Design and Implementation of a Heterogeneous Multimedia Mail System

Schubert FOO & Siu Cheung HUI
Division of Software Systems
School of Applied Science
Nanyang Technological University, Singapore

Abstract

Multimedia electronic mail (email) systems have become viable enhancements and replacements for traditional and widely accepted ASCII-text only mail systems. Multimedia email systems allows users to use the richness and more varied forms of other media types (such as graphics, images, speech, animation, text and video) to convey the intended meaning of the message.

Recent research efforts have resulted in the emergence of a number of multimedia email systems. However, the majority of such systems are mainly homogeneous systems which are generally more concerned with providing the necessary tools to allow multimedia mails to be composed and electronic communication to take place among users. Provision of basic functionalities alone is insufficient to ensure long term success and large scale users' acceptance of multimedia email. There is a distinct need to address both aspects of efficiency and effectiveness in the delivery of multimedia electronic mail systems so that it can be an realistic alternative to traditional text mails.

This paper proposes a number of key design issues pertaining to the system and user level in the delivery of the next generation of multimedia electronic mail systems. It demonstrates how these factors have been considered in the design and implementation of a prototype multimedia system, MEmail, to function over the heterogeneous academic environment of Nanyang Technological University (NTU), Singapore.

Keywords: multimedia information system, electronic mail system, heterogeneity, interconnectivity, filtering, query, information retrieval, object oriented database

1 Introduction

The surge of interest in Internet has opened up a whole arena of users who are not longer confined to the academic community but to the business community and general public. Each user will be able to tap into the information superhighway to download and upload information freely and be able to communicate with other users around the world via
newsgroups and electronic mailing. Within Internet, text-only electronic mail remains the main form of interpersonal communication medium.

However, with the rapid advances in information processing capabilities and the availability of larger storage devices, this scenario is likely to change. Text-only messages are likely to give way to multimedia messages which will allow richer and more varied forms of message representations (such as graphics, images, speech, animation, text and video). This changing scenario is evidenced by the amount of ongoing research in multimedia and the small but growing number of commercial multimedia email systems that are available today. Nonetheless, these systems have not taken off in a big way as its predecessor due to their lack of ubiquity. Reasons for this failure can be attributed to the lack of data interchange data format, the huge storage requirements of video and other media, and the lack of standard facilities for viewing and composing multimedia documents. Along with the advances of technology, email users of today have higher expectations. It is insufficient just to provide the basic functionalities of mailing systems alone. There is a need to address the efficiency and effectiveness of email systems as a means to provide value added service in electronic communications.

This research is initiated to examine existing multimedia systems, to derive key design issues in multimedia electronic mailing and to implement a prototype for further study and evaluation. This paper proposes a number of key design issues and demonstrates how they are factored in the design and implementation of a multimedia email system, MEmail. MEmail provides a local transparent heterogeneous multimedia email facility across different computer platforms linked together via different local area networks within the academic environment of Nanyang Technological University (NTU), Singapore.

The paper is divided into five sections. In the following section, the key design issues in multimedia electronic mailing are first identified. These issues in turn form the basis for the design and implementation of MEmail. Section 3 examines each design issue in turn and illustrates how it is being treated and implemented in MEmail. An overview and the current status of the work, together with some preliminary findings are presented in Section 4. Finally, the paper concludes with a summary of the accomplishments achieved through the design and implementation of MEmail.

2 Key Design Issues In Multimedia Email Systems

The authors have divided the key design issues in multimedia email systems broadly into two categories pertaining to the system level and the user level. In arriving at these key issues, a survey of existing multimedia systems (which included the Andrew Message system [1], Diamond system [2], Montage system[3], Microsoft MSmail [4] and NeXT MediaView [5]) was carried out in order to identify each system's characteristics, strengths and weaknesses from which the key issues pertaining to the system level were identified.
At the user level, a simple user survey was conducted for a subset of email users within NTU. In the survey, users were asked to respond to the type of characteristics they would like their "ideal" email system to exhibit and the type of functions which it should support.

Based on the above output and authors' perception, a list of key design issues are proposed and presented in this section. These issues are by no means exhaustive, but are considered as important considerations in multimedia email design. Issues associated with the basic functionality of mail systems such as the provision for composing, sending, receiving mails, creating and managing folders, filing, printing, deleting mails, and so on must obviously be present in any mailing system and therefore not included as a key design issue.

Not in any order of priority, the key design issues from a system viewpoint include the:

- **Ability of the mailing system to function over a heterogeneous environment.** Organizations using a homogeneous set of computers throughout its entire organization is a rarity. This is especially so for large organisations and multinational corporations. Existing multimedia email systems have been successful in small local user communities but have not perhaps achieved the critical mass of general users due to the very nature of their homogenous design which require the same make of computers be used in order to exploit the multimedia capabilities.

  In a typical heterogeneous environment (such as NTU), personal computers, workstations and even mainframe computers of different makes can co-exist within the network. The exchange of multimedia documents becomes complex in such an environment due to hardware and data format incompatibilities among them. In addition, one should not expect all computers used within the email environment to be equipped with identical media handling facilities. Thus, some computers may support both audio and video media types while others may only support the audio media. In this instance, the mailing system should still be able to detect the deficiency in the latter and report it to the user; but at the same time still being able to play the audio part of a video clip, if necessary.

- **Ability of the system to communicate and exchange messages with other multimedia mailing systems** (interconnectivity). Mailing systems should not be designed as closed-door systems if it wishes to gain long term support and usage from the masses. The main concern of this interconnectivity problem lies on the lack of a standard method for transporting multimedia electronic messages as well as lack of agreement on the data formats among the different mail systems. For example, users of Andrew, Diamond, NeXT and MS-Mail systems are currently incapable of exchanging messages among each other. Vendors have vested commercial interest in particular representative formats so that the prospect of an early agreement is not conceivable.
This problem can be tackled using two approaches. First, is the use of the "top-down" approach where vendors produce their own standard format and enforce all users to switch to this standard. This approach as verified on Andrew, Diamond and other vendor specific systems is unlikely to succeed because users are reluctant to change their working environments and send messages if readability is uncertain. Second, is the use of the "bottom-up" approach where users will send a multimedia message in whatever format is used in their system. At the recipient end, the mail reading program will make provisions to recognise this mail as a foreign mail and will initiate the corresponding program (supplied by the originator) to handle and display the message. In order for this approach to work, these display and translation software must first be distributed by the sender to the receiver's mail system, installed and integrated with other mail systems' software into mail reading program before it can be used.

- **Provision of a good message handling and storage mechanism for multimedia mail.** In cases where a piece of mail is to be sent to more than one user, using a distribution list or otherwise, information sharing and handling becomes crucial due to the size of these multimedia messages. At such, the practice of physically sending a copy of the same message content to each recipient must be avoided. Network traffic should be minimised as much as possible. In addition, the system must be able to satisfy the potentially enormous storage requirements for multimedia messages. Therefore, the mailing system should be made accountable for the overall handling and storing of messages for better repository utilization. Data compression is also desirable to reduce the amount of storage requirements of multimedia mails.

Only one single copy of the same message should be kept by the system to be shared by all users. To minimise network traffic even further, the message header can be the only piece of information sent to each recipient initially. The message body should be sent across the network only when it is specifically requested by the user. In addition to this, the system should send only those media data contained in the message body which are supported at the recipient's machine. For instance, if the recipient's machine do not have audio handling facilities, the audio media information contained in the message body should not be sent unless it is been specifically requested by the user.

- **Extendibility to handle and support new media types.** The term "media type" although traditionally meant to denote the familiar text, graphics, image, audio and video, can also be extended to include other forms of information such as tables, formulae, spreadsheets, word-processed documents, CAD/CAM drawings, etc.. Such information are generally not properly supported in mail systems, instead, they are often treated as attachments to the mail. Therefore, it becomes desirable for the system to be extendible to accommodate and manipulate these new media types. Such a facility is possible if a mechanism to incorporate and manipulate these new media types is facilitated in the system architecture design.
The key design issues from the users' viewpoint include:

- **Presenting only relevant and important mails to the user and discarding all other forms of junk mails.** Users of mailing systems are too well aware of the use (or abuse!) of distribution lists and bulletin boards which have resulted in them being inundated with large amounts of junk mails which are intermixed with important ones. This resulting information overload results in two implications. Firstly, it takes considerable time for the user to read and distinguish among the junk and important messages. Secondly, the large volume of messages also presents difficulty for the user to browse and find the desired previously read message.

The presentation of only relevant mails is possible if some form of filtering can be introduced to intercept and verify all incoming mail. Junk messages are discarded while some form of appropriate action on useful messages, such as automatically routing to folders, auto-replying, printing it, and so on can be taken.

- **Availability of a set of resource management tools to aid management, browsing and retrieval of messages.** Existing email systems do not generally provide sufficient tools for browsing or retrieving messages that were read in the past. The use of folders to denote different categories is sufficient for message organisation but becomes increasing difficult for message browsing and retrieval, especially when the number of kept messages grow over time.

It is thus desirable for the system to aid the user locate and retrieve any message within the mailing system effortlessly. Some form of query and retrieval process can be employed to achieve this goal. This is a classic information retrieval (IR) problem for which a number of established solutions exists. For instance, the user's information needs is expressed through query formulation using keywords which are then matched against a set of index terms extracted from the message header or body. The number of keywords that matches with the index terms will determine the extent of match or relevance between the query and the message. The system, having found the relevant messages that comply with the user's query, will return this set of output together with other possible messages of potential interest to the user.

- **Provision of a "good" user interface to allow access and use of the system's facilities, while at the same time tailored to strike a balance for use by both groups of novice and expert users.** The user interface determines the quality of interaction between the end user and the mailing system. This can ultimately result in either the user enjoying and accepting the system or despising and rejecting the system. Good interface design requires attention to be focused on aspects at task level and dialogue level so that the correct devices and dialogue styles are employed. Additionally, the established good human factors in interface design, such as being consistent, provide feedback, minimise error possibilities, provide error recovery, provide adequate on-line help, minimise memorization
and accommodate multiple skills level should all be incorporated in the design of the user interface.

3 MEmail - A Heterogeneous Multimedia E-Mail System

MEmail [6]-[9] is a research prototype built to provide a transparent multimedia email facility across the heterogeneous computer platforms within the academic network of NTU. MEmail attempts to incorporate the key design issues factors identified in the previous section in its design and implementation.

![Figure 1. Network Architecture of MEmail in NTU](image)
MEmail, developed using an object-oriented approach, is a client-server based system which allows email users to store, manage, retrieve and exchange multimedia messages (which can comprise text, graphics, images, video and audio). MEmail's system architecture is shown in Figures 1 and 2. Clients can either be Unix workstations or PCs. MEmail makes use of mail and media servers and object-oriented databases to process, store and manage the different forms of media data. A production-rule based system is employed to filter incoming messages so that the system will only deliver what is deemed "relevant" to the user, while discarding all junk messages.

MEmail is integrated with a typical query and retrieval facility found in traditional IR systems. Users are allowed to query on the known fields of the mail (such as From, Subject, Folder, Date and so on) as well as the contents and description of each media object in the message. The provision of this facility is made easy since MEmail is built using databases which in itself encompasses powerful query and retrieval capabilities. MEmail supports relevant feedback, so that if users can identify a list of relevant messages, the system will make use of information contained in these messages to identify new related messages and present a re-ranked message list to the user.

3.1 Design Considerations

The key issues of Section 2 were considered and factored in the design and implementation of MEmail. These are elaborated below:

Heterogeneity Support

MEmail is designed specifically to handle a heterogeneous network environment where different makes of computers can co-exist together. The exchange of multimedia messages is complex in such an environment because of the differences in hardware and data formats used in these systems. In using the client-server architecture for the design,
there are three possible approaches for clients to access the mail server: off-line method, on-line method and disconnected method.

In the off-line method (e.g. uucp, POP-3), client applications periodically connect to the server, downloads all messages to client machine and deletes these messages from the servers. In the on-line method (e.g. NFS, IMAP4), the client manipulates data directly on the server machine. The client must remain connected to the server throughout the whole login session. No mail data is kept on the client site and the client retrieves all the data from the server as it is needed. The disconnected method (e.g. PCMAIL(RFC1056)) is a combination of both earlier approaches. In this model, the client downloads some of the messages from the server, manipulates them on the client machine and then at some later time updates the changes. The server does all the synchronization and repository functions of the whole system. However, none of these three approaches (without any modifications) are suitable for multimedia messages because having one server to act as both message storage and multimedia storage can cause severe overloading at the server and hence cause system degradation.

MEmail adopts the disconnected method in the design but instead of using a single server, uses more than one server: one for message handling and storage and different servers for media storage and processing (Figure 2). If necessary, these servers can reside on different sites in order to reduce the load at a single site. Such a design also facilitates nicely in handling the heterogeneity problem since the media servers in addition to their storage function, can be used for handling translations and transformations to resolve incompatibilities of hardware and data formats between different client machines.

In MEmail, different media servers are used to handle different media types. An email message created in the sender's machine will have its constituents of various media stored in the respectively media servers in its original form. Prior to sending the information to the recipient, the media servers will first check for the hardware support in the recipient's machine. If this is present, a subsequent check on hardware and data format incompatibilities is carried out. Appropriate translations and transformation are then applied as necessary to the recipient's machine requirements at the media servers before they are sent to the recipient. Although, this approach of handling heterogeneity requires more processing, it nevertheless, preserves the original format of the various media types in the originator's message. The other alternative approach of converting all media data into some internal standard format representation was considered but not implemented in MEmail, as the preservation of the original form of message outweighs the benefits of reduced processing requirements of the latter approach.

**Interconnectivity**

The interconnectivity issue is unfortunately a problem without a prospective short-term solution. Obviously the optimal solution is to have all the email systems' community to agree, identify and use a de-facto standard for data representation and method for transporting multimedia electronic messages.
In considering the interconnectivity issue in MEmail, the assumption is made that such form of consent and co-operation is unlikely to happen so quickly, so that messages will still have to be translated between mailing systems. Thus, the "bottoms-up" approach has been adopted in MEmail with the aim to use a minimum number of translators by promoting the usage of a de-facto standard data format representation. At such, translators will still be needed for interchanging the data format from the proposed standard to each other until such time a de facto standard emerges.

The proposed standard mail representation format of MEmail is MIME [10], an extension developed for SMTP[11] mail systems to include multi-part messages. The choice for this combination is twofold. First and more importantly, is the flexibility and extendibility to enable multiple (and new types of media) objects to be stored in the same single message. Second, the Internet (which uses SMTP as its mail transport agent and TCP/IP as its transport medium) community, with an rapidly-increasing number of new users each day, is far too large an email community to ignore. For every different mailing system which MEmail wishes to communicate, there will be a corresponding pair of translators needed - to convert to and from each other's format.

**Extendibility to support new media types**

The issue of extendibility is best approached by recognising the fact that different media types are essentially different objects with different attributes. It becomes therefore, a natural choice to use an object-oriented approach in designing MEmail since these objects together with its operations can be associated with different classes. These classes can then be organised into class hierarchies, thereby allowing generalisation and aggregation to occur.

MEmail is able to support the integration of a new media object to the system by defining a new metaclass object (instance of class) with its attributes, operations and functions to perform these operations. MIME fits into this design by allowing these objects to be combined together into one same file, so that the constituents of each multimedia message can be compacted together prior being sent to the recipient. It also permits a metamail program to be used to determine how to display the various multimedia objects.

**Media Storage and Support**

The media servers, in addition to being used to solve the heterogeneity problem, also serve another purpose as being responsible for media storage and support. The accountability for the overall storage of messages is achieved in the system by the architectural design where each media server is responsible for managing its own media type. The main advantage of such an approach is to ensure that only one copy of each unique media object is kept and that no duplication exists. This makes it not only possible for the system to store only a single copy of a multimedia message which can be shared by many users, but also that these objects can be shared among different messages which contain them. Such a scheme together with data compression techniques such as MPEG and JPEG will reduce the data storage requirements substantially.
Message Filtering

In order to minimise junk and maximise relevant mails reaching the recipient, some form of an automatic filtering mechanism is desirable. There are essentially two main approaches used in filtering: *keyword filtering technique* [12] and *production rule based system* [13].

In keyword filtering, each message is to be sent is represented by a series of 'keywords'. These keywords are then matched against an index in the recipient's filtering mechanism which will either accept or reject the document or message (for examples: see [13] -[16]). Two problems are inherent in this technique. The first is the difficulty in selecting keywords to represent the subject content of the messages. The second is that the use of only pre-defined descriptors to represent the message content is a severe limitation to the filtering system.

Production rule based filtering makes use of the fact that email messages are semi-structured messages so that rules can be formulated to process and filter these messages (for examples: see [13],[17]). A semi-structured message is a message containing a known set of fields, but with some fields containing unstructured text or non-textual information, such as audio clips or images.

The structure of the rules is very similar to those used in logic study and rule-based expert systems. Rules are represented in the form of IF (condition is TRUE) THEN (prescribed action) syntax. Multiple conditions when specified are "ANDed" together to obtain the result. Boolean combinations are possible within fields so that compound rules can be formulated. Each user has his or her own user profile to store all the pre-defined rules. The user can monitor and check to see if the messages received are those of interest or little relevance. New rules or changes to existing rules can be made periodically to ensure proper filtering. This technique exploits the structure of semi-structured messages by allowing the user to define superior filtering conditions compared to the keyword filtering technique. Although most rules can be intuitively defined, its main disadvantage lies in the difficulty for novice users to formulate the rules correctly and in the syntax required.

MEmail adopts the production rule based approach for message filtering. Due to the added constituents in the data model for multimedia mail, the user will have more filtering options. For instance, the user can delete all incoming mails which contain video clips if such a facility is not present at the client machine. Alternatively, the filtering can pick up mails containing only audio clips. In this way, MEmail can be configured to act solely as a voice mail system.

Mail Query and Retrieval

Most existing multimedia mail systems are either folder or file-system based which limits its IR potential. The use of a database system to construct mail systems is only demonstrated by Kent et al [18]. The main advantages of using database systems for
building email systems include those of data organisation, data integrity and security, and built-in powerful query and retrieval engines.

MEmail supports both filing systems and object-oriented databases leading to enhanced IR characteristics. Users have different information needs and interests which change over time such that it would not be possible to prescribe an "optimal" IR model to satisfy their changing demands.

MEmail uses a modified best match search based on the probabilistic model for information query and retrieval. The best match search will result in a ranked output so that documents which are most "similar" to the query are presented in order to the user. In order for a measure of this similarity to be computed, some form of weight assignment is made to the original message and query words.

In addition to normal query and retrieval capabilities, MEmail will allow, after a sorted list of output is obtained, the user to perform a relevance feedback search. In using relevant feedback, the user will first select the most relevant messages from the sorted list and invoke the system to look for similar messages to those selected. The system will then re-weight the search terms and re-order the messages. Unchecked messages which are similar to the relevant documents, but are earlier given lower weights, would now be brought up to the head of the output list. This approach to IR, adopted in MEmail, provides the flexibility to the users to control the search criteria and messages retrieved.

**User Interface Design**

MEmail's user interface design is one based on considerations for both novice and experienced users of mailing systems. For example, users can choose between a text or graphical user interface to define the production rule filtering definition in their user profile. Users who prefer the "point and click" paradigm will be able to select the latter interface which provides more prompting and requires minimum typing. In addition, the desirable human factors in design identified in Section 2 were closely adhered in designing the layout and functionality of the user interface. Whenever possible, the whole interface screen would be used to present groups of related information to the users, with menus, commands and status areas of the interface remaining consistent between interfaces.
4.2 Implementation Details

Figure 3 shows the functional components of MEmail. The Mail server consists of two specialised components with each performing certain message processing functions:

- **Mail manager** which mediates all the processing for message handling for each subnet system (such as notification of new mails, error reporting in sending out mails, etc.).
- **Filter manager** which intercepts incoming messages and performs predefined actions based on the rules defined in the user profile.

The Media server also contains two components:

- **Object manager** which provides the main storage, modelling, management and retrieval support of mail messages. Figure 4 shows MEmail's data model which employs the object-oriented design paradigm. Storage support for MEmail can either be implemented on database systems or file systems (using directories and files). Since the mailing headers and media storage are separated, two data storage models, namely, the Mail Storage Server which resides in the mail server and
Media Server Storage which resides in the media server are implemented separately.

Figure 4. MEmail's Data Model

- **Operation manager** which intermediates the display and translation of different media objects across the heterogeneous environment.

Each client subsystem (the UA of MEmail) contains five components:
• **Control panel** which is responsible for the management of various kinds of user interactions.
• **Authoring tool** for message browsing, composition and destination definition.
• **Query tool** which is used for query formulation and message retrieval.
• **Filter tool** which is used for user profile definition or modification.
• **Local object manager** which functions similarly with the server's object manager but stores and processes messages which are currently edited or created by the client.

MEmail's **control panel**, which is front end user-interface of MEmail, is shown in Figures 5a and 5b (for Unix and PC clients respectively). It is divided into a number of areas:

- **Toolbox area** (for different message handling functions such as compose, send, reply, forward, extract, move, print and delete mail),
- **Menubar area** (which uses a click and drag paradigm to perform operations similar to Toolbox area plus other utilities such as folder management, address book management, and help information),
- **query and retrieval area**, and
- **editor area** (for message composition and editing).

The **authoring tool** employs the select/copy/cut/paste paradigm plus WYSIWIG concept to allow users to have an exact feel of what is been created or edited. In this manner, multimedia objects can be combined and integrated easily in the message. Users are allowed to attach other messages to the current one being composed. These attachments are represented as icons in the editing area. Message formatting is achieved via the use of the grabbing, dragging and dropping paradigm.

The **query tool** is an integral part of the control panel to allow immediate user access to carry out message query and retrieval. Messages can be queried through a combination of the following fields: FOLDERS, FROM, DATE, SUBJECT, TEXT content and CONTENT-TYPE. The ORed operator is intrinsically implied within fields except for the SUBJECT and TEXT content where both AND and OR relations can be used within query words. The normal relational operators for DATE ( =, <, >, <=, >=) are supported. The TEXT content allows the various media descriptors to be queried in addition to the SUBJECT query. In addition, a search on the CONTENT-TYPE can also be performed. Thus, a user can pose a query to search for all messages which contain images.
Figure 5a. MEmail Control Panel for Unix Workstation Client

Figure 5b. MEmail Control Panel for Personal Computer Client
The filter tool allows the user to define or modify the filtering rules in user profile by calling up either of the two available editors (text-based and graphical-based). Users can apply filters to the header fields: FROM, SUBJECT, KEYWORD and DATE. Wildcard characters and pattern matching allow more general conditions to be defined. In addition, Boolean operators are also provided to allow more complex rules to be formulated by combining fields. The normal relational operators for DATE are supported. The different types of action supported by MEmail including PRINTing, filing messages to defined FOLDERs, automatic REPLYing of messages, FORWARDing of messages and DELETing the incoming message.

The defined set of rules which represents the user's interest at that point in time is saved into a user profile and stored in the server database. Rules are first syntactically and semantically checked before they are converted from their defined infix form into postfix form. These rules are verified and tested for rule conflicts which must be subsequently resolved before being stored in the user profile. Security and privacy are maintained for all user profiles in the server. The same user who has access to different servers can have different user profiles in different servers.

Figure 6 MEmail's Extendible Layered Architecture

MEmail utilises a layered extendible architecture which serves as the interface between mail-enabled applications and system services providers as shown in Figure 6 and Table 1. Although, this architecture is unnecessary more complicated for satisfying MEmail's
requirements, it is nonetheless developed with future extendibility in mind. Basically, the architecture is divided into two layers:

- **MEmail Application Programming Interface (API) layer** which caters for the functions directly involved with any mail-enabled applications. These APIs are implemented as class libraries to provide a set of generic multimedia and mail services.
- **Service support layer** which includes the storage support, transport support and media support. This layer facilitates MEmail APIs to directly link to the services provided by the system.

MEmail APIs are classified into three main groups to enable developers to build the necessary servers and clients for message enabled applications.

### 4 Future Extensions

The prototype of MEmail is completed and currently undergoing end users' evaluation. MEmail offers storage management and transportation of multimedia messages across different computer platforms within NTU. The Mail and Media Servers are implemented on SUN Sparc workstations. The Versant object-oriented database system is used as the Object Manager. All the major functional components of the clients machines are implemented on both Unix workstations and PCs. This research has demonstrated the successful exchange of multimedia messages between Unix workstations and PCs which have significant hardware and data format incompatibilities.

Users' preliminary informal indicators reveal that most of the filtering rules are predominately based on information of senders or the groups to which the senders belong. Keyword filters are also used to tap into general research interests and used as a means to keep users informed of the developments of other research groups within NTU. Filters have shown their usefulness to discarding "junk" messages. However, users are still cautious to ensure that genuine messages are not discarded accidentally due to poor rules definition. In other words, users prefer to filter through more than less.

The query mechanism provides a simple but powerful means to allow the user to recall kept mails in various folders. The availability of pattern matching, wildcard facilities together with the provision of relevant feedback enhances the query formulation and retrieval.

The layout of the main user interface facilitates ease of navigation to initiate various functions to perform different tasks. The integral query and retrieval area in the control panel allows immediate access to such a facility. The retrieved message area also serves as the new mail notification area. Users can click on the message listing to read new mails or browse old mails. The consistency in layout and operations helps reduce the learning curve of new users to the system.
Table 1. Functions of MEmail APIs

<table>
<thead>
<tr>
<th>API Class</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEmail APIs</strong></td>
<td></td>
</tr>
<tr>
<td>Client API</td>
<td>Support clients to read, send and store messages at client site.</td>
</tr>
<tr>
<td>Mail Server API</td>
<td>Support storage of new messages, deletion of old messages, receiving</td>
</tr>
<tr>
<td></td>
<td>incoming mail outside MEmail subnet, mail retrieval, media sharing</td>
</tr>
<tr>
<td></td>
<td>and filter mechanism.</td>
</tr>
<tr>
<td>Media Server API</td>
<td>Multimedia storage, retrieval, and media translation between formats.</td>
</tr>
<tr>
<td><strong>MEmail Services</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td></td>
</tr>
<tr>
<td>Message Services</td>
<td>Message maintenance including folder management and message creation,</td>
</tr>
<tr>
<td></td>
<td>filing, querying, deleting and printing.</td>
</tr>
<tr>
<td>Media Services</td>
<td>Display and authoring different media types including labelling of</td>
</tr>
<tr>
<td></td>
<td>media types for query.</td>
</tr>
<tr>
<td>User Services</td>
<td>Message addressing and distribution list facilities, Alias facility and</td>
</tr>
<tr>
<td></td>
<td>users' profile maintenance for message filtering.</td>
</tr>
<tr>
<td>Mailing Services</td>
<td>Sending and receiving messages between users of system, and new mail</td>
</tr>
<tr>
<td></td>
<td>notification.</td>
</tr>
<tr>
<td><strong>Service Support</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Layer</strong></td>
<td></td>
</tr>
<tr>
<td>Storage Support</td>
<td>Provide necessary storage requirement for MEmail APIs.</td>
</tr>
<tr>
<td>Message Support</td>
<td>Provide underlying structure for actual exchange of messages from</td>
</tr>
<tr>
<td></td>
<td>source to destination. (RFC822, SMTP).</td>
</tr>
<tr>
<td>Media Support</td>
<td>Basic functions to support multimedia capabilities (display, record,</td>
</tr>
<tr>
<td></td>
<td>edit).</td>
</tr>
</tbody>
</table>

As extensions to this effort, further work falls into three categories. First, is a need to accumulate more user experience to provide a means to further confirm the functionality of the system, the added effectiveness provided by the filtering and querying facilities, and to incorporate improvements as a result of users' feedback. Second, is to derive a
performance matrix and used it as a platform to measure the performance of the system with other existing systems. This will allow bottlenecks and inefficiencies to surface which will provide additional scope for improvement. Finally, the suitability of the IR model used for query and retrieval can be carried out. A set of separate controlled tests to allow recall and precision measures to be obtained would prove useful in evaluating the IR model and concepts used in the filter and query tool. Some preliminary work on fuzzy retrieval methods utilising a fuzzy thesaurus for IR retrieval has already been explored. In future, the IR model can be upgraded to allow even more sophisticated filter and query facilities to be incorporated into the system.

5 Conclusion

In this paper, we have identified a number of key design issues for the delivery of the next generation multimedia email systems and demonstrated how these are factored and realised in the design of MEmail. A layered approach and the use of the object-oriented paradigm for data modelling and database support have been utilised in the design and implementation of MEmail's architecture. Such an architecture exhibits the advantages of independence, maintainability, flexibility and extendibility. It allows improvements in information query and retrieval techniques to be incorporated into the system with greater ease. In addition, this architecture forms a basic platform to allow other message-enabled applications (e.g. CSCW applications, computational email) to be built.

References


