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PIXMAIL: PICTURES THROUGH MAIL[1]

Meera Blattner
Francisco Sierra
Peter Prassinos

Technology Information Systems
Lawrence Livermore National Laboratory

and

University of California, Davis

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Abstract

PixMail is a set of procedures for sending pictures through internet mail. The pictures can be sent or received by personal computers, terminals with or without raster capability, and facsimile machines. Optical scanners may be used as input to the picture file and printers may be used as an output device once the raster file is stored in a form used by a paint editor. No additional equipment needs to be purchased by the users to send or receive PixMail (unless facsimile input/output is desired) and it is no more difficult to send or receive than ordinary UNIX mail. PixMail uses the protocols of existing electronic mail for transmission from any ARPAnet or MILnet user to any other.

1. Introduction

Universities, government agencies, and government supported R & D facilities routinely use internet communication for electronic mail. Lawrence Livermore National Laboratory has been a member of the ARPA Internet community since the inception of the Internet (Berch, 1986a; Berch, 1986b). Electronic mail in these international networks is text-based. Raster graphics was not easily available to many netmail receivers until the popular personal computer began to invade the office and home. Workstations and personal computers are increasingly used by universities, laboratories, and government offices. With raster capability it is easy to display scanned images and graphics, however, internet mail has not utilized this capability. Some encoding schemes are available for particular operating systems, but there seems to be no generally accepted method for transmitting pictures through mail. Local area networks with compatible hardware and software have moved in a very different direction. Products are designed that link

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sophisticated workstations and exchange CAD specifications diagnostic features, monitoring information, and document processing for desktop publishing (Bairstow, 1987). Voice messages are used routinely within organization communication systems. Corporate networks have a dazzling array of graphics and sound capabilities that are many years away for internet users.

Technology Information Systems (TIS) is a program within Lawrence Livermore National Laboratory. The mission of TIS is to integrate diverse computer-based information systems for scientists, engineers, and managers (Hampel, 1985; Hampel, 1986). TIS has created tools that make it possible to access remote information centers on a variety of different computer systems and to download, upload, postprocess, and combine textual and numeric information (Blattner, Darmohray, and Burton, 1987; Breazeal, Blattner, and Burton, 1987; Burton, 1986). This work has lead to the development of the Intelligent Gateway Processor (IGP). The IGP software has been under development since the mid-70s and has used UNIX continuously during that time. TIS software is being used by five government agencies with over 3,000 users.

In addition to user interfaces and tools for accessing remote computer systems, the IGP also provides electronic mail (Berch, 1986a,b). The goal of IGP electronic mail (EM) is to integrate with existing programs new capabilities in message editing, mailbox management, and message disposition. EM co-exists with a number of UNIX-based user agents and can share a common mailbox format with most. Its address format uses the current standard for ARPA internet mail transfer and messages, making it possible to exchange messages with mail systems implemented on a large variety of equipment and diverse operating systems.

Several years ago TIS began to explore the possibility of sending multi-media mail to users of heterogeneous systems, such as those on ARPAnet. The first effort was the transmission of facsimile (FAX) images through IGP electronic mail. An IGP system functioning as a central switch was to deliver and collect FAX images. Before this project was completed TIS extended its goals not only to collect and distribute FAX but to transmit bit-map images to personal computers, workstations, or terminals with raster editing capability. A parallel effort within TIS was examining methods for sending sound through mail. Another TIS project had already begun to explore the possibility of sending forms and form-entry operations through electronic mail. This work is being done in conjunction with the University of California, Davis. Faculty and graduate students are collaborating with TIS software developers to provide multi-media capability.

2. The TIS Multi-Media Project in Context

In 1980 an internet multi-media document structure was introduced (Postel, 1981), and in 1982, multi-media mail was exchanged between the Information Sciences Institute of the University of Southern California, the Massachusetts Institute of Technology and Bolt, Beranek and Newman (Reynolds, Postel, Katz, Finn and DeSchon, 1985; Thomas, Forsdick, Crowley, Robertson, Schaaf, Tomlinson, and Travers, 1985). The multi-media mail sent at that time consisted of text, recorded voice, and images in the form of digitized displays. Other institutions that have been active in this area are: Carnegie-Mellon, University of Michigan, M/A Linkabit, and SRI International (Expres, 1987). Facsimile and data transmission experiments were first conducted between University College London, Comsat Laboratories, and ISI in 1981. An experimental multimedia message systems, Agora, was introduced in France in 1979 (Naffah and Karmouch, 1986).

Sending and receiving multi-media mail is a computationally intensive process. For this reason, multi-media mail experiments have typically been conducted on high-performance workstations such as the Sun 2, Sun 3, Xerox Dolphin and the Three Rivers Perq. Another difficulty is that a multi-media message may contain a large amount of bit map or digitized voice data and there may be difficulty in storing the message in the workstation's memory. Special equipment is required for sound because sound input/output capability is not generally supplied by workstation vendors. Another problem that has delayed the development of multi-media mail is the lack of generally accepted standards for the transmission of graphics, voice, images, and typeset text. Much of the effort expended by multi-media mail pioneers was in the development of graphics and voice editors.

Many IGP users are restricted to more modest hardware than that on which multi-media communications currently are available. Furthermore, the TIS capability of implementing an advanced page description language for text and graphics for users within the next few years is limited. Yet the needs of the users dictated that we move ahead in the direction of picture transmission and display.

3. The Goals of the TIS Multi-Media Project

TIS received funding for PixMail from the Air Force in Spring 1987. We set the following goals for our project:

(1) Multi-media electronic mail using the protocols of existing electronic mail for transmission from any arpanet or milnet user to any other.

(2) Picture, form and sound capability for users with personal computers as workstations.

(3) Fax input/output capability for users whether or not they had personal computers.

(4) The software had to be easy to use and understand.

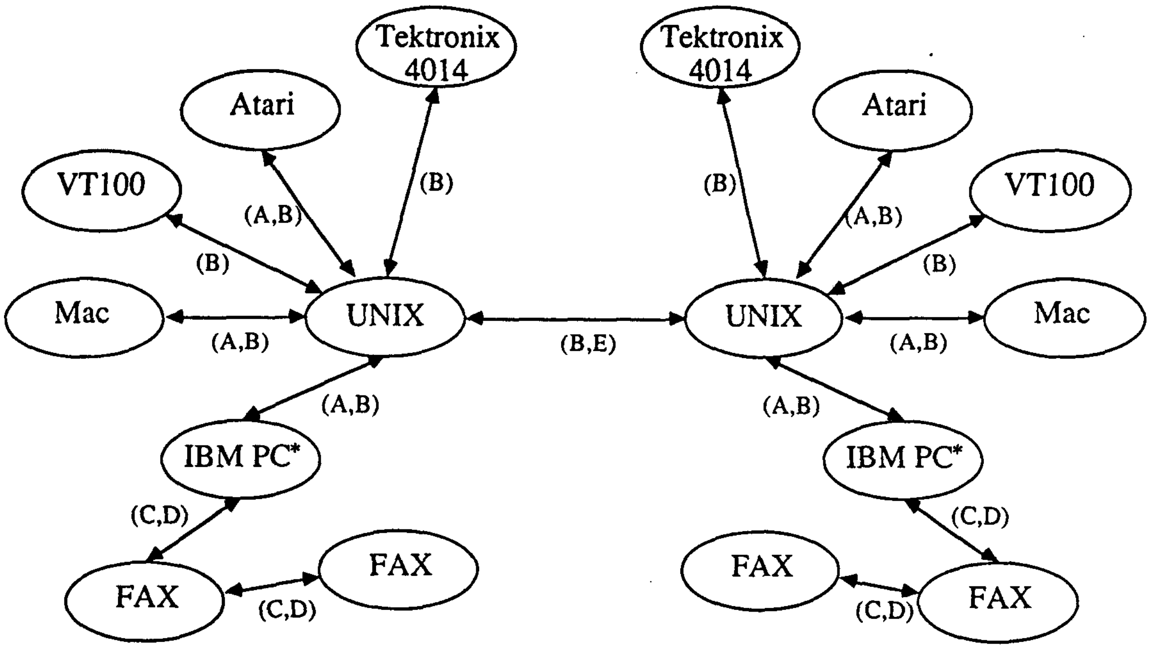
(5) No additional equipment need be purchased by the users except for a FAX conversion board.

(6) The first version of PixMail was to be delivered in three months after project initiation.

Our solution was to continue work on communicating facsimile images and to use the existing editing capabilities of personal computers. An image may be created using an existing paint editor, such as MacPaint or Degas, that produces bit-mapped files on a personal computer, an optical scanner, or through FAX input. Some of the most difficult aspects of multi-media communication has been editing, filing and retrieving multimedia documents, hence we would leave those functions to editors that have already been implemented. We translated the internal bit-map format into facsimile code CCITT T.4 for RS-465 mapped to ASCII (we call this ASCII-FAX) for transmission as a text message through electronic networks and internetworks. At the receiving end, the recipient's host computer decodes the message and displays or stores it. The message may be downloaded to a personal computer with a FAX board and sent to a FAX machine.

4. Project Overview

Figure 1 shows the PixMail system as it currently exists.



(A) Terminal Emulation
(B) Unix Electronic Mail With ASCII–FAX
(C) FAX Encoding
(D) Telephone Lines
(E) Internet Communication

* With FAX Communication Card and Graphics Board

Figure 1: Pictures Through Mail

Sending pictures

The procedure for sending a message is initiated by invoking PixMail to convert a bit-map file to ASCII-FAX. The ASCII-FAX conversion program does more than convert a sequence of 0's and 1's to ASCII-FAX; it also appends a header to the file. The user enters electronic mail and includes the ASCII-FAX file and the header with the message body. A file may be generated on a personal computer by an optical scanner, facsimile board, or a paint program. In this case, the user must upload the file to the host computer before invoking PixMail.

Receiving pictures

When the user receives a mail message that contains picture information, the first lines of the message body containing viewing instructions are displayed on the screen. Three different situations may arise. The user may i) view the picture on the machine that displays the mail message, ii) save the picture on the host computer, or iii) send the picture to an IBM PC for FAX output. In response to a PixMail query one of these options is selected. If the first option is chosen, the message header is stripped and the message body is changed from ASCII-FAX to a bitmap file and then displayed. In order to download or store files the user follows the usual procedures.

5. ASCII-FAX

FAX bitmaps are encoded in the CCITT Fax Standard T.4/RS-465. Hence the problem was to move streams of 0's and 1's in Fax Standard by ASCII-based electronic mail. The original project of sending FAX through mail had encapsulated the FAX code and attached it to electronic mail. For a variety of reasons, we chose to send an ASCII representation of FAX instead.

FAX code has two representations: horizontal line or squares of pixels. For simplicity and because FAX conversion to PC boards uses horizontal lines (Group III Facsimile) we also chose to use horizontal lines. The lines are changed into runs of whites and blacks, always starting with white. For example: 0, 23, 55, 2, .. would be, 0 white pixels, 23 blacks, 55 whites, 2 blacks, and so on until an end of line character is reached. The process is repeated for each line until and end of file is encountered. A FAX machine encodes the integers into FAX code, so 23 becomes 0000100. Only the first 64 integers are used in sequence, after 64, multiples of 64 are used together with numbers less than 64 until 1728 is reached.

ASCII-FAX would take the sequence, such as 0, 23,55, 2, ..., and change it to an ASCII representation, in this case, !8x#... ASCII has 177 characters with approximately two thirds of them printable. The number of printable ASCII characters was only three more than we needed for the integers in FAX, so we could uniquely map FAX to ASCII and conversely. No separators are necessary between numbers. Six numbers, 2, 3, 4, 5, 6, 7, have a FAX encoding that takes 4 bits, while nearly all of the others have an encoding of six to nine bits with eight an average number. On the average, we computed that an ASCII-FAX document is about 20% less efficient than pure FAX because the runs of 2, 3, 4, 5, 6 and 7 occur frequently. ASCII is much more reliable than streams of digits when transmitted through netmail. The great advantage of ASCII-FAX is that computer hardware and software process bytes very efficiently. The translation of ASCII-FAX is very efficient. We estimate it is 5% to 15% more efficient than UUencode (Unix User's Manual, 1986) because UUencode requires 35% more space in terms of bytes than the file it is encoding. ASCII-FAX contains a checksum for reliability. Overall, we believe ASCII-FAX is much better than ARC and UUencode for mail files.

FAX requires a lot of bitwise computations and state transitions to decode; ASCII-FAX requires only a subtraction, and sometimes a register shift, for decoding. Bytewise computations are usually faster with standard hardware and high level software. Bitwise computation requires special hardware capabilities and machine language to be faster than bytewise computation. Thus ASCII-FAX decodes faster than FAX on a computer. For now, ASCII-FAX is simple and appropriate.

6. PixMail Components and Functions

Every effort is being made to develop PixMail in a machine independent way; all software is being written in C. Of course, a C compiler is required for the machine running PixMail software. Portability is facilitated by separating the hardware constraints into one module. Our prototype system, as seen in Figure 1, is for the Macintosh, IBM PC with a raster graphics board and a GammaLink FAX conversion board, Tektronix 4014, and an Atari ST workstation. VT100 type terminals with no raster capability may use characters for pixels. By implementing PixMail for the personal computers and terminal types listed above, we believe that PixMail software is available for most types of personal computers (if one includes the great number of IBM PC clones). So far, pictures in mail have been sent to UNIX-based receivers and we do not anticipate problems with installation on machines that run other operating systems.

6.1. PixMail Headers

After a file is converted into ASCII-FAX, a header is appended to the top of the file. The header provides information for transmitting the size and resolution of the images for display on a variety of terminals. The header is composed of two subheaders: a meta-header and a media dependent header. The purpose of the meta-header is to distinguish file information from conventional mail information. The meta-header provides the system with information concerning the type of document, the type of encoding, a sequence number for multiple page documents, and other pieces of information. The media header contains information concerning the number of rows and columns in the picture, pixels per inch, and pages.

PixMail headers allow for any type of picture encoding to be used. ASCII-FAX is provided with the package but the user may prefer UUencode/UUdecode or some other encoding algorithm instead. A different version of ASCII-FAX may be used in the future; we are experimenting with a number of different encoding methods.

6.2. PixMail Functions All commands are invoked by one keystroke. A sample of PixMail commands are given below:

Change graphic size: a prompt for the size is displayed. The original file is unchanged.

Normalize scales: change the size of the display to approximately the original size of the data.

Scroll to right, left, up or down:since FAX images have greater resolution than most terminals, it is necessary to scroll the image. The image may be scaled down but information is lost. The original unscaled image is always retained in a file.

Step to right, left, up or down: scrolling is done in steps.

Scale horizontally or vertically: scaling is done in percentages.

Read graphic: scrolls to right and then jumps to the left and continues the cycle. This is to facilitate reading text.

Inverse display: change black to white and white to black.

Rotate: FAX images are often received upside down.

7. Concluding Remarks

This paper has introduced PixMail, a set of procedures for simply and inexpensively sending pictures through mail. The purpose has been to provide a capability to our electronic mail system that is well within the current technology.

Our prototype version of PixMail included the conversion of the bit-map file into and out of Macpaint. This would give the user the additional capability of using the Macpaint editor to modify or annotate a received document and return it to the sender. The file was to be downloaded and Macpaint invoked without user intervention. We have not developed on these particular functions for other paint editors. However, most paint editors provide the capability to convert into and out of their format from a bit-map display (Macpaint is not one of them). For this reason it is straightforward to add these capabilities to Pix-Mail.

We have discussed the possible consequences of the X.400 standard being accepted by TIS (CCITT Draft Recommendations, 1987). If, in the future, we implement a system that uses the recommendations of the ISO, we may have to rethink our document transmission procedures. We anticipate practical systems that transmit structured documents to become available within the next five years. At that time we will have to compare the functionality of a complex and sophisticated multi-media document mail system to our simple system that sends pictures through mail. It is inevitable that all systems are replaced by a better technology as it becomes available.

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