Using Object-Relational Database Systems and XML in the Context of Mobile Environments

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Abstract

In this paper, we present an architecture for presentation, access and exchange of information in a mobile computing environment. In the project MOVI, a new approach is developed which enables applications on mobile computers for exchange and visualization of multimedia objects with applications on stationary database servers via the Object Bus.

We focus our attention on new strategies for the adaptation and integration of database techniques regarding the management of multimedia data types at the particular conditions of mobile infrastructures. We believe that object-relational database systems e.g. Informix and Oracle8i are ideal repositories on the stationary server side for next generation multimedia applications, especially in inter-networked LAN or WAN environments.

Moreover, our approach illustrates the use and benefits of XML technology as a generic gateway to any mobile device.

The basic idea of this paper is the integration of object-relational database technology and XML techniques in a Mobility Information Center (MIC) as a framework for mobile environments. The major aim is to optimize the mobile data exchange and presentation by using of media specific queries, data preprocessing and reduction methods within the database system as well as XML/XSL based data transformation and presentation on mobile end systems. All these methods are influenced by contexts like local resources, available communication channels, and user preferences.

1 Introduction

The project "Mobile Visualization" (MoVi)[1] [3, 4] is focused on investigations which shall enable the graphic presentation of scientific and of other, even multimedia data in a mobile environment. The presented architecture is one main part of the project.

In the following, we focus our attention on the work packages *multimedia data management and access* as well as *data exchange*. These work packages address the investigation and development of strategies for the efficient exchange of multimedia objects over wireless and wired networks. All strategies consider the dynamically changing resources of mobile end systems and network resources.

One typical mobile scenario for us is a person accessing very different public or private data stored on several globally distributed *stationary data servers* (SDS) – the Infoverse – for example from a *mobile end system* (MES) using wireless networks, like GSM (Global System for Mobile Communication). The information contained in the Infoverse could have multimedia character, e.g. WWW data including audios and videos and data with textual descriptions and images that are managed in different database systems.

Therefore we need a suitable architecture which includes the several methods for the access, exchange, reduction and retrieval adapted to the mobile computing environment [10].

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At present in the field of database research, new architectures and models for multimedia database systems [1, 2] are investigated and designed, especially on the base of the object-relational technology [11]. Such a object-relational database management system (ORDBMS) provides a suitable environment for using and managing multimedia information. Therefore, it must support the various multimedia data types (e.g. images, text, audio, video) in addition to providing facilities for traditional DBMS functions like database definition and creation, data retrieval, data access and organization, data independence, integrity control, data replication and concurrency support. The functions of a multimedia DBMS basically resemble those of a traditional DBMS.

In the context of mobile environments, the question is how we can integrate known compression/conversion algorithms into the database system or how we can map the already developed request processing and information retrieval methods to server-side built-in operations. The aim is to use the new possibilities of object-relational database systems as stationary data servers by integration of combined features from document/image management, information retrieval and mobile computing. An other issue in our approach is to support several QoS levels. That means that the database system must support the specified QoS levels dependent on user defined parameters and available resources on mobile system.

In spite of the comfortable possibilities for management and retrieval of multimedia data in object-relational database systems [12], there is a need for application and device dependent presentation and visualisation of the complex data structures on mobile environments. A universal interface to the database system is required in order to use the object-relational multimedia functionality and to realize the derivation of the application and device dependent visualisation. In this context XML, the eXtensible Markup Language [5] as the universal format for publishing and exchanging data offers new solutions.

XML is rapidly gaining momentum in e-commerce and Interned-based information exchange, where its simplicity and custom-defined tags make it usable as a semantics-preserving data exchange format. The benefit of XML is that the concept of isolating source from target applies not only to wireless world but also to any set of data transformation, no matter how simple or complex. XML/XSL implements a generic gateway to any mobile device (e.g. PDAs, WAP phone).

However, to realize this potential, it is necessary to be able to extract structured data from XML documents and store it in a database, as well as to generate XML documents from data extracted from a database. Therefore we developed the database independent *DaS* utility (*Da*tabase to XML *S*ervlet), which offer this functionality.

The next section contains a brief survey of the MIC framework architecture for selection, exchange and presentation of information in a mobile computing environment.

2 Mobile Information Center

The Object Bus Architecture of the Mobility Information Center (MIC) has to serve as a flexible platform for the efficient exchange of user data and applications between stationary data servers and mobile end systems. Our main concept is an object oriented approach with the *Object Bus* (OBus) as one central feature. This Object Bus serves as a transparent layer for mobile communication and is responsible for the delivery of messages.

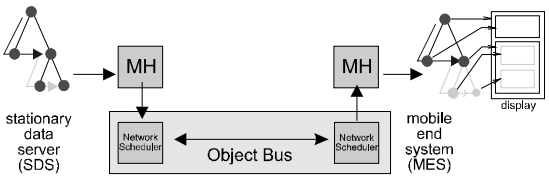

Figure 1. Traversal and exchange of structured objects

This object bus was extended in order to face and minimize the problems caused by limited bandwidth, end system resource limitations, and frequent disconnections. Basic components of this extended object bus are *Network Schedulers* and context-sensitive *Request/Reply caches*. They use techniques like priority- and QoS-controlled communication, transparent data compression and context-controlled caching to provide basic solutions for these problems. The second main feature is the introduction of *Message Handlers* (MH) that act in place of the communicating processes when exchanging structured objects.

A prototype of the Mobile Multimedia Information Center was built to demonstrate the use of our

object bus architecture, the multimedia database access as well as the deployment of exchange strategies and the information retrieval. The application consists of several modules: the user interface, a huge database holding actual multimedia data and visualization tools.

Figure 2. Multimedia application on a mobile client

All these modules are implemented as CORBA clients and servers that communicate via the OBus. The complete database is stored at the stationary multimedia support server at the office or can be accessed via this server.
More details about the components of the Object Bus Architecture and the experimental validation results of our methods and communication protocols you will find in [3, 4].
Based on this architecture, we present in the next section our approach of the integration of an object-relational database system as an extension of the Stationary Data Server (SDS) within the MOVI framework architecture.

3 ORDBMS: Challenges and Issues

At present there is a new family of object-relational DBMS (e.g. Informix , Oracle8, Universal DB2) provides all some new important extensions, especially multimedia extensions [1, 2, 11, 12]. These capabilities allow the behavior of the multimedia objects to be implement directly into the DBMS. Object-relational database systems support a number of multimedia data types - such as images, audio, or video - in their built-in system provide class hierarchies.
All of these features are very important to enable the object-relational DBMS to handle a broader set of application requirements.
In the scope of the MOVI project the aim is to integrate known compression or conversion algorithms into the database system or to map the developed request processing and information retrieval methods to server-side built-in operations. So we reach the effect *to relieve the communication components of the MIC object bus architecture (e.g. Message Handlers) from this functionality* and to transfer this to the database backend side (SDS).
Forinstance the functions included in the Image DataBlade Module, which we can use within the

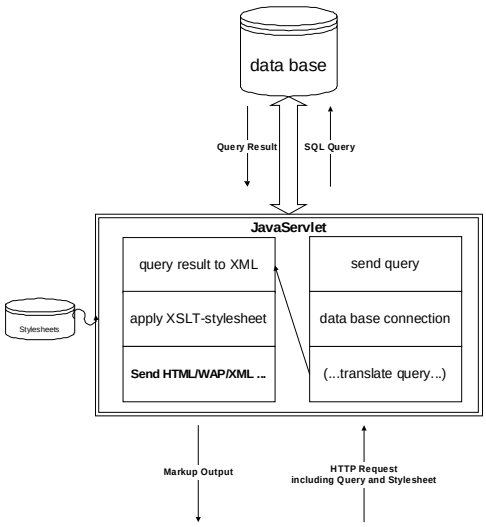

Figure 3. Database to XML Servlet

MIC framework for image preprocessing and data reduction based on the user preferences and the available resources on mobile end systems.
As an other fact the querying and searching techniques in DBMS need to extend to information-retrieval capabilities. In information retrieval the emphasis is more on finding the objects that satisfy as closely as possible a user's query and leads so to an *reduction of the amount of information* in the case of limited bandwidth of the communication channels. By using specialized indexes for complex object retrieval we can achieve large performance increases in comparison to blob retrieval for non-indexed.
The technical realization of the above functionality is done as a *part of the Stationary Data Server (SDS)* in the system architecture of MOVI.
Beside our data preprocessing approach (e.g. image conversion/compression) we can use content based retrieval techniques on images (based on the

Informix Image DataBlade) in order to reduce the amount of data which have to be transferred.
We believe, that the use of an *object-relational database system (e.g. Informix) for multimedia data management, data preprocessing, QoS and information retrieval will be an excellent, integrated approach* in the MOVI framework [7]. On the other hand there is the need for an application and device independent interface to the database system. Based on the XML technology, we present in the next section our approach of the XML/XSL integration of the Stationary Data Server (SDS) within the MOVI framework architecture.

4 DAS: Database to XML Servlet

XML [5] the eXtensible Markup Language, has quickly emerged as the universal format for publishing and exchanging data in the World Wide Web. Although XML was originally conceived as a replacement for HTML, it has emerged as a generic data exchange format. Its hierarchical structure and user-defined tags can be adapted to a wide variety of structured and semi-structured data, and many operations on XML documents – parsing, editing, validation, transformation can be performed independent of the actual tags in the document.
A key advantage of using XML as a data source is that its presentation is separate from its structure and content. The XML data defines the structure and content, and then a stylesheet is applied to it to define the presentation. XML data can be presented in a variety of ways (both in appearance and organization) simply by applying different XSL[2] stylesheets [13] to it. For example, a different interface can be presented to different users based on user profile, browser type, or other criteria by defining a different stylesheet for each different presentation style. or, stylesheets can be used to transform XML data into a format tailored to the specific application that receives and processes the data.
However, to realize this potential, it is necessary to be able to extract structured data from XML documents and store it in a database, as well as to generate XML documents from data extracted from database. We need methods to convert XML documents to relational tupels (in both directions) translates semi-structured queries over XML documents to SQL queries over tables and converts the results to XML.
Therefore we developed the *DaS* utility [6] (*Da*tabase to XML *S*ervlet, see Figure 2), that solves these problems. The utility is based on widely accepted standards – JDBC[3] for database access and DOM[4] for XML document access**.**
In the scope of the MIC framework, by using of the DaS utility we have now the possibility to exchange XML structures over the object bus. On the mobile end system (MES) device dependent XSLT stylesheets convert the XML document into the target presentation. This enables to present context in the format best suited to target device (e.g. HTML, WML, Plain Text, see figure 3), influenced by contexts like local resources and user preferences.

5 Conclusions

In this paper, we have described some parts of our framework approach based on object-relational databases and XML techniques. The major aim is to get a basic system for mobile multimedia information exchange, retrieval and presentation, allowing applications to access to globally distributed multimedia information and to exchange it effectively with respect to mobile resources and other parameters of the global environment.
Moreover, we considered especially the new possibilities of object-relational database technology by using of content based information retrieval and reduction methods as well as media specific queries within the database system in order to reduce the amount of data to be transferred.
With the integrated *DaS* utility we are able to generate XML documents from databases. As a result, based on the XML philosophy, we can reach any set of data transformation and reduction as well as XSL controlled visualisation to any mobile device like PDAs and WAP phone.
Until now, we could only present some prototypes as part of the complete architecture, because the implementation is just in progress. Later we will

[2] XSL provides for stylesheets that allow you to transform XML into HTML or other text-based formats, rearrange or filter data.

[3] JDBC is a java API for SQL-based access to relational databases.

[4] DOM (Document Object Model) specifies an object model for XML documents, with objects for elements, PCDATA and entity references.

Figure 4. Content delivery für PDAs, Browser, WAP

perform an experimental validation of the complex framework architecture.

In future work, studies will be performed in order to develop a suitable transaction management [8, 9] in the context of a mobile environment. Traditional transaction mechanism and criteria have to be adjusted to accommodate the limitations of a mobile computing environment. The major aim is to develop a new approach of a context based and transaction-driven multimedia data management with support for content based and media dependent request processing.

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