

**A Quality of Service Driven Approach to
Architecture and Components for
Distributed Multimedia Presentational Applications ¹**

-Extended Abstract-

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1. Introduction

Multimedia technology is now available and allows the development of advanced applications integrating several types of information such as images, texts, graphics, audio and video [Fox, 1991; Narasimhalu, 1991]. Associated to multimedia technology, recent advances in high-speed networks lead to consider distributed systems [Berra, 1990; Blair, 1993] as the support for different kinds of applications such as presentational applications providing remote access to multimedia documents [Miller, 1993] or conversational applications involving multi-directional, real-time communications [Rangan, 1993].

Since Quality of Service (QoS) has been mainly discussed for communication protocols, we consider QoS in a more general sense, i.e. for any component of a distributed multimedia system. Examples for these components are: local operating systems, file servers, database systems and user

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interfaces representing the human factor. For each identified component, a so-called QoS interface is defined, details on this QoS interface and its parameters can be found in [Kerhervé, 1994b]. This approach allows to characterize the specifics of distributed multimedia systems (which distinguish them from "ordinary" distributed systems) in terms of QoS. Following these considerations, we present a QoS driven approach for architecture and components for distributed multimedia systems.

In the framework of the "Broadband Services" project of the Canadian Institute for Telecommunication Research [Wong, 1993] involving several Canadian universities¹, our sub-project especially investigates the impact of dynamically changing QoS on the design of applications and we develop methods for the management of the quality of service related resources within a distributed environment [Kerhervé, 1994b]. A multimedia news-on-demand service has been identified as the target application and provides the functional requirements for the project [Kerhervé, 1994a]. In this paper, we present the architecture of the system focusing on the quality of service interfaces.

The paper is organized as follows. In Section 2, a computational architecture for distributed multimedia presentational applications is developed. Section 3 presents the different types of interfaces and their role within the application. Section 4 gives the status of the prototype and discusses future work.

2. Computational Architecture

An important requirement for distributed systems is the interoperability between components of systems and among systems. Different approaches can be identified. On one hand, there are programming environment to support the implementation of distributed systems, e.g. Advanced Networked Systems Architecture-ANSAware, Object Management Group Common- Object Request Broker Architecture, OSF - Distributed Computing Environment. On the other hand there is Open Distributed Processing (ODP), a joint standardization effort of ISO and ITU resulting in a Reference Model on OPD [Nicol, 1993].

In order to be independant from a certain implementation platform, we decided to follow the guidelines given by the Reference Model of Open Distributed Processing [Nicol, 1993; Raymond, 1993].

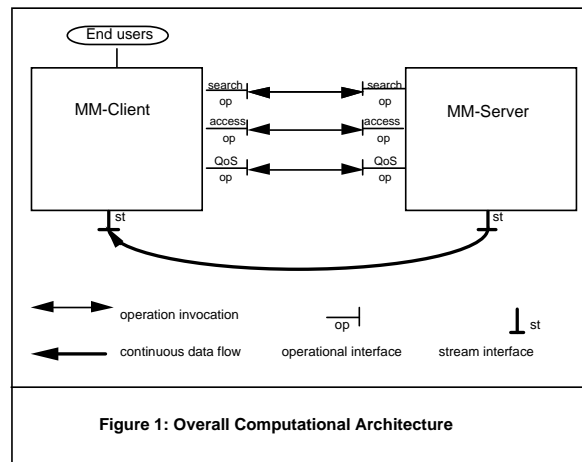
In this section a computational architecture for the news-on-demand service is developed within the framework of the Reference Model of Open Distributed Processing (RM-ODP). RM-

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ODP provides a framework for the description of distributed systems supporting distribution, portability and interoperability [Raymond, 1993]. The main concept of the RM ODP is the viewpoint. A viewpoint is an abstraction, focused on parts of an ODP system determined by a particular interest. There are five viewpoints: enterprise, information, computational, engineering, technology. An introduction to ODP can be found in [Raymond, 1993; Vogel, 1994].

In this paper, we consider the computational viewpoint which is a functional decomposition of the system into objects that are candidates for distribution. Computational objects are providing operation through computational interfaces and interaction between computational objects is described in terms of interface binding.

For the news-on-demand system, we identified two main computational objects: a server, storing multimedia documents, and a client providing access and delivery for these documents. Figure 1 illustrates the computational viewpoint of the considered news-on-demand service. It contains two main computational objects, a multimedia server (MM-Server) and a client (MM-Client). This both objects will be referred as components. Both objects have several interfaces: operational interfaces providing operations for search, access and QoS negotiation, and stream interfaces supporting the continuous data transfer.



The multimedia client provides several functionalities according to the users's specific needs: multimedia news storage and analysis, multimedia news consultation or multimedia news production. At present, we concentrate our efforts on the multimedia news consultation and the prototype we are implementing offers the consultation user interface. The multimedia client is also responsible for the presentation of multimedia news and then integrates synchronization mechanisms in order to enforce the temporal scenario attached to the multimedia document for its integrated presentation[Lamont, 1994]. The multimedia client also offers a user interface for the specification and the negotiation of the quality of service.

The multimedia server provides reliable and coherent storage of multimedia documents as well as concurrent access to these documents and to their components. It is responsible for the evaluation and execution of user's queries on the multimedia database and is also concerned with the efficient organization of the storage spaces. The multimedia server also stores control information such as synchronization scenario as well as parameters for quality of service negotiation.

3. Interfaces

In the previous section, we described the general architecture of the system. In this section we present in details the different interfaces: inter-component interfaces (between the client and the server) and intra-component interfaces that are the different interfaces in each component.

3.1. Inter-component Interfaces

As shown in Figure 1, the interfaces between the multimedia client and the multimedia server can be separated into two different kinds of interfaces: operational interfaces and stream interfaces. An operational interface corresponds to a service requested by the client and provided by the server. A stream interface corresponds to an exchange of continuous information between the two components.

Three operational interfaces are defined between the client and the server: the search, the access and the QoS negotiation interfaces. We here make a distinction between the two complementary steps of the retrieval process : the search and the access. The first one provides for the retrieval in a set of multimedia documents while the second concerns the access to a single document. In the search operational interface, the multimedia client sends the criteria that will be used by the server to isolate the corresponding set of documents. The documents will not be immediately sent to the user, the client only receives the identifiers of the corresponding documents. The access operational interface will then be used to specify the document that will be sent to the client. Between the search operation and the access operation, the client uses the QoS negotiation interface to specify and negotiate the QoS parameters.

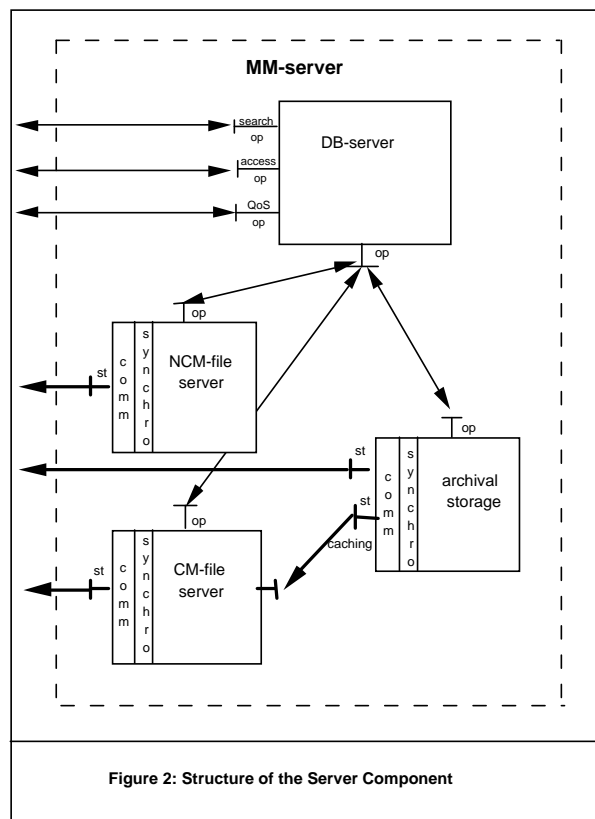
The stream interface is used to transfer the multimedia document from the server to the client. This interface will be implemented using a multimedia transport service. This interface also includes QoS negotiation with the transport system.

3.2. Intra-component Interfaces

In this section, we present the different interfaces that are defined inside the two components: the multimedia server and the multimedia client. We essentially focus on the multimedia server.

3.2.1. The multimedia server

The multimedia server provides reliable and coherent storage of multimedia documents as well as concurrent access to these documents and to their components. The main component of the multimedia server is the database system which controls and executes the retrieval and access to multimedia news. Actually, due to performance constraints for storage and access to multimedia data, especially for continuous data (sound and video), the database management system can use services from specific components such as continuous media servers or archival storage servers. Nevertheless, all the access to the data stored in specific servers will be controlled by the database system. The database system is in charge of deciding how and where the data will be stored. How the data will be stored concerns the internal model used for the storage, while the question where the data will be stored concerns the sub-components that are used for the storage and their localisation.



The multimedia server is composed of the following sub-components: the database (DB) server, continuous media (CM) file servers, noncontinuous media (NCM) file servers, and archival storages. The objects (shown in Figure 2) called continuous media (CM) file server, noncontinuous media (NCM) file server, and archival storage are supposed to contain recently published documents in continuous and non-continuous formats and archived documents, respectively. From a technology point of view, they are implemented by conventional databases, special purpose file servers and tertiary storages, e.g. juke boxes containing CDs or tapes. Synchronization mechanisms and communication software are present on each sub-component. All the QoS parameters associated to the different sub-components are stored and managed by the database server. The database server is the sub-component implied in the QoS negotiation protocol.

The server's intra-component interfaces fall into the same two previous categories: operational and stream interfaces. An operational interface is defined between the database server and the three other servers: NCM file server, CM-file server and archival storage server. This interface corresponds to the dispatch of sub-requests to the different sub-components to allow the access and transmission of multimedia news composed of sub-objects located on different devices.

3.2.2. The multimedia client

In the multimedia server, we presented four sub-components which are candidates for distribution and can be implemented on different machines. The components of the multimedia client are software components, resident on a unique machine. These components are: user interfaces, QoS software, communication software, synchronization controller and decoder.

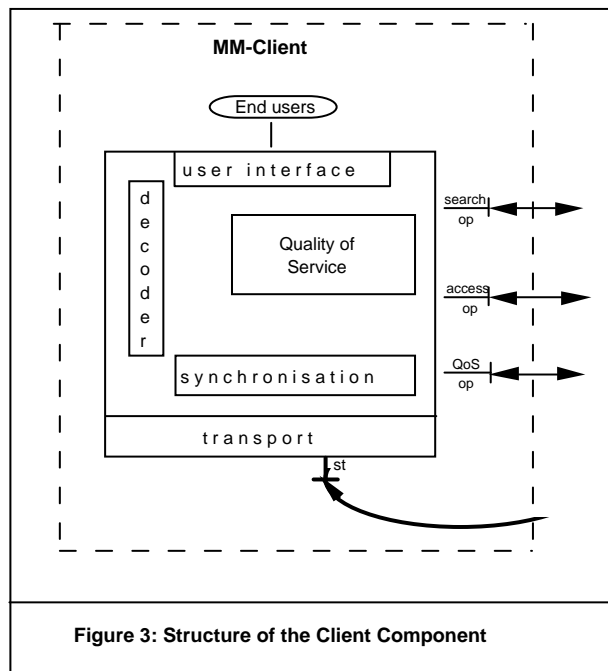


Figure 3: Structure of the Client Component

At present we concentrate on the user interface for the retrieval of multimedia news. This interface should provide several retrieval techniques [Berra, 1993]: retrieval by keywords, browsing, guided tour, full text retrieval, similarity retrieval. Several techniques such as retrieval by keywords, browsing or guided tours are general for all the media while others, such as similarity retrieval or full text retrieval, are specific for still images or texts. The consultation interface presently offers retrieval by keywords and browsing.

Since we suppose that a user is not willing to deal with raw numbers, we agree principally with a "quality query by example" for the QoS user interface [Kalkbrenner, 1993]. However our approach is to present the user a set of predefined parameters which corresponds to his experience, e.g. audio quality known from the telephone or the compact disc. Further more, the user can check the offered quality by a QoS demonstration, listening to or watching examples which are provided for all variants. Following this approach, the QoS software implements the negotiation and renegotiation protocol.

The communication software implements resource reservation oriented protocols, e.g. STII. A description of the synchronization mechanisms and their inter-relation with decoders adopted in this project can be found in [Lamont, 1994].

4. Conclusion

We presented an integrated architecture for distributed multimedia applications where the parameters of quality of service are considered in the different components. We have detailed the two main components: the multimedia server and the multimedia client and presented inter-component interfaces and intra-component interfaces.

This approach follows the guidelines of the Reference Model of Open Distributed Processing rather than to provide an ad-hoc approach. In particular, we focused on the QoS issues in a general sense which allows to deal with the specifics of multimedia in a unique way.

A prototype is presently under development in the following environment: IBM Power PCs running AIX by a local ATM switch. This prototype supports UDP and STII based communication, MPEG and Moving JPEG video encoding.

Future work will include investigation on the interaction of QoS with real-time operating systems, non continuous media file servers, scalable encoding schemes and database systems. We will also study the impact of our approach for global multimedia information systems, e.g. World Wide Webster and QoS for interactive multimedia applications (CSCW, conferencing systems).

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