Abstract

Computational electronic mail is essentially the embedding of programs within traditional electronic mail messages. In so doing, it transforms the mailing system into an 'active' system since the mailing reading software at the recipient's end will recognise that the mail message is intended to be executed rather than to be read. Upon confirmation by the recipient, the program will be executed accordingly. If appropriate, output from the program can be channelled back to the sender automatically for further processing.

This paper describes the design of a prototype computational electronic mail system, CEmail, to function over the Internet mail environment. The system uses the scripting language Tool Command Language(Tcl) and its toolkit, Tk, for mail composition and execution. The contents of the message can include multimedia. The Multipurpose Internet Mail Extension (MIME) format is used for mail representation. The Simple Mail Transfer Protocol (SMTP) is used to transfer an outgoing active mail to a SMTP server machine, which in turns uses SMTP to send the mail to the world at large. Mail from the world at large arrives on the recipient's Post Office Protocol (POP) server where it awaits to be downloaded and executed by the recipient's mail reading program. The paper demonstrates how CEmail can be used to automate a number of everyday functions in typical library environment. Examples include automatic overdue reminders with automatic renewal, survey generator, interest group information dissemination, general information dissemination and seminar scheduler, interlibrary loan servicing and electronic enquiry system.

Keywords: computational electronic mail, active mail, multimedia, library automation, SMTP, POP, MIME, Tcl/Tk
1 Introduction

Electronic mail (email) has been widely accepted in both industry and academia as a very useful medium for interpersonal communication. Recent multimedia research efforts have resulted in the slow emergence of multimedia mail systems as a viable enhancement and replacement of the traditional ASCII-text only mail systems. These multimedia mail systems, such as MEmail [1], Andrew Message system [2], Diamond system [3], Microsoft/MSmail [4] and so on, allows multimedia messages (which can comprise text, graphics, images, speech, animation, video, etc.) to be exchanged between users. However, these systems are passive systems in that information can only be 'displayed' at the recipient's end. A logical extension would be to make the mail 'active' so that what is sent is in fact an embedded computer program which can be executed instead.

The idea of computational electronic evolved as a result of increasing attention being focussed on Computer Support Co-operative Work (CSCW) [5]. Broadly defined, CSCW is an attempt to provide computer based solutions to facilitate interaction among a group of two or more people that may be physically or temporally distributed. CSCW can be classified along the two fundamental dimensions of time (synchronous or asynchronous) and space (centralized in one location or distributed over several)[6] as shown in Figure 1. Therefore, CSCW solutions must be designed to provide support for one of the four possible combinations.

<table>
<thead>
<tr>
<th>Same Time</th>
<th>Different Time</th>
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<tbody>
<tr>
<td>Face-to-Face Interaction</td>
<td>Asynchronous Interaction</td>
</tr>
<tr>
<td>Eg. Electronic Meeting Room, Group Decision-Support System</td>
<td>Eg. Information Kiosk, Project Management Team Room</td>
</tr>
<tr>
<td>Synchronous Distributed Interaction</td>
<td>Asynchronous Distributed Interaction</td>
</tr>
<tr>
<td>Eg. Conference Calls, Videoconferencing</td>
<td>Eg. Electronic Mail, Voice Mail</td>
</tr>
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</table>

Figure 1. Time and Space Classification of CSCW

If an electronic mail system can be extended to allow users to compose computational electronic mail which can be activated at receipt time to solicit information via recipients' interaction or without any user interaction, then it may become a prototype model for Quadrant
IV of the CSCW model. Computational electronic mail can be applied to numerous applications. Examples include electronic forms, survey generators, meeting schedulers, document distributors, electronic mail order catalogues, and so on.

This paper describes a computational mail system, CEmail, designed to function across the Internet mail environment to allow users to exchange active mail. It demonstrates how such a system can be applied in a library environment to automate a number of functions thereby enhancing the level of services offered to users. The paper is divided into five sections. Section 2 introduces a number of basic concepts and describes CEmail's system architecture and design considerations. Following this, various functional components of CEmail are presented and detailed. Section 4 proposes a number of cases to show how CEmail can be applied in a library environment to automate a number of functions. The paper concludes with a summary of CEmail and the status of the proposed system.

2 Overview of CEmail and System Architecture

Each email message being transported from the sender to the recipient comprises three basic elements:

1. Transport medium (TM) which involves the underlying layer protocols to provide the data communication between computers or systems (e.g. TCP/IP, uucp, X.25/X.29).

2. Mail transport agent (MTA) which is responsible for transporting mail from source to destination. It is often considered as the back-end of an email system which contains several components which include routing mechanisms, local delivery agent and remote delivery agent. (e.g. SMTP (Internet mail protocol), MHS (Novell's Message Handling System), SNADS (IBM's System Network Architecture Distribution System).

3. User agent (UA) which is the interactive portion of an email system to provide the functionality of mail systems, such as message authoring, reading, distributing, storage, query and retrieval, and so on. UAs are generally developed for individual mailing systems depending on the level of support and services offered for the system.

CEmail is a client-server based system to allow email users to store, manage, retrieve and exchange 'active' multimedia messages. The system architecture is shown in Figure 2. In this configuration, personal computer (PC), Macintosh (Mac) or workstation clients are connected to inter-networks for sending and receiving mails. When a computational mail is to be sent, CEmail uses SMTP to send the mail to the local SMTP/POP server computer (i.e. MTA), which in turns sends it the addressee's SMTP/POP server computer by means of the SMTP protocol. The mail resides in the remote addressee's server until it is being picked up by CEmail using the POP Version 3 (POP3).
There are a number of reasons for using this configuration although it is possible for the client to communicate with the addressee's server directly. First, it reduces the amount of time needed for the client to "hunt" for the remote computer, establish connection and download the mail. Instead, the mail is simply downloaded to the local server which plays the role of the MTA to ensure it is being delivered to the remote computer. Second, there is no guarantee that the remote computer will be available continuously for receiving mail. The SMTP server handles this by holding the mail until the remote computer is ready to accept it, thereby eliminating the need to maintain and process unsent messages at the client computer.

Incoming mails are delivered using the SMTP protocol and stored in the SMTP/POP server. The server puts the mail in the recipient's "mail drop" until such time is being picked up by CEmail (i.e. UA). When a check on new mail is involved, CEmail will use POP3 to pick up all corresponding mail and move them to the client for subsequent processing (such as browsing, deleting, forwarding, etc.). SMTP is not used to receive mails at the client directly since it works best when the computers it knows about are always ready for mail. This means that CEmail must be continuously running on the client listening and waiting to receive mails. In addition, SMTP does not work well in a laboratory or other common place environment where a user might use different clients on different occasions for mail applications.

The mail representation format of CEmail is Multipurpose Internet Mail Extension (MIME [9]), an extension developed for SMTP mail systems to include multi-part messages and multi-media support. The active mail within the message is actually a multi-part message stored in the mail. The use of MIME provides the flexibility to incorporate traditional multi-media data and new types of media data (such as tables, spreadsheets, formulae, word-processed documents, CAD/CAM drawings, etc.) in the same message. A metamail program distributed along with CEmail will enable such media types to be "displayed" at the recipient's computer.
An active mail can be constructed using two approaches. The first approach is to compose and compile the mail into an executable form at the sender's end. This is transported in binary form to the recipient's end where it will be executed upon activation by the recipient. The second approach is to use an embeddable and interpretable language (e.g. Tcl/Tk, Unix's shells) to generate a script file which requires no compilation at run time. The script file is transmitted, loaded and executed at the recipient's end. The first approach suffers from the major disadvantage in that both the sender and recipient computers must be of similar type and uses the same operating system. For example, a program written for a PC cannot be executed on a Macintosh or a Unix workstation; or a program compiled on a 32 bit architecture computer will not be able to run on a 16 bit architecture computer. For this reason, the second approach is the preferred route. As long as a common interpreter is available on different client machines, executing an active mail poses no problems. The disadvantage of this approach, however, is slower execution time since interpreted codes executes slower than compiled objects codes due to the extra processing required.

CEmail adopts the second approach and uses Tcl/Tk [10] as the language/tool used to compose and execute active mail. Tcl and Tk are two complementary packages which provide a programming system for developing and using graphical user interface (GUI) applications. Tcl is a simple scripting language written in C for controlling and extending applications. Tcl is embeddable: its interpreter is implemented as a library of C procedures that can easily be incorporated into applications. Tk is a toolkit for the X Window System. It extends the core of Tcl facilities with additional commands for building Motif-like user interfaces. Tcl/Tk is currently available on PC, Macintosh and Unix platforms. Tcl/Tk commands are usually place into script files and invoked just like Unix shell scripts using the default Tcl/Tk interpreter, wish.

In CEmail, a subset and derivative of Tcl known as SafeTcl [11] is specially proposed for developing active mail applications. Although Tcl/Tk is a "trusted" language which provides the basic syntax and primitives for a mail-enabled language, it is considered by some as "unsafe" due to its flexibility. SafeTcl essentially filters out a number of such unsafe commands (e.g. execute system calls to delete files, change passwords, etc.) and introduces a number of its own primitives as substitutes. swish is the corresponding interpreter for SafeTcl scripts.

Active mail can cause uneasiness among recipients mainly because of security issues and the potentially destructive consequence of execution (e.g. reformatting of hard disk, virus introduction, theft of confidential information, etc.). To alleviate such fears, an authentication process (which can include the use of passwords or security keys) in active mails can be introduced to provide some form of re-assurance. Thus, a recipient will feel more comfortable in executing an active mail from a known and trusted source. For each newly created SafeTcl window, there will be an authentication header to declare it is safe to be executed. For unauthenticated mail, the recipient is informed accordingly that a program from an untrusted source is to be executed. In this case, the recipient should trust the program a little bit less than most.
3 CEmail Functional Components

Figure 3 shows the functional components of CEmail. The Control Panel, the UA of the mail system, is a graphical user interface to provide access to the four main system components:

**Authoring Tool.** This employs the select/paste/move paradigm for active mail composition. An active mail essentially takes the form of a question-answer format where the sender will provide information and solicit input from the recipient. As multimedia can be supported in the CEmail design, the sender can use text and attach different media files (such as image, audio, text) within the mail. These attachments are represented as icons in the editing area. These may be activated at the recipient's end by double clicking on them. The metamail program distributed along with CEmail will determine the type of media and load the corresponding program to 'display' the media.

The response from the recipient may take the form of clicking on checkboxes, radio buttons, push buttons, entering text or attaching media files. Questions can be tagged as compulsory to ensure a guaranteed response from the recipient. Figure 4 shows the authoring tool used to construct an active mail to notify library users of overdue items and to request for action which they wish to take (i.e. return or renew the overdue item).

When mail composition is completed, the **Script File Generator** takes over to generate a Safe-Tcl script file. Information stored in other media attachment, with the exception of text, are represented in their "natural" format as 8-bit character or binary data. Such data cannot be transmitted over some transport protocols such as SMTP. They must first be encoded into BASE64 format (or other allowable forms such as QUOTED-PRINTABLE) since SMTP
restricts mail messages to only 7-bit ASCII data with lines no longer than 1000 characters. This is carried out by the Media Attachment Encoder. BASE64 imply an encoding that consists of lines no longer than 76 ASCII characters.

**Template Tool.** This tool allows the user to generate regular and highly repetitive active mail without the need to use the authoring tool by using a set of fixed layout and required input from the recipient. Using the library overdue reminder example of Figure 4, what is different for different users is the user_name and details of the overdue item. By using templates, only changes in the input needs to be defined. Two files are required: a *template definition file* to define the contents of the mail and a *template usage file* to define the remaining parameters required to complete the mail. The Template Tool will make use of these templates to automatically generate the active mail and deliver it to the recipient. Such a facility is provided to allow batch processing to take place in CEmail. As in the case of the Authoring Tool, the Script File Generator and Media Attachment Encoder are used to construct the various components of the active mail in the required MIME format. Figure 5 shows the contents of the template definition and usage files for constructing the library overdue reminder of Figure 4.

![Figure 4. CEmail Editor (v1)](image-url)
Mail Manager. This communicates with the MTA to receive incoming mail and send outgoing active mail. Upon starting up CEmail, the Mail Manager will access the selected mail server and download all incoming mail. Passive and active mail are distinguished and stored in separate directories. The header of an active mail contains a Content-Type of 'multipart/enabled mail' to allow this distinction to take place. The Mail Manager is also responsible for announcing new mail to the user.

Each user in the client computer is given a number of unique mailboxes (directories) for mail storage according to the number of different server accounts. This will enable the client computer to support multiple users with multiple accounts. CEmail processes only active mail in
the active mail store. Passive mail are processed separately using existing passive mail readers (e.g. mail, vmail, Eudora, etc.).

When an active mail is ready to be sent, the Mail Manager will obtain the header information (From, Subject, To, Cc) and combine the Safe-Tcl script file together with other media attachments in BASE64 format into the required MIME format. This is then delivered to the MTA for transmission to the recipient's server via SMTP.

**Browsing Tool.** This is the mail reader for recipients to execute the active mail. When an active mail is selected to be read, the **MIME Component Parser** first extracts the Safe-Tcl script file and other media attachments from the MIME file. These attachments are decoded from BASE64 format back into their original form using the **Media Attachment Decoder**. The **Safe-Tcl Shell** loads the *swish* interpreter to execute the script file. Based on the contents of the active mail, appropriate response are obtained from the recipient. CEmail checks for unanswered compulsory questions whenever a reply back request is chosen. If such questions are detected, CEmail will prompt and remind the recipient to answer them before replying back. This process will continue until all such questions are answered before all the replies are collated and returned to the sender. Figure 6 shows the Browsing Tool for displaying the library overdue reminder example.

![CEmail Browser (v1)](image)

**Figure 6.** CEmail Browser (v1)

### 4 Use of CEmail for Library Applications

With the evolution and promotion of information technology, public, academic and other library users with email accounts will become commonplace. Internet, with its large number of users
(each with one or more email accounts) will continue to grow at a phenomenal rate. Email communication will become an even more popular medium for interpersonal communication.

Nonetheless, in the context of library applications, such as the academic library environment of Nanyang Technological University (NTU), email usage is limited despite the large number of library users (including all students and staff) with email accounts. Current typical usage of passive ASCII text-only email include loan overdue reminders, reserve book pickup request, and interpersonal communication for inter-library loans, replies to reference enquiries and other general enquiries.

With the introduction of CEmail, this scenario can change significantly. Librarians have an active tool at their disposal which can be used to automate a number of functions and to provide a higher level of service to users. This section illustrates a number of potential application areas where CEmail can be used as part of the automation process. In almost all instances, CEmail provides a point-to-point transmission vehicle to shuttle information to recipients and obtain responses back to the sender. Returned responses can be further processed, analysed and follow up actions taken accordingly.

Case 1: Automatic Overdue Reminders with Automatic Renewal

The automated circulation system generates a list of overdue items and borrowers on a regular basis. This information can be used to generate a corresponding set of active mail of overdue reminders using CEmail. One generic template or two different templates (one for single overdue item and the other for multiple overdue items) can be used. A borrower (recipient) on receiving the reminder will acknowledge and select an option to return or renew the overdue item.

The response is automatically channelled back to the circulation department which will in turn automatically renew the item or set the status of the item in the catalog to reflect that it will be returned. In the case of renewal, another active mail (or normal mail) can be sent back automatically to the borrower to confirm the renewed status and new due date. An acknowledgement can be obtained if necessary. CEmail when used in this way will help automate and enhance the process of overdue reminders, loan renewals and most up-to-date status of the holdings list.

Case 2: Survey Generator

CEmail provides a convenient electronic platform to generate surveys and obtain feedback from library users. Surveys may be needed for various reasons: to gauge the level of service offered by the library, obtain feedback regarding major planned changes, generate users' interests profiles, and so on.
CEmail can be used to generate a survey which is automatically sent to the survey population. A facility exists in CEmail to allow the sender to select and designate various survey questions as compulsory questions. This ensures that pertinent survey information which is needed for further analysis or follow up action is returned. Survey data collected can be automatically parsed, extracted and allow statistics to be generated.

Using CEmail for surveys offers a number of advantages over normal paper-form or telephone surveys. The whole process is more efficient and effective. It is cost effective as it saves on printing, paper, mailing, telephone and human costs. Delivery is fast when compared to hand-delivery since it only takes a fraction of the time to transmit the mail electronically. It is secure since encryption and authentication can be applied during mail delivery. Surveys are not longer confined to text-only data but can include multimedia data. Only 'valid' survey returns are collected since all the required pertinent information required for analysis is guaranteed to be returned. As data is returned electronically, it is already in a form suitable for electronic processing to take place.

**Case 3: Interest Group Information Dissemination**

Using CEmail as a survey generator provides a convenient means for the library to maintain a catalog of interest groups. These groups may not necessarily be confined to academic research or study, but can include social and other informal groups (e.g. arts, music, food, games, etc.). This catalog may be cross-linked to the bibliographic or existing databases in some manner (e.g. subject, author, keywords). New acquisitions or special information can be disseminated to users in a timely manner. For instance, students may be notified of new acquisition of reference or text books related to their field of study; researchers of new periodicals, conference proceedings; music and art enthusiasts of new releases, and so on.

Active mail can be composed and used to inform users of such information. Since multimedia is supported, the mail can even contain excerpts of audio clips or art images from the newly acquired items. Used in this way, recipients can get the most up-to-date information on acquisitions in the library. It allows them to review and 'sample' such information and even to automatically reserve it if such a facility is provided in the mail.

Such an application can also be used for recommending new books or other media types for library acquisition. Publishers can provide an on-line catalog of new titles (including contents page and excerpts) which are automatically disseminated to the various "reviewer" groups for their recommendations. Recommendations received are automatically collated and analysed by the acquisitions department for further processing and purchasing.
Case 4: General Information Dissemination and Seminar Scheduler

CEmail can be used to disseminate general and special announcements and invite library users to attend seminars and training sessions. This facilities in the planning and organisation of training seminars which may be conducted from time to time (e.g. library orientation, training for catalog searching, use of audio-visual equipment, etc.).

In the active mail, users are introduced to the event and invited to participate by selecting the schedule (date and time) which is most appropriate to them. Replies are automatically returned back to the organiser for confirmation. If the schedule chosen is unavailable, another active mail is automatically sent to the recipient to make a further selection. This automatic process continues until all the responses are processed or when all available places are filled. Such a system will allow a confirmed list of participants to be generated for all seminar dates. If necessary, automatic reminders can be sent to these participants nearer to the date of the event.

Case 5: Interlibrary Loan Servicing

In this application, a library user will go through the normal search of the local library for an item. If this fails, a further search on the union catalogue (i.e. a shared catalog of all participating inter-libraries (e.g. SILAS)) is performed to identify various libraries holding the required item. An interlibrary loan request is subsequently submitted on a standard electronic form. This form is automatically processed to generate an active mail which is sent to the participating library.

Depending on the form of the loan (i.e. book, photocopy of a paper, or on-line data), the recipient library will take one of two actions. In the case of a non on-line item, an acknowledgement of the request is sent back to the requesting library and normal arrangements for the delivery of the loan item is made. In the second case of an on-line item, it will be downloaded (interactively or automatically) and attached directly and sent back to the requesting library. This is possible in CEmail since it allows multimedia objects to be attached and returned. The on-line data (such as MS Word, Wordperfect, HTML, Postscript, Latex documents, or even audio data files, etc.) is first encoded in BASE64 format as before prior to transmission. The returned mail can be forwarded directly to the requester who will use CEmail to display the document.

Case 6: Electronic Enquiry System

In this scenario, users will use CEmail as an enquiry system to request for various forms of on-line information such as addresses of publishers and authors, bibliographic information, holdings information, definition of words, other forms of searches, and so on. Such a facility requires the existence of databases to store the information, and query and retrieval engines for query processing and document retrieval. Various standard templates are provided for users to enter
the desired request. An active mail is constructed and sent to the recipient (a reference librarian). By identifying the type of enquiry request, information is extracted automatically from the mail and formulated into the necessary query request and submitted for processing. Output from the request (such as a page from an encyclopedia or extracts from periodicals, reference materials, company and institution profiles, standards, project reports, etc.) can be attached and returned to the user automatically.

Why would anyone want to use such a system in this manner when the information is already on-line to be queried and downloaded? Interactive usage of such a system constitutes essentially to an information kiosk system. It is a form of asynchronous interaction (Quadrant II of the CSCW model) which requires the user to be at the same place (i.e. at a computer terminal) to carry out the whole enquiry process. The user may not be able to do this for various reasons but wish to submit the query and await the response at a later time. In addition, the user would have to learn to use the different systems in order to obtain the desired results. It is almost certain that learning to fill in forms (especially if there exists uniformity among forms) is easier than learning how to use the different systems of the information kiosk.

5. Conclusions

A computational email system is proposed to enable active mailing to function over the Internet environment. This is made possible by adopting the Internet email protocols: MIME as the standard mail representation format, SMTP as its MTA and TCP/IP as its TM. Additionally, MIME fits well into the design of computational mail as it enables multipart mail to be constructed in the one same message. The scripting language Tcl/Tk is used to define and execute the active mail portion of computational email.

The first prototype of computational email (CEmail v1) was developed as an add-on tool to an existing heterogeneous multimedia electronic mail system, MEmail [12]. It successfully demonstrated the functionality and feasibility of active mailing. The second prototype detailed in this paper is currently under construction using the proposed system architecture and functional components. The paper has demonstrated through a series of examples how this prototype can be applied to automate a number of everyday library applications, thereby enhancing the level of services which can be offered in the future. These include the provision for automatic overdue reminders with automatic renewal, survey generator, interest group information dissemination, general information dissemination and seminar scheduler, interlibrary loan servicing and electronic enquiry system.

References


