A Mail-Based Teleservice Architecture for Archiving and Retrieving Dynamically Composable Multimedia Documents *

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Abstract

In this paper, a teleservice for archiving and retrieving multimedia documents using public networks is described. This teleservice encourages a broad range of commercially applicable multimedia archiving applications suitable for an asynchronous access mechanism. It is based on an integrated architecture comprising stand alone archive clients and a multimedia archive server which is realized using a database management system. Archive clients access the archive server via an extended X.400 Multimedia Mail Teleservice. This teleservice reflects the specific requirements of dealing with multimedia documents in a networked environment by supporting a global reference mechanism. The archive server can dynamically compose new versions from an original archived multimedia document including extractions of subsequences of continuous data streams, coding and quality transformations. Thus, users can retrieve multimedia documents that explicitly reflect his individual workstation environment, information needs, and preferences. Since this feature allows to determine in advance the data volume to be retrieved and transmitted, users have more control over their service charge. The concept, architecture, and functionality of the teleservice as well as a sample instantiation of the proposed architecture showing an application called multimedia calendar of events are described. A comprehensive discussion of this prototypical implementation provides our experiences.

1 Introduction

In the near future, many users on possibly heterogeneous platforms will have access to multimedia mail allowing them to interchange multimedia documents over public networks. Besides its usage for conventional interpersonal messaging, this technology can also be exploited for innovative, commercial multimedia applications. It is especially suited for domains that can cope with the mail delay, i.e. which do not require immediate delivery of requested multimedia data, like, e.g., a product offering service, a virtual travel agency, subscription service for multimedia documents, or cooperative authoring of multimedia documents.

In this paper, we introduce an archiving and retrieval teleservice for multimedia documents which employs such a multimedia mail implementation. Connectionless, asynchronous multimedia mail

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is applied as a means for interchanging multimedia documents between *archive clients* and an *active multimedia archive server*. Since the special requirements of multimedia data within a networked environment are reflected in the underlying mail implementation as well as in the archiving components, it extends those functionality provided by usual electronic document archives. One feature is that searching for documents is possible by descriptive search criteria addressing document contents as well as multimedia specific data. This allows, for example, to select documents which do not contain video clips longer than 1 minute. Another feature is support for dynamic document composition. It allows to retrieve other versions of originally archived multimedia documents which are dynamically created by the archive. In other words, a copy of the original document is tailored to meet the user's individual information needs, preferences, workstation environment and cost restrictions (charge of the teleservice provider, network and storage costs). Furthermore, it is possible to retrieve only a description of a document's structure which can be helpful for a user who has to decide if it is worthwhile to retrieve the document completely. The uncertainty with respect to the returned amount of data and the resulting costs faced in formulating queries is less critical. Users can control which of the following types of query result they want to receive: (1) a report of the number of matching documents, (2) for each matching document some application specific descriptive information, or (3) complete documents.

The *archive access protocol* defined between archive clients and the server is using the multimedia mail service developed at GMD-FOKUS which is based on the principles of CCITT Recommendation X.400 Message Handling System [3]. The client/server-communication employs both, the *store-and-forward mechanism* inherent to electronic mail and the *referenced object access* (ROA) mechanism which complements electronic mail submission and delivery in case of high-volume multimedia information content such as video.

In our prototypical implementation of the proposed teleservice, the archive server which is described in-depth in [28] is based on the VODAK *database management system* (DBMS) [18] which is a research-prototype developed at GMD-IPSI. Our standalone archive clients provide functionality for the authoring and presentation of the multimedia documents as well as the management of the user access to the archive server. Except for its asynchronity, for the teleservice users, the utilization of the mail service is transparent.

The remainder of this paper is organized as follows. We conclude this section with a review of related work. In section 2, we introduce the multimedia mail implementation relevant for us. The architecture of our teleservice is described in section 3, while in section 4, we explain its functionality. A sample instantiation of the proposed architecture is outlined in section 5. In section 6, we evaluate our approach and discuss the experiences made by a sample implementation. We conclude the paper with a review of issues that have been out of scope, and an outline of our current state of implementation as well as future work.

Related Work

To our knowledge, the integration of a multimedia database system with multimedia electronic mail for the realization of a multimedia archiving teleservice is a new approach not reported in any previous work. Research in both areas from which technologies are applied have started almost simultaneously. Information about multimedia mail can be found, e.g., in [2, 7, 22] while research on archives for documents (mostly office documents) is reported, e.g., in [5, 30]. With respect to multimedia database systems, a research field which is still developing, first approaches were data-

base systems for specialized data such as spatial databases [20, 26] and pictorial databases [27]. Spatial databases were attractive because of the fact that the semantics of the objects and operations could be clearly defined. One of the first multimedia efforts in managing multimedia data was the *Multimedia Information Manager* in the ORION object-oriented database system, developed at MCC [31]. The integration of the new data types is accomplished through a set of definitions of class hierarchies and a message passing protocol not only for the multimedia capture, storage, and presentation devices, but also for the captured and stored multimedia objects. This way, a high degree of flexibility is achieved since new storage or presentation devices are easily included by providing the corresponding classes as subclasses of the existing classes. Another project is MINOS, in which the *Multimedia Object Presentation Manager* was developed at the University of Crete [4]. Synchronization mechanisms for distributed multimedia systems are addressed in [25]. An approach for an integration of multimedia into a distributed office application environment based on a multimedia database is described in [24].

2 Multimedia Mail

Research within the area of multimedia mail has been going on for almost 10 years [2, 19, 22]. While the early approaches have been very restrictive and support for continuous data was not fully provided, today's approaches are less restrictive and more powerful.

Within the BERKOM project, a Multimedia-Mail Teleservice for public networks is under development [7, 19]. It is based on the principles of CCITT Recommendation X.400 *Message Handling System* (MHS) [3] and provides an extended *Interpersonal Messaging Service* running in an open heterogeneous environment on a series of different hardware and software platforms. Implementations may include access to de facto standard Internet Mail SMTP [21] and competing multimedia mail standard MIME [1].

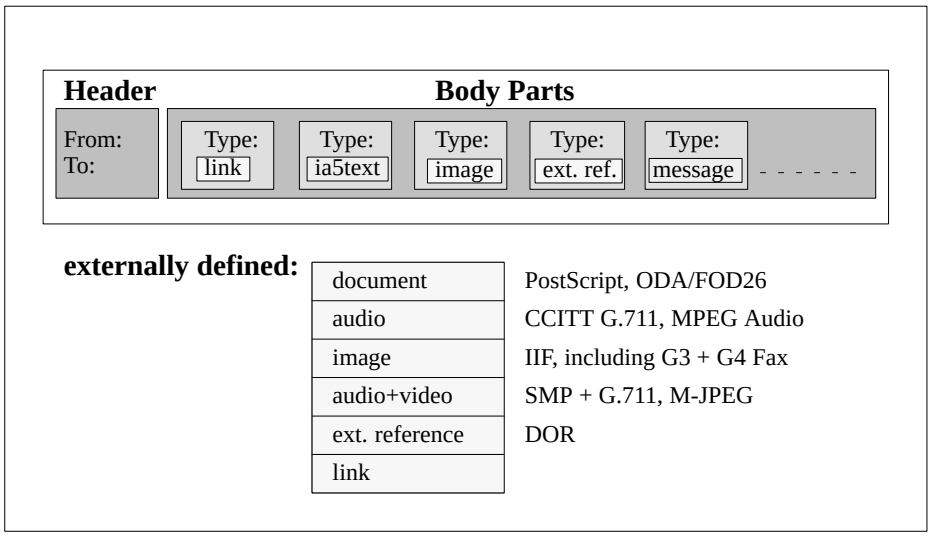

Figure 1: The BERKOM Multimedia Message Structure

In terms of X.400, the body of a message consists of a sequence of *bodyparts* (figure 1). A bodypart contains data of a certain information type. Due to the fact that the information types supported by

X.400 do not meet the requirements of an extensive multimedia mail service, the BERKOM project makes use of the extension mechanism of X.400 (88), the *externally-defined bodypart type*. This mechanism allows to integrate additional (commonly used) multimedia and hypermedia information representations as message bodyparts. Graphics, video, and audio as well as multimedia/hypermedia documents may now be included in a message. A special LINK bodypart contains information about how contents of bodyparts are related. The only content types which are mapped onto standardized bodypart types are TEXT and MESSAGE.

The *Message Transfer System* (MTS) is based on a *store-and-forward mechanism*. Most of the existing nodes between originator and recipient in a X.400 MTS have message size restrictions. Large messages, one of the characteristics of multimedia information conveyed through electronic mail-systems, may lead to congestion in *Message Transfer Agent* (MTA) implementations as well as may go beyond storage capacities at the recipients' sites. As a consequence, a powerful *reference mechanism* is needed, which makes it possible to include a reference to mono or multimedia data within a message instead of including the data itself. The data is then stored in a specific, remotely accessible store (figure 2).

The *external references* are based on the universal reference mechanism *Distinguished Object Reference* (DOR) [14], defined as part of the *Referenced Object Access* (ROA) model, described in the international standard *Distributed Office Application Model* (DOAM[13]). The DOR standard describes a data structure and a coded representation of external references that specifies the store, the access method(s), the type of the data object, a local reference to the data object and quality-of-service (QoS) parameters. It allows data objects to be localized and distinguished globally.

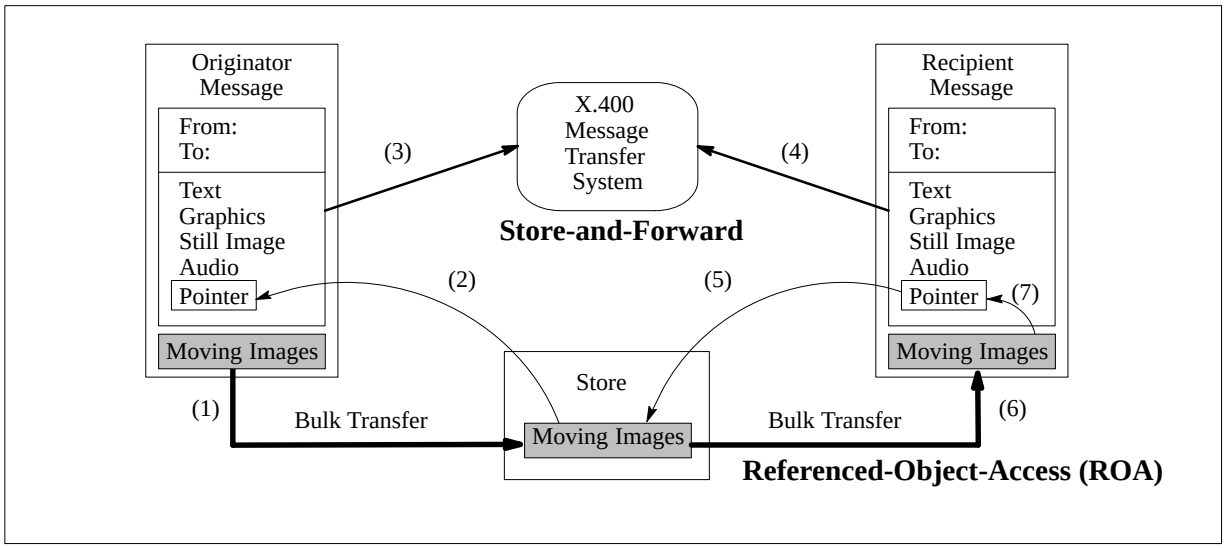

Figure 2: Two exchange mechanisms: Store-and-forward plus Referenced-Object-Access

The recipient of a message is free to resolve the reference using communication protocols which provide direct access to the stored data object. In the BERKOM project, a non-realtime service and protocol, the *Referenced Data Transfer* (RDT) [16, 23] has been implemented to retrieve the referenced data object from the store. In case a client wants to view message bodyparts such as audio and video without prior local storage, a *realtime* protocol must be used between the store and the client's

site. There are a number of activities going on regarding the design and implementation of such realtime protocols, in particular for the transport/network layer, where the transport user may specifiy QoS parameters (e.g. throughput and transit delay) to be fulfilled by the transport connection. The integration of such realtime protocols within the Multimedia-Mail Teleservice is under development.

As mentioned above, the LINK bodypart of a multimedia mail describes the relationships between the mail's different content parts. The BERKOM-profile uses the concept of *links* between two parts of information to allow structuring for the whole range from simple annotations to complex references between bodyparts. This scheme may also lead to hypertext/hypermedia-like messages as required for the Multimedia Archive Teleservice.

For separation of archiving specific information from the remainder of the message body, an externally defined bodypart type called ARCHIVE is introduced. Multimedia mails exchanged between archiving recipients always provide a bodypart of this type which can be accompanied by a document contained in the remaining bodyparts. Its contents is only completely interpretable by the receiver specified in the mail header. From the perspective of the mailsystem, however, an ARCHIVE bodypart is a document component as well which is treated in the usual way.

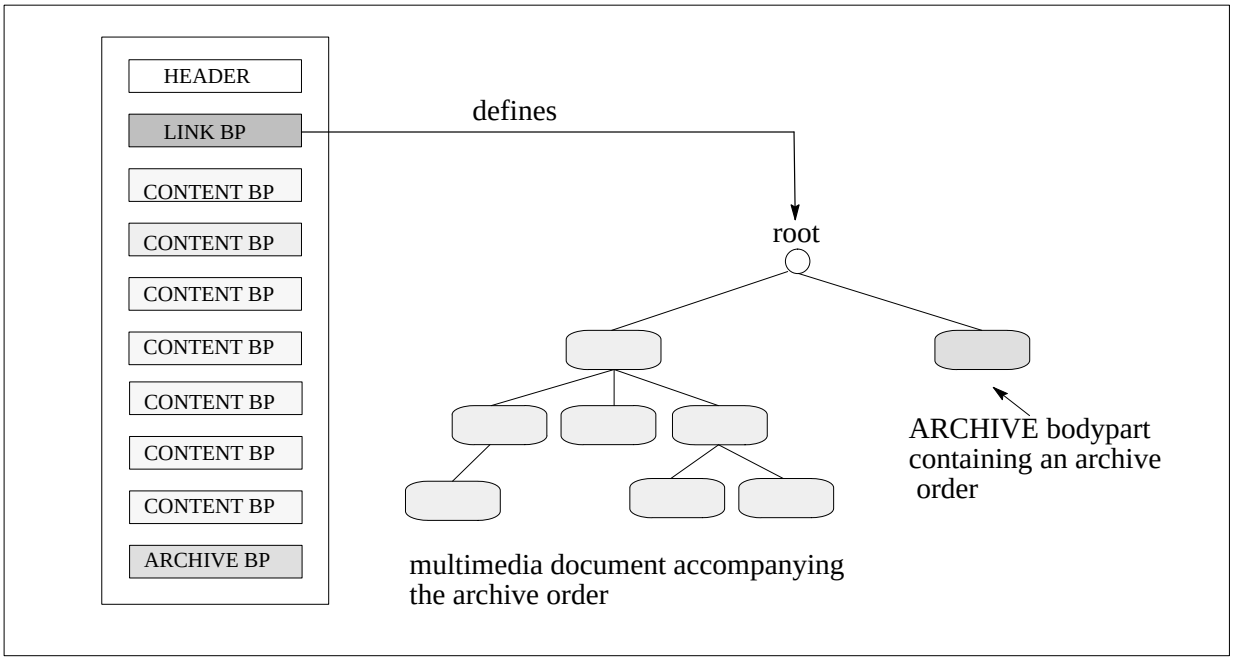

Figure 3: Structure of a sample archiving multimedia mail

Figure 3 provides an illustration of these aspects. Besides the header which contains mailing specific information, the shown sample mail consists of nine bodyparts. The LINK bodypart defines a mapping of the remaining eigth body parts into a hypermedia document structure. In general, one branch directly below the root embodies the actual multimedia document (of arbitrary size and structure) to be communicated (in figure 3 this is the left branch). The other branch exclusively comprises the ARCHIVE body part containing archiving specific information. This can be perceived as an archive order with an attached hypermedia document.

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