Demonstration of an MPEG-7 Multimedia Data Cartridge

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1. INTRODUCTION

Multimedia Database Systems (MMDBMS) organize and store multimedia data for content retrieval. The relying multimedia data models, e.g., [5], represent abstractions of media objects for querying, indexing, and so on. However, most currently available implementations reveal some shortcomings. Either they are limited by one kind of multimedia data supported or by the capacity of their semantic modeling. Despite the upcoming MPEG-7 standard for representing low-level and high-level features of multimedia and respective annotation and use tools (see http://www.mpeg-industry.com), we are not aware of any MMDBMS product which integrates this standard for the purpose of a more meaningful indexing and querying.

In this context, our paper presents a **Multimedia Data Cartridge** (MDC) that implements an object-relational data model for the core part of the MPEG-7 [4, 3] standard, introduces query processing and optimization methods for the access and retrieval operators and finally realizes an **Multimedia Indexing Framework** to support the retrieval. This framework relies on the GiST technology [2] and extends the build-in index of Oracle by means for high-dimensional feature vector indexing, and enhanced access functionality (e.g., k-NN search).

2. DESCRIPTION OF THE SYSTEM

The **Multimedia Data Cartridge** (MDC) currently consists of two parts (see figure 1). The first part is the *Multimedia Data Model* which contains the metadata describing the multimedia content relying on MPEG-7 descriptions. For this purpose, the MPEG-7 schema is mapped, with the help of Oracle's *extensible type system*, to a database schema, i.e., to respective object types and tables. The complete database schema can be obtained from http://www-itec.uni-klu.ac.at/~harald/codac/schema.pdf. The main principle of the mapping is to distinguish between important MPEG-7 datatypes serving as anchors for descriptions, types which are subject to frequent queries and less important types, like types appearing in large choices and some optional elements and attributes. For instance consider the MPEG-7 *StillRegionType* and *VideoSegmentType* which is a delegate for images and videos (e.g., StillRegion describes complete images or parts of them). Both types are mapped to own object types and tables as they are entry types for descriptions. Some of their elements and attributes are again object types with tables, others are specific *SYS.XMLType*. The decision is here mainly on the importance for the querying process. For instance, the element with type *TextAnnotationType* was chosen to be detailed further, because it is of importance for free-text search in MPEG-7 documents. Therefore, object tables detailing the kind of annotation are created (e.g., FreeTextAnnotation). The optional element *Mosaic* detailing the characteristics of a Mosaic image (if created) of the video described is specified as *SYS.XMLType*. Note that using *SYS.XMLType* does not move the type out of the query range, but it requires the use of XML-Path expressions in an SQL query (with the consequence of a more difficult expression of joins etc.). A further important type is *ScalableColorType* which is used for storing feature vectors of color histograms extracted from images described by the *StillRegionType*.

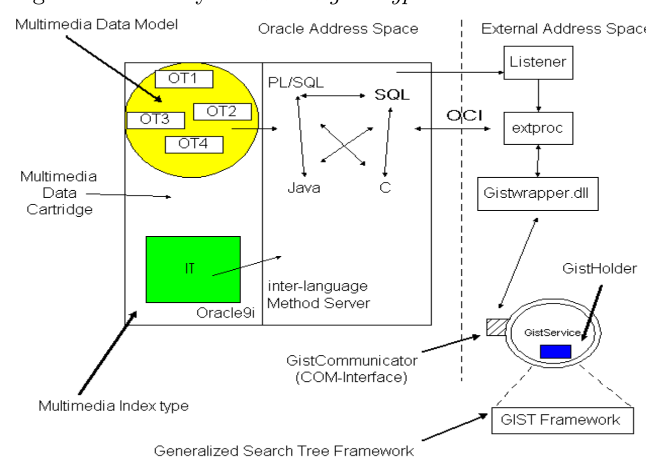

Figure 1: Overview of the Multimedia Data Cartridge (MDC) Architecture

The second part of the MDC is the *Multimedia Indexing Framework* (MIF), an extensible environment for multimedia retrieval. The framework consists of three modules (see figure 1):
– The **GistService** is realized in the external address space and runs as an own process in the Operating System environment. It manages all available access methods and offers cur-

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rently support for the Generalized Search Trees (GiST [2]) to support efficient NN-search in high dimensional vector spaces. The two main components are the *GistCommunicator* and the *GistHolder*. The GistCommunicator is a COM-Object and is used for inter-process communication between the database (the GistWrapper shared library) and the implemented access methods. The GistHolder manages all currently running index trees and the accesses to them. Each index tree is identified through a global/unique ID.
– The **GistWrapper** is a shared library and is used by the database to connect to the GistService module. The GistWrapper has two tasks, namely to provide access to the GistService through database procedures and the transformation of input and output data to be used by the GistService and the Database.
– The **Multimedia Index Type** is an extension of the build-in indexing mechanisms of Oracle. It is plugged into the Oracle Address Space and may so be addressed as any build-in index. The newly introduced multimedia index type consists of several *indextypes* that represents the available access methods and their corresponding *operators*. Each indextype needs an appropriate implementation (*object*). This object delegates all necessary index methods (e.g., ODCIIndexInsert, ODCIIndexCreate, ...) to their corresponding implementations. In MDC, most methods are forwarded to the GistService. Index in use for instance the R-,X-trees and the SS,SR-trees.

First experimental results (see [1]) have shown that the MIF outperforms clearly the build-in Oracle Text Index for exact match queries, e.g., for 200.000 data entries, 96 dimensions we achieved an average improvement factor of 14. Furthermore, for the not yet available similarity search, the performance results show comparable results as for the exact match queries while taken into account the increased search effort. Experimental details may be obtained from [1].

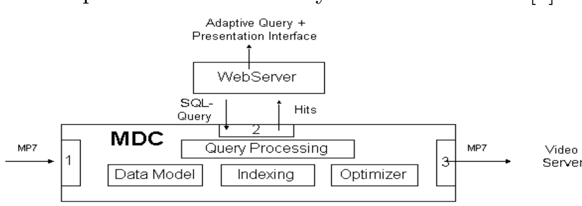

Figure 2: Distributed Multimedia Environment

Indexing, Query and Presentation Interfaces
Figure 2 shows how the MDC is embedded into the distributed system's context. Three interfaces, as marked in figure 2 are relevant for the distributed system.
(1) We provide plug-ins for various tools which handle and produce MPEG-7 data, e.g., for the Video Publisher Tool[1]. The MPEG-7 documents to be included into the MMDBMS are analyzed and then split into respective MDC object types and tables.
(2) The MMDBMS content may then be queried and presented with the help of *Adaptive Query and Presentation Interfaces*. These interfaces are build dynamically in the *Adaptive Web Server* based on the actual usage environment descriptions (see in detail below).
(3) Finally, we provide an interface which offers a connection to video servers where we are synchronizing the generated MPEG-7 information (describing the query hits) with the described MPEG-4 streams for enabling stream adaptation during network transfer.
In order to serve multiple client front-ends (e.g., hand-helds, PCs or Palms) the database queries are submitted through an *Adaptive Query and Presentation Interface*. Adaptation means the dynamic adjustment of the interface to the usage environment. The usage environment comprises the client's terminal capabilities (e.g., Hardware, Software) and the usage preferences (e.g., user prefers only audio files). Besides the query, also the results (meta-data) and the respective streams are shown and their presentation windows are adapted. The terminal capabilities are described with the help of the Composite Capabilities/Preferences Profile (CC/PP) which is a standardized framework developed by W3C, based on the RDF format. A CC/PP implementation, *DICE*[2], was extended and integrated into the Web Server to adapt the query and presentation interfaces to the respective usage environment descriptions.

Example of the adaptation functionality:
a) The user receives (after identification) an interface to enter the profile information, i.e., terminal capabilities and usage preferences. Parts of the terminal capabilities may be automatically extracted. Default values are presented elsewhere. This profile information is not required for each query, but will be stored in a cookie with a certain life span.
b) The CC/PP profile descriptions are sent to the adaptive query server and the DICE adaptation engine. The server interprets these descriptions in order to categorize the user into a usage class. This usage class will accompany the user through its query and presentation session. That means depending on the usage class of a user, the adapted query and presentation content is derived.
c) The elements each usage class has to display or to present are specified in a Mark-up language which is transformed into html with the help of the DICE adaptation engine. In order to allow the submission of queries and the presentation of query results, the DICE engine had to be extended to deal with multimedia elements.
d) The user specifies then its search criteria and submits the query to the Adaptive Web Server which on its turn presents a query to the database server. The result set from the database is returned to the user and presented again in an adaptive way.

3. REFERENCES

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[1] `http://www.video-wizard.com/index-n.htm`

[2] `http://users.aber.ac.uk/sdl/ccpp-info/dice/`