Digital Library for Multimedia Content Management

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Abstract

Digital Libraries are emerging technologies for document management. These documents includes multimedia objects. It requires new methods of all aspects of multimedia data management. Starting from the source through storage to delivery. Digital libraries have to use all modern network and servers technologies in order to supply services of a high quality. Its universal nature makes the digital library an excellent foundation for other multimedia-based services such as distance learning. In this paper we describe the first attempts of PSNC and POL-34 network to build a digital libary as a base system supporting different application areas.

1. Introduction

High performance computing and networking infrastructure has been developing in Poland for the last five years. Five high power computer centres and over 20 metropolitan area networks, which have been founded in this time, were connected with a countrywide ATM network POL-34 in 1997. It is based on SDH 622 Mb/s system from TEL-ENERGO S.A.

Pozna_ Supercomputing and Networking Centre (PSNC) is one of the designers of the Polish National Broadband Network POL-34. The main goal of this initiative is to provide scientific users with new opportunities for the development of science-oriented applications and telematic services. The range of the development covers a new implementation of standard Internet services as well as multimedia and metacomputing applications. At present, in the scope of POL-34 network, several projects are prepared to be operational as well. Because most of the metropolitan area networks in Poland are based on ATM technology all the projects can be developed in the end-to-end mode. The ATM technology is provided directly to the end-user.

New multimedia services, which are being deployed in broadband networks, require new systems for multimedia content management. Examples of the usage of such a system are considered later in the paper. The principle assumption is that for the management of multimedia content of different multimedia services, a common platform is designed – digital library system (DL). A pilot system was developed in the 1998. Since that time some former design issues had to be revised. This led to the next stage of DL system development.

2. Digital Library at PSNC

A pilot DL was developed in the first half of 1998. This installation uses the available software resource existing at PSNC. It provides the foundations for multimedia content management. The Architecture of this system is presented in Figure 1.
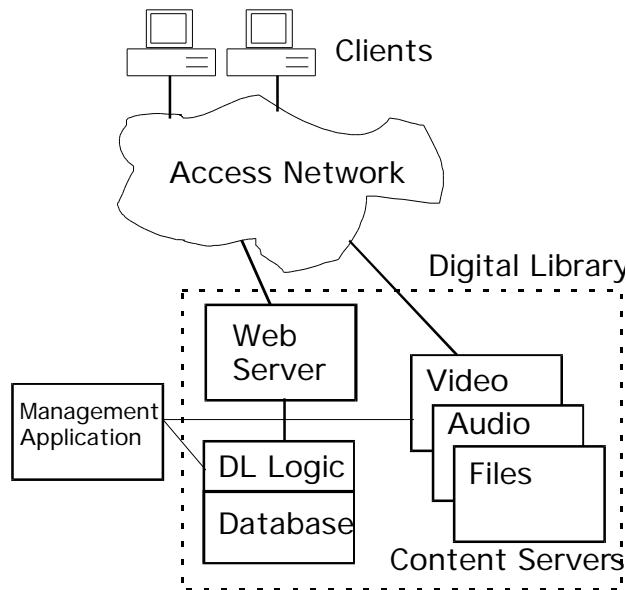
Figure 1: Pilot system architecture

The DL is based on a few components. Inter-component communication is network based, so each one can be placed on a different host, however we do not use any middleware. All communication is based on standard or proprietary protocols.

Main components are:
- metadata management application (DL Logic)
- content servers for storing and serving multimedia objects
- web server for the presentation of library content
- GUI mangement application for content load and management

The main component of this system is the Oracle database which stores all metadata. This describes the library content and user privileges. DL logic was implemented using a server stored procedures written in PL/SQL. DL logic means rules imposed on library and document structure, user privileges and searching capabilities. These procedures are the interface used by other components accessing metadata.

Different types of servers serving specific types of objects can be used to store objects. In our installation we used the following servers:
- Oracle Video Server for storing digital video objects,
- Progressive Networks RealAudio Server for storing audio objects,
- Oracle Web Applicaton Server for storing all others file based objects.

The last of these servers has an application for the presentation and searching of library documents through the web interface. This application is also written in the PL/SQL language. Based on metadata stored in the database forms are generated for searching library content as well as web pages presenting library content. For presentation purposes a graphical three dimensional interface using VRML scenes was developed which allows simple and fast browsing through the library structure and content.

A very important component of this installation is the GUI application supporting users with a functional interface to library content. The application is written in the Java language using JFC (Swing) graphical components. This allows it to be platform independent. The application does not present library content, but supports only the content load and management. The application uses system access control rules implemented in the database, which allows restricted access by particular users to specific library branches or documents. This allows for distributed content management, where each user interested in publication can be granted his own branch of the library for which the content he is responsible.

The application allows the loading of new documents. The document can be assembled by putting together objects of different types (text, images, video, audio) and defining the structure of the document manualy dividing it into chapters and pages containing selected objects. Objects are then described by simple metadata

such as: author, title, description or keywords. Defined in such a way a document is presented in a standard form on web pages. But "standard form" does not always fulfill our required needs. This problem is solved by using HTML as way of presenting library documents. With this concept a user creates an entire publication using any HTML editor and stores it on a local disk. After pointing its localization document is analysed by the application. All objects included in the document are described by metadata and sent to content servers and data describing the whole document and individual objects are sent to the database. Links contained within HTML pages are fixed in such a way that they point to new physical locations of used objects. The document is then presented using its own HTML, not automatically generated pages.

The application uses SQL*Net protocol and JDBC driver for communication with database. But content has to be placed on different servers depending on its type. In the cases of the RealAudio server and the Web Application server standard FTP protocol is used to transfer content onto them, but the Video Server required an agent to copy video files to realtime file system and tag them.

This system responds to all of the requirements specified earlier and allows the realization of services it was developed for. But shortly after its implementation requirements increased vastly. This was caused by new services appearing which were supported by digital libraries and new user expectations. This system was not so open or scallable to allow further development.

Most important flaws are:
- closed metadata subsystem
- use of proprietary protocols

New services, new requirements caused new design principles. The most important of these are presented below.

Distributed library and interoperability. Especially in the broadband network spread over the whole country an important aspect is the possibility of creating multiple local digital libraries serving local users, but allowing their global integration as well. This requires a new mechanism for exchanging information on library content between libraries, so a user can see all of the content through one entry point. In the future, intereoperability with other libraries should also be provided.

Quality of service. New methods for the presentation of multimedia objects according to a user's requirements and technical possibilites need to be developed. This is especially true for access network bandwidth and streaming media.

Performance and resource management. For mass usage of new services we need a new model of performance and content servers resource management. We also have to develop content caching and network multicasting to improve network usage.

Access control. We also have to develop new methods for access control. Creating new mechanisms assisting digital libraries is a mistake. It forces users to remember another password and creates new problems in existing security policies.

Based on the above requirements a project of a new digital library system addressing all of the mentioned problems is now developed. Some of the new project principles are:
- component based system design for allowing more flexibility in extending library functionality by simple addition of new components
- use CORBA middleware for inter-component and external communication and IDL for component interface definition
- use RDF standard as a consistent way of storing, exchanging and managing library and documents' metadata; this particularly requires new schemas especially for the description of the library structure and user privileges
- use LDAP based directory services as a central place for user authentication and authorization for easier integration with other IT systems
- use of models describing particular content servers performance and agents monitoring and reporting servers load for peformance management and admission control

The new system has to provide a common platform for digital library systems deployed in POL-34 network and provide interoperability between these libraries and other libraries. It should also deliver new mechanisms to support new services in the broadband network in particular, distance learning services.

3. Usage Scenarios for Digital Library

A digital library system was designed as the framework for several multimedia service scenarios, which will be realized within it. The main topics addressed in this area are:

- The management of different types of data including stream based data,
- The creation of multimedia publications,
- The storing of documents and objects contained in these documents,
- The possibility of describing objects and documents by simple metadata for searching,
- Access control for content.

The above mentioned problems are covered by different multimedia services which are developed in the POL-34 network. The digital library framework is foreseen to be the operational environment for these multimedia services (Figure 2).
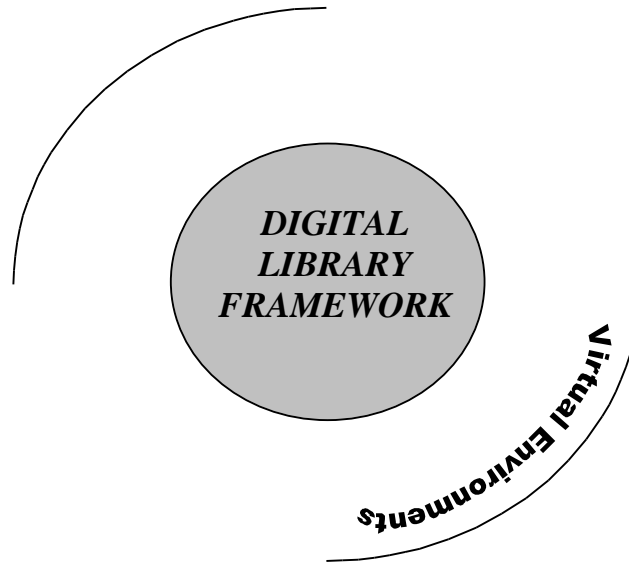

DIGITAL LIBRARY FRAMEWORK

Virtual Environments

Figure 2: Usage scenarios for digital library

The first of the mentioned services is the *distance learning system.* It is planned to realize the distributed teaching environment composed of three different levels: offline lectures, interactive on-line lectures and remote exercises in virtual laboratories. In the scope of off-line lectures, there is projected to provide a set of lectures stored in the database. The digital multimedia library system is the natural environment for preparing, storing and distributing the content. Having assured scalability and flexibility of the system the content can be easy prepared and managed. The video broadcast extended with some content-depended information is stored in the digital library environment and served by it to the listener synchronously. The Internet access to lectures makes this service easily accessible but the quality of media will be decreased. Especially when the content will be served in multicast groups. Regarding this we assumed such a form of accessing the lecture to be used additionally to standard lectures being given. Students can access these lectures when they study a subject at home for the purpose of knowledge consolidation. It does not put high requirements as far as quality is concerned but only aims at helping students with home exercises. Another approach is to prepare an environment for distributed on-line lectures. The transmission infrastructure over the ATM countrywide network provides a good facility to develop advanced forms of teleteaching.

The second example of service, which will be implemented in the digital library framework, is *the digital edition of a book*. The original printed text form will be extended with parallel multimedia events. An animation and sound served by specific content servers will be synchronised with text presented by management applications on Web pages. The content will be created with the usage of specific applications for data input. The publication decomposed into basic multimedia objects will be formed when data will be accessed. The digital library will be used to digitize the work, store it and finally provide it to the user. The whole content will be served via IP as well as ATM network in dedicated VN. Both cases will have the assured QoS required for each specific media.

Both mentioned implementations will be developed in 1999. Pilot implementations will be used as testbeds for multimedia delivery techniques in the national backbone network.

The scenarios for our environment concerned additionally are in the project phases. Especially two of them are interesting in the scope of the advanced digital library system in the national network treated as a high performance infrastructure for multimedia. First project considered aims at developing collaborative virtual environments, which can be embedded in the framework of a distributed digital library. The second example is a Media on Demand server. The designed and implemented structure will meet requirements for different media distribution. More attention will also be paid to network performance issues for this service.

As one can see in the examples presented above great importance is put on problems regarding performance of the interface between the digital library and communication means. The national ATM network will be the basis of these tests.

4. Conclusions

The high performance computer and networking infrastructure is crucial for the development of advanced services compliant with IST. Pilot projects have already been developed and now, in several cases, the final stage will be entered. The most important thing is to concentrate on the implementation around the digital library concept as a framework for other services based on media transfer to an end user. The operating framework is going to be a considerable testbed for communication related issues, especially QoS, CoS and DiffServ communication.