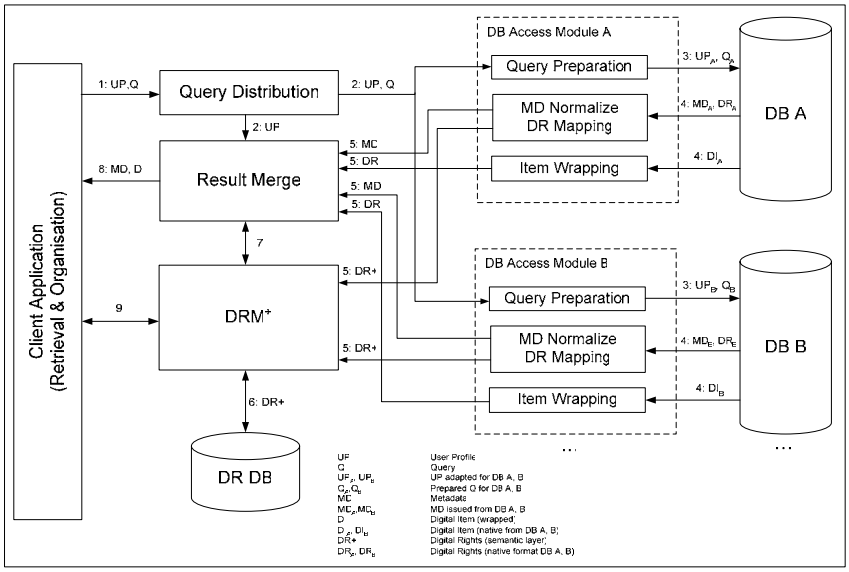

Figure 2: System architecture diagram: Multiple multimedia data base access modules can be plugged to the core system, consisting of the central rights management module DRM+ and a query distribution and response merging tool.

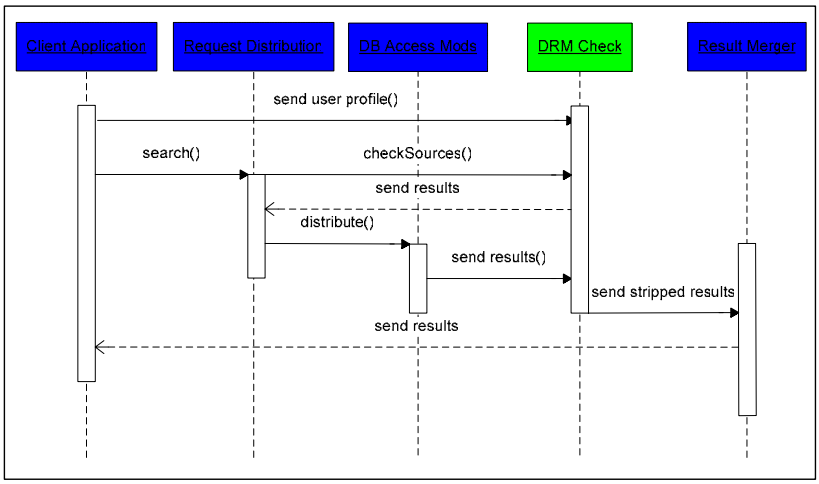

Figure 3: Sequence diagram describing the process of searching and the roles of the client application, the query distribution and all other components.

4 Implementation Details

Figure 4 illustrates the main modules of the ELARM framework, namely database access, broker, DRM+ and the user interface. The database access module consists of single modules that handle communication and data normalization for each data source. The broker manages connections to databases, controls the workflow including rights management and caching and delivery of results to the user interface. The user interface sends queries from users to the broker, presents the results and manages a shopping basket for RIO's. User interface and broker are implemented as rich clients. All databases are accessed using Web Services[9].

[9] For more information about Web Services see http://www.w3.org/2002/ws/

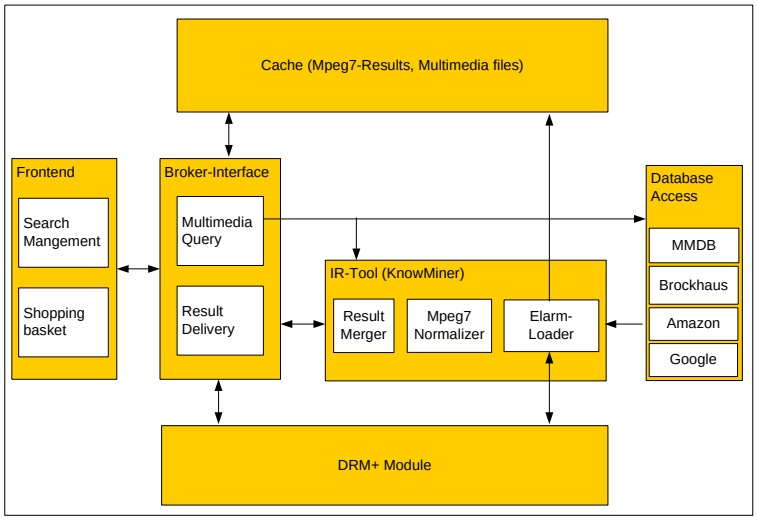

Figure 4: ELARM system overview showing the core modules and interfaces of the implementation.

Whereas Web Services unify the data exchange, data formats need to be converted from the multimedia query language used in ELARM to each database specific query language. The result records are converted into MPEG-7. The multimedia query is based on the Z39.50 specification[10] and extended to support arbitrary query objects, like text, image and semantic annotations. The resulting MPEG-7 format contains instance metadata provided by the database like title, description, author and date and content descriptions of the included multimedia content like images and videos. Optional some DRM information in MPEG-21 can be included by databases if available. As mentioned before in ELARM four databases have been included. Google, Amazon, the Brockhaus multimedia image data of 2005 with all metadata converted to MPEG-7 and the multimedia database of our previous prototype. Table 1 shows all multimedia objects from each currently supported database.

Table 1: Supported multimedia objects of each database (T … Text, S … Semantic descriptions, I … Image, V … Video)

Database	**Query**	**Result**
Multimedia database	T, S, I	T, S, I, V
Brockhaus	T, I	T, I
Amazon	T	T, I
Google	T	T

The MPEG-7 records are delivered to a knowledge discovery and information retrieval tool called KnowMiner, which is described in detail in [7]. KnowMiner takes care about data gathering, result merging and information extraction. KnowMiner supports parallel database querying and merges the results using two simple ranking algorithms:

- Take a subset of each database and concatenate them.
- Take the first result of each database, concatenate them, take the second results and concatenate them and so on.

[10] URL: http://www.niso.org/z39.50/z3950.html

However, more sophisticated methods can be applied like analyzing the content of the results and perform similarity comparisons. Information extraction algorithms can be used to supplement missing information from single databases.

4.1 User Interface

The overall digital catalogue (shown in Figure 5), which offers all available information objects of different media types and data sources, can be seen as the range of goods in an E-Commerce application. Like in an online shop users can browse and search through items and put them into their baskets for purchase. The ELARM system offers multiple shopping baskets, which can be organized hierarchically.
Summarizing the contents of a folder a user gets instead of the price in an electronic shop the combined usage and rights information of the underlying objects. In addition to the generation and organization of folders and the browsing and navigation inside the digital catalogue, the user interface visualizes the summarization of the actual information. This is taken from the existing metadata and the information objects rights based restrictions, which is stored in MPEG-7 and MPEG-21 formatted XML documents
The multimedia retrieval capabilities include searching using keywords in combination with images and semantic descriptions. The user interface also handleslogin and authentication of the user and visualization and organization of the personal workspace. This includes the creation of information objects and annotation and bookmarking of multimedia documents and collections.

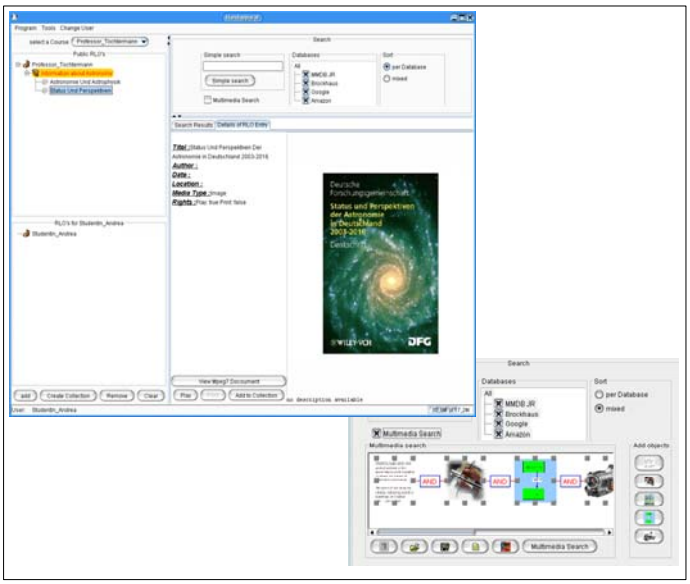

Figure 5: ELARM user interface and its advanced multimedia query interface

5 Summary

Within this paper we have presented a system called ELARM, which allows the retrieval and organization of multimedia documents from different heterogenous data bases in context of E-Learning. The system includes a complex and powerful module for digital rights management, which allows the mapping of arbitrary rights expression languages to MPEG-21 based on an internal ontology for rights management in the context of an LCMS. The user interface allows the creation and publication of collections of multimedia documents specific to courses by teachers and allows students to access and adopt these collections.

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