1980 APL Users Meeting

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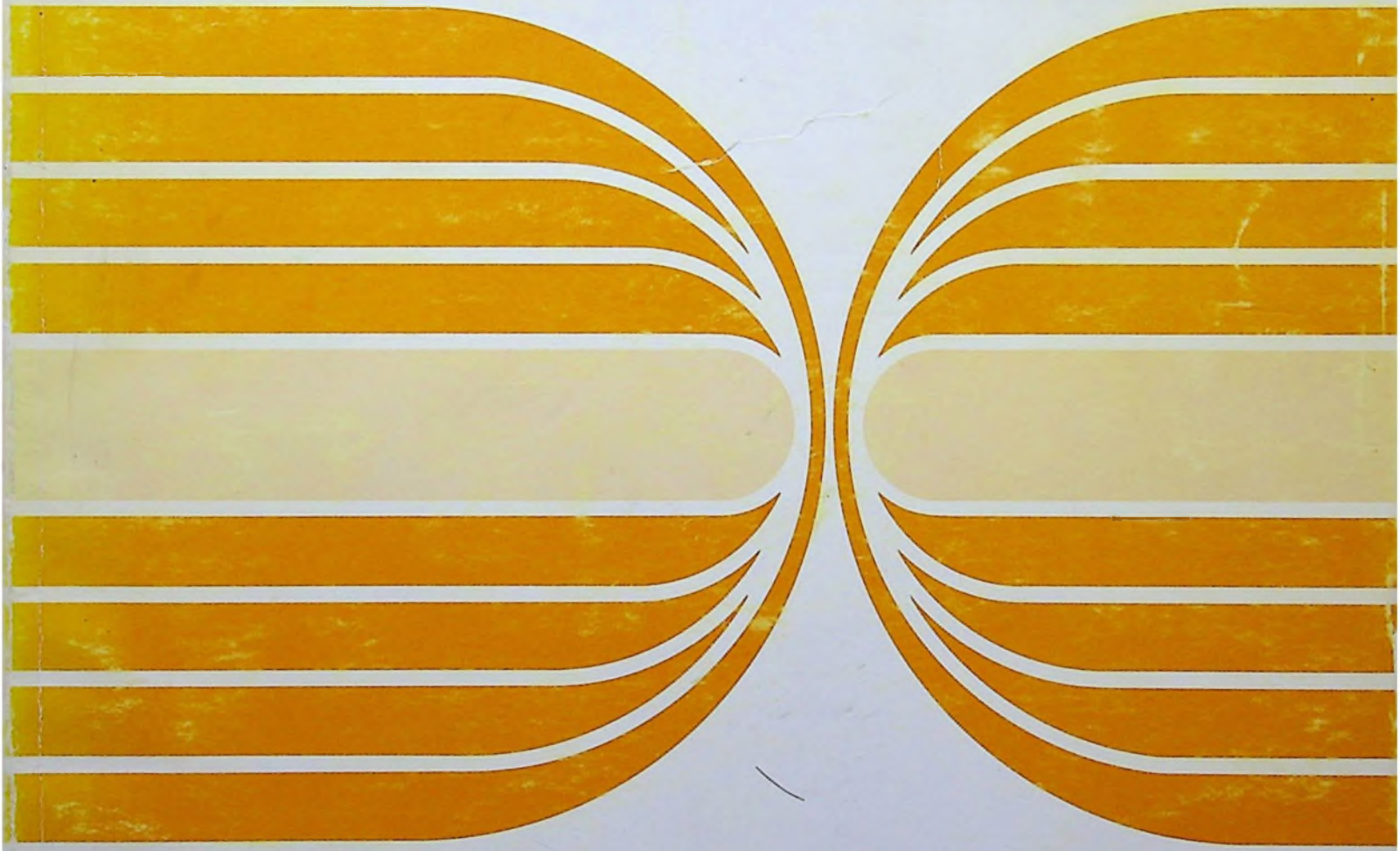

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CORPORATE COMMUNICATIONS USING THE SHARP APL MAILBOX

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Abstract

Perhaps more than any other single factor, the advent and growth of electronic mail systems has been markedly changing the appearance and pace of modern offices. Access to an ordinary telephone is today synonymous with access to world wide telecommunication networks. This, coupled with the fact that timely and cost-effective communication is absolutely crucial to any corporation, particularly those which are geographically dispersed, has made electronic mail an ideal mechanism for transferring information.

The SHARP APL Message Processing Facility (Mailbox) was developed ten years ago in early recognition of a growing need for efficient inter-company and intra-company communication. The reasons behind this growth are discussed in the paper. Some of the features of the Mailbox which make it particularly attractive, and some of the human factors involved with using computers to send messages are also addressed. In addition, the paper briefly examines certain design considerations associated with developing the Mailbox, including providing both security and a high degree of message integrity.

1. Introduction

Few technologies are presently receiving as much attention in business and management circles as is the area of communications. Man has been communicating, with varying degrees of success, since the beginning of time. And yet, even today, studies have shown that the single most important factor impeding increased office productivity is communication.

Every company is, to some degree, dependent upon communications to conduct its day-to-day business. In fast-paced business situations, it is vital that a company be confident that the necessary information is being directed to the appropriate individuals as efficiently as possible. Messages which are delayed or not delivered can mean lost business or cause incorrect actions to be exercised in delicate situations. Further, a message delivered late can often cause someone to act upon information which is no longer valid.

"Electronic mail" is a growing field which offers an extremely attractive solution to the problem of providing timely and cost-effective communication, both within a company and outside it. The fundamental concept of sending information as impulses along a wire is not new; indeed, systems employing this basic idea have been in

operation since 1844, when the United States government completed the first telegraph line from Washington to Baltimore. The first message transmitted over this telegraph line was, "What hath God wrought?" Now, more than one hundred thirty-five years later, people planning and directing modern offices are asking themselves the same question.

2. The Growth of Electronic Mail

During the last decade, certain factors emerged which together have become the driving forces behind electronic mail. First, electronic technology has made it possible to implement large international electronic mail networks. This means that a user may now communicate with a central computer or another user over a much expanded range. Second, large scale integration technology has made it economically feasible to build low-cost intelligent terminals and communications interfaces. Third, large organizations, or organizations with geographically dispersed personnel, have required enhanced communication mechanisms to effectively manage themselves and to disseminate information in a controlled fashion. This ability to communicate efficiently has had an increasingly high value in our highly competitive business environment.

Since the beginning of the Industrial Revolution, management has focused on the factory, rather than the office, as the place to improve productivity. Indeed, the tremendous strides made in the manufacturing process have contributed heavily to the success of industry. Yet today, there is growing concern about our declining rate of productivity.

Each year, white-collar workers are steadily growing in number and in impact on our society. Peter Drucker, in his book **Management: Tasks, Responsibilities, Practices** [Druc74], supports this view and observes "Increasingly, the central human resources are not manual workers — skilled or unskilled — but knowledge workers: company presidents, but also computer programmers, engineers, medical technologists, hospital administrators, salesmen and cost accountants; teachers and the entire employed educated middle class which has become the center of population gravity in every developed country."

The emergence of the "information society" is represented in the growing concern for professional effectiveness. According to the U.S. Department of Labor, postwar productivity in the manufacturing sector of the economy declined from a 3.3 annual percentage rate during the years 1947-1966, to a 1.5 annual percentage rate during the period 1967-1977. In the same period, wages have risen over 6 percent annually. Add to wages the overhead associated with office workers, and the problem of spiraling administrative costs becomes obvious.

Although there are a variety of causes for the declining rate of productivity growth, lack of progress in the office is clearly a major contributor. While advances in science and technology have steadily improved productivity in the agricultural and industrial sectors of our economy, improvements in the information sector have definitely not kept pace. In fact, offices have remained virtually unchanged for over a century. Electric typewriters are more sophisticated than their manual counterparts were one hundred years ago; microprocessor-driven calculators have replaced noisy mechanical adding machines; and photocopiers have made a lasting appearance. These are certainly the most important innovations in the office, and indeed, practically the only ones.

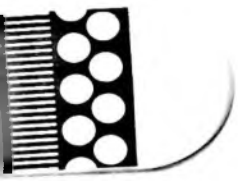
Why have increases in office productivity not been comparable to those occurring in

the factory? The basic lack of technological equipment specifically designed to enhance productivity is the most obvious reason. It has been estimated that the American management community sustains a per capita investment of about $25,000 for each blue-collar worker, and roughly twice that amount for each agricultural worker [Grov79]. This is in sharp contrast with the average capitalization per office worker: estimates range between $2,000 and $4,000 or only 4-8 percent of the investment per worker in agriculture.

While offices have remained virtually stagnant, the business environment they are endeavouring to service has changed dramatically. Contemporary offices function in a fast-paced, sophisticated world, and the scope of problems confronting businesses today requires adaptability and control far beyond that offered in the typical modern office. To be sure, the need for proper communication channels has never been so great.

Why then are the two most common forms of dispersed corporate communication, the telephone and the postal service, so inadequate? In the United States alone, almost 75 billion pieces of mail are moved annually by the postal service and, of this figure, four out of five pieces are business letters [Gott77]. No data is readily available concerning the number of pieces that are lost, damaged, or pilfered. But that aside, the United States Postal Service, and their marginally less-efficient Canadian counterparts, are hard-pressed to cope with the current level of postal traffic. Mail simply doesn't move fast enough or reliably enough in many cases. In fact, it often seems that first class mail moves slower than it did in the middle of the last century by Pony Express! And even when it is moving, both postal services have the uncanny ability to go on strike just at the time they can disrupt the largest volume of mail.

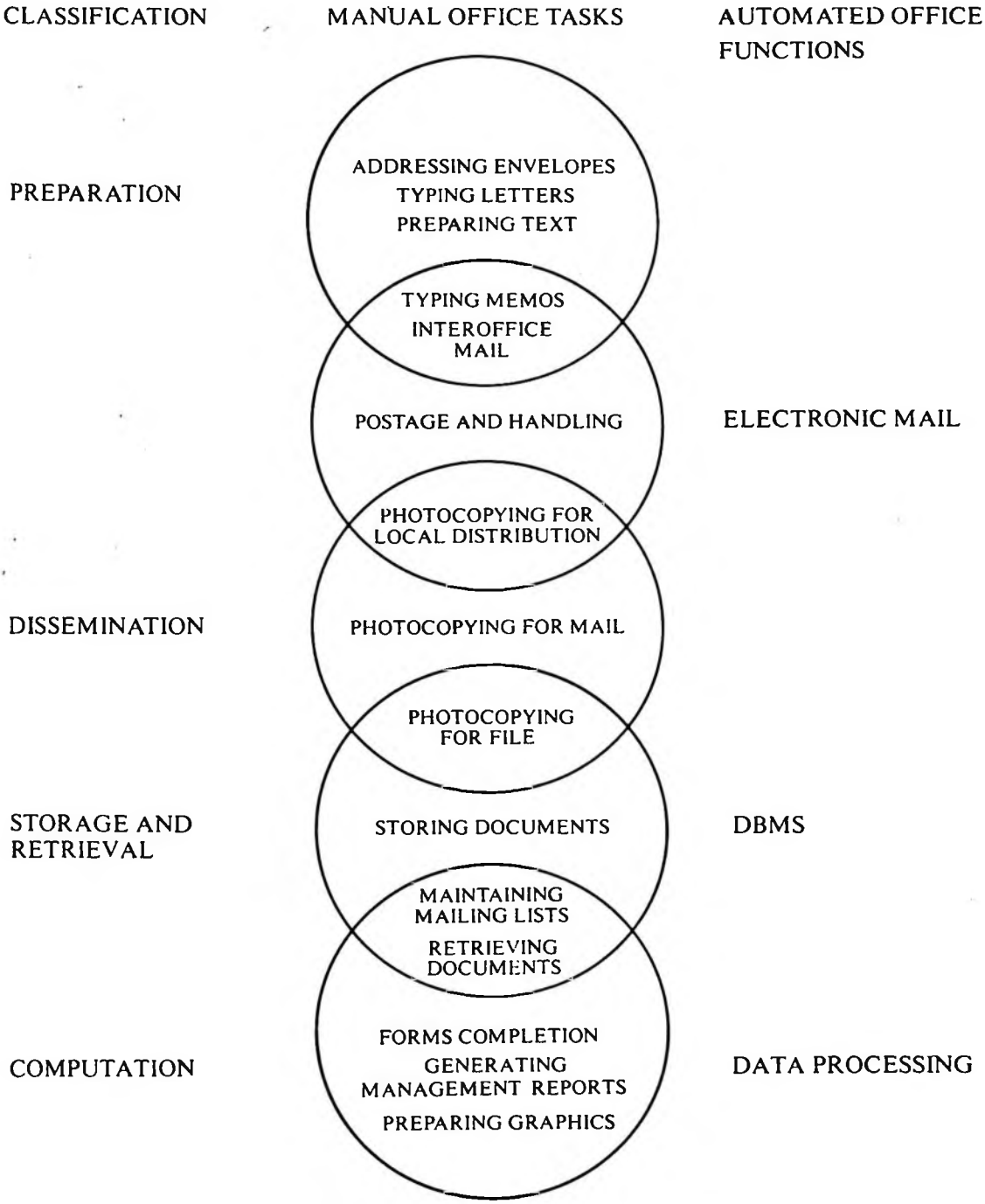
Mail service difficulties are by no means relegated to the government postal services. Many companies are experiencing similar turnaround problems with their own intra-company mail service. Research into one large organization, Exxon Corporation, reveals that in-house mail spends one percent of its time being originated, one percent being copied, three percent being typed, twenty-one percent sitting in incoming/outgoing bins at various points during its journey, and seventy-four percent in the delivery system [OEM80]. A full forty-five percent of the internal Exxon mail spends three days getting to its destination — days that could be critical to decision making. These figures are typical for large corporations, and almost certainly illuminate what the future might hold for smaller corporations which are expanding at a rapid rate.



In anticipation of these continued problems, many companies have begun investing in alternative forms of moving letters and packages vital to successful operation. Parcel and courier services are the obvious choice for packages. Electronic mail is the obvious choice for letters and memos. As shown in Figure 1 (after [Mier80]), electronic mail can be viewed as a superset of not only the postal system, but also interoffice mail handling, memoranda, and mail reproduction. Electronic mail obviates the need for reproducing mail because each recipient receives his own personal copy.

In contrast to the postal system, the inefficiency of the telephone stems mainly from its inherent requirement that individuals be simultaneously in a position to converse with each other. The most striking cases of this occur with people attempting to communicate across time zones, but the fundamental problem is much more general and is one most everyone has encountered. For example: Mr. Allen needs to discuss a problem with Mr. Burger. Allen calls Burger, who is out of the office, so someone takes a message. When Burger returns the call, Allen is tied up on another line, and so Burger leaves a message. Allen calls again, but now Burger is in a meeting. When the meeting ends, it's already almost five o'clock. Burger pessimistically calls back, and

is unsurprised to learn that Allen has already left for the day to go to his favourite pub. This exercise in futility has become one of the most frustrating games in business — and it can go on and on, sometimes for days. Studies have shown that, on the average, the caller fails to reach the person being called on the first attempt in 28 percent of all business telephone calls [Pott77]. The same type of thing can occur when trying to get together for a face-to-face meeting. Communication merry-go-rounds can cost valuable time in crucial situations.



Manual Office Task and Their Automated Counterparts

Figure 1

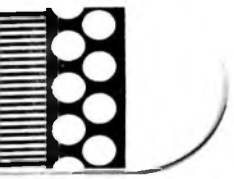
The telephone has other serious inefficiencies as well. Phone calls often come at inconvenient times, or interrupt a train of thought. The recipient of the call might be tired, or otherwise in an unreceptive frame of mind when the call is received. This can result in pretentious displays, where the recipient feigns interest, or even misunderstandings. After all, it is unlikely that the caller (who is probably in a reasonable frame of mind if he is making the call) will of his own volition attribute the recipient's attitude and tone to an off-moment or an off-day. With the Mailbox, the recipient can choose when and where he wants to receive his communications, and can adjust the timing to when he is best able to cope with them.

Telephone communication also has the disadvantage of being verbal and impermanent. At the end of the call, there is no written record of what conclusions or decisions were reached, or of those that were not. And of course, no telephone call would be complete without the social amenities and convivialities that accompany verbal exchanges.

The inefficiencies of the telephone are supported by a study conducted by Fortune magazine, in which managers consistently cited the telephone as the highest time-waster [Rowa78]. The situation is indeed ironic, for the telephone is undoubtedly the most widespread method of communication in common use today.

3. The Mailbox System

The SHARP APL Message Processing Facility, known as the Mailbox, is an advanced electronic mail system that is available throughout I.P. Sharp's international time-sharing network. The Mailbox is secure, and provides an efficient means of electronically moving information between people, wherever they may be, rather than between geographic locations. By interacting directly with a central computer via a remote terminal, the user can bypass all the costly and time-consuming steps normally associated with the preparation of a letter or other written communication. The same efficiency and permanence of the Mailbox, as well as its positive timing-related impacts, makes it an attractive substitute for other forms of communication as well.



Each Mailbox user has access to a terminal. Since the terminal serves only as a link to the computer, the same one needn't be used all the time. For example, while travelling, it is often convenient to carry a portable terminal to stay in touch. The fact that the actual location of the terminal is irrelevant, is one of the factors that makes electronic mail so unique.

Associated with each member of the Mailbox is a unique **address code**. The address code serves to identify the senders and recipients of messages filed through the Mailbox, and is usually the person's initials or a short form of his name. William Shakespeare might have the address code *WMS* or *BILL*, for example.

Any number of individuals can be assembled into a Mailbox **group**. A group contains the address codes of each of its members, who usually share a common interest or are associated with the same company or organization. For example, the group *MKTG* might contain all people involved in marketing. A message addressed to a group is sent to everyone in the group, as if each address code had been typed explicitly. Thus, it is as easy to send a message to a single individual as it is to address a large distribution list.

A message can be sent to one or more individuals or groups, and also "carbon-copied" (*CC*'d) to others. An additional distribution list feature lets the user carbon-copy people,

without making this fact apparent to any of the message's other recipients. Before a message is sent, it can be optionally classified as *CONFIDENTIAL*, *PERSONAL*, or *PERSONAL AND CONFIDENTIAL*. These external classifications are largely a matter of convention between sender and recipient, because the Mailbox always carefully guards each message regardless of its privacy level.

A message can also be marked *URGENT* and/or *REGISTERED* by its sender. Urgent messages print before non-urgent ones when the recipient reads his mail. Registered messages cause a confirmation of receipt to be reported back to the sender each time the message is received. The *REGISTERED* classification is not made apparent to any recipients of the message.

Figure 2 illustrates a sample Mailbox message. When a message is sent, the Mailbox automatically assigns a unique message number to it, and records the time and date it was filed. Along with the distribution list and external classification set by the sender, this information is assembled into a message "header". The text of the message follows the header, and may be anything from a simple memo to an elaborately-formatted document or report.

```
URGENT CONFIDENTIAL FROM JBC
NO. 1235813 FILED 11.08.56  MON  6 OCT 1980
FROM JBC
TO   TAM
CC   DEB FPS GEOFF GRB

ON YOUR DESIGN AND IMPLEMENTATION TIMETABLE FOR THE FINANCIAL
PLANNING SYSTEM, EVERYTHING LOOKS SATISFACTORY WITH THE POSSIBLE
EXCEPTION OF THE COMPLETION DATE OF THE FINAL PHASE.  IT SEEMS
TO ME THAT TARGETTING FOR THE MIDDLE OF APRIL IS GETTING
DANGEROUSLY CLOSE TO THE MANDATORY DEADLINE OF 27 APRIL 1981.
I THINK IT MIGHT BE PREFERABLE TO SHORTEN THE PRILIMINARY
DESIGN AND QUALIFICATION TEST PHASES BY SEVERAL DAYS, TO ALLOW
MORE OF A BUFFER ZONE FOR ANY UNANTICIPATED PROBLEMS IN THE
OTHER STAGES.  THOSE PHASES ARE PROBABLY A BIT OVERALLOTTED
RIGHT NOW ANYHOW -- 35 PER CENT OF THE EFFORT ON QUALIFICATION
TESTS SHOULD BE ADEQUATE, FOR EXAMPLE.

I'D LIKE TO SEE A DISCUSSION OF THE FINANCIAL PLANNING SYSTEM
AND THE PROJECT TIMETABLE PLACED FIRST ON THE AGENDA FOR NEXT
WEEK'S MEETING. ANY POTENTIAL DESIGN PROBLEMS OR OMISSIONS THAT
CAN BE ILLUMINATED NOW WOULD BE WELCOMED, AND SHOULD EXPEDITE
THE MEETING ITSELF.       /JIM
```

Sample Mailbox Message

Figure 2

Learning to use the Mailbox is simple. In fact, most users become comfortable with its main facilities within a matter of hours. Mailbox commands are generally English words that are easy to remember because of their suggestive meanings. For example, to determine information about incoming messages that have not yet been received, type *UNREAD*. The Mailbox will respond with the serial number of each pending message, along with its sender, privacy level, and an indication of whether the user was included

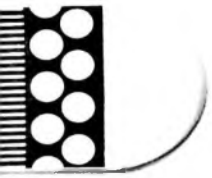
in the *TO*, *CC*, *BCC* class of the message header. *UNREAD* also tells the user about outstanding messages that he has sent, and which recipients they are still active for.

To get a more condensed report of pending mail, type *PREVIEW*. The Mailbox will respond with the number of pending messages, their senders, and a count of those that are classified as *URGENT*, *CONFIDENTIAL*, *PERSONAL*, and so on.

To read some or all pending messages, just enter the command *PRINT*. If any messages are classified higher than nonconfidential, the Mailbox will ask for the highest privacy level it should display, and will automatically bypass messages above that level. Messages that the user chose to bypass can be printed at any time just by entering the *PRINT* command again. This enables an individual to read all confidential mail, but perhaps save personal messages until circumstances permit them to be displayed in privacy. Further, because Mailbox messages can be manipulated as data, it is possible to involve them in auxiliary operations such as filing, cross-referencing, or retrieving.

Sending mail is also easy. The user types the word *SEND*, and the Mailbox responds by prompting for the address codes of the recipients of the message. When this information has been entered, the Mailbox prompts for the text of the message, which can be of arbitrary length and complexity. After the user signals the end of the message text, he simply gives the command to send the message. The message is filed, and its message number and timestamp are printed: it is then **immediately** available to all of its recipients, regardless of their geographic locations.

Before sending the message, the user can also choose to alter any aspect of it, including the distribution list, privacy level, or the message text itself. Another simple command will cancel the message being prepared and start over from scratch. Even after it has been sent, the sender can still retract the message (at once making it unavailable to its recipients), and then either modify and resend it, or else discard it.



The Mailbox also provides a forwarding facility, so that messages which can be better dealt with by someone not on the original distribution list may be passed on to that person, with one simple command. The user may also extend the message he is forwarding by adding his own commentary or preface to it. Further, if the message is classified as *CONFIDENTIAL* or *PERSONAL*, then the Mailbox automatically notifies the original sender that the message is being forwarded.

Another Mailbox command, *WHOIS*, lets an individual perform a variety of inquiries about himself or other members of the Mailbox. For instance, it is possible to ascertain the address code of another user, the identity of a user with a particular address code, the composition of a group, or the groups to which any individual belongs. All of the facilities of the Mailbox are described in detail in [Gold80].

Using the Mailbox, a person need never feel tied to an office as the only source of information regarding recent developments, and he need never feel out of touch when he can't make it in to work. If the user is on vacation, or otherwise expects not to be reading his mail regularly, he can just send a special Mailbox message to that effect (possibly including who to contact in case of difficulty). Then, anyone who sends the person a message will be automatically notified of his unavailability. When he returns, the accumulated messages will provide a complete account of the activities that transpired during his absence.

The Mailbox user who is away from the office on business can enjoy the benefits of

electronic mail wherever he happens to be, and not constantly have to worry about checking in with his office. Consider, for example, the somewhat exaggerated case of the corporate professional who begins a hectic week-long business trip. To him, being out of town is synonymous with being out of touch, and he has no recourse but to attempt to contact his office at least once a day. Even as his plane leaves the runway, calls begin pouring in for him, and message slips begin piling up. But what follows is a series of frustrating attempts by him to reach his office. He may, for instance, try to temporarily escape from one of his many scheduled meetings. However, this can be awkward, or even impolite. He may instead try to call the office during lunch — but where is his secretary? She is out at lunch also, of course. Finally, between afternoon appointments, he spots his chance to catch up on what he's missed. He eventually finds a pay phone to call from, only to discover that he has no change. At the hotel room that evening, our traveller has a lot of time on his hands. Everyone has long since left the office, and there is little to do other than sit back and watch sit-com reruns. A week later, the weary businessman returns home only to find that, despite his valiant efforts, a stack of yellow slips and numerous impatient clients await him. He can now settle back and face the two days' worth of catching up that are in front of him.

With the Mailbox, traumatic experiences such as this are avoided. Today's lightweight portable terminals make it possible to extend the realm of office communication to just about any place, be it home, a hotel room, or even a customer's office. As long as there is a telephone and an electrical outlet around, efficient communication can occur at any time with people who don't know where you are or where you will be — and vice versa.

4. Human Design Considerations

Interactive computing may be loosely defined as an information systems capability which allows both specialists and novices to interact with the computer in a responsive, conversational manner. In order for this to work, the system must combine ease of use and functionality in an environment in which it is comfortable for people to interact. The area of man-machine interfacing plays heavily in this, as it has a major impact on how receptive people will be toward using a particular piece of software. If the software is inflexible or has quirks that cannot be circumvented, there is a strong risk that people will shy away from using it, or be wary when they have to.

The manner in which a piece of software communicates with the end user can be broken down into at least two categories: **procedural** considerations and **syntactical** considerations [Mart73]. Procedurally, the Mailbox was designed for people with or without any computer background. It is both easy to learn and easy to use. For example, the message sending process is composed of a logical progression of steps which, once learned, become subconsciously anticipatory in nature. Several other features combine to make the process simple and straightforward. Where multiple option selections are possible, responses may be combined and placed on a single line. This results in faster dialogue sequences with fewer inputs. In fact, one can even specify the distribution list, privacy level, and text of a message, and send the message, all in one single input line. This is performed most frequently in cases where the text of the message to be transmitted has been previously composed (for example, it might be the output of some earlier phase of processing). In addition, when composing a message, it is always possible to replay all information that has been specified and change any that is not correct.

On syntactic considerations, the Mailbox uses simple prompting schemes which are

consistent in format. For example, all prompts ending in "?" are questions which require a "*YES*" or "*NO*" response. User responses are typically terse, and may be abbreviated if desired. Also, a user can get a help message at any prompt, just by pressing the RETURN key. (The dialogue structure was designed to minimize the likelihood of help being needed, but occasionally the user might become confused or forget the name of the command he wishes to select.) In addition, the Mailbox will always respond to an entry, so the user knows that his input was either processed successfully or else rejected — and, if the latter, precisely what was incorrect.

The conversational programs provided by the Mailbox serve the vast majority of its users. However, some sophisticated Mailbox members prefer custom interfaces to the message sending and printing routines, and to the inquiry capabilities. The Mailbox therefore also provides a number of primitives to perform base-level functions, such as reading or sending a single message. Users can then write their own interfaces to these primitives, to give the Mailbox the profile they desire. A facility known as *□PROF* further provides a mechanism whereby the Mailbox can remember the user's profile, and invoke it automatically each time he accesses the Mailbox. This modularity and flexibility has had very positive effects on user satisfaction. It has also made it straightforward to integrate the Mailbox into other systems which require the ability to automatically transmit status or textual messages to people.

The general conversational programs and the more specific primitive functions combine to make the Mailbox attractive to widely differing classes of users. The system is robust and resilient against errors. Designed to be "bullet-proof", every possible precaution was taken to ensure that a user cannot accidentally or intentionally cause the Mailbox to fail or act in a disadvantageous manner.

5. Technical Aspects of the Mailbox

The Mailbox is composed of a variety of programs for sending, receiving, and disposing of mail, for making inquiries on messages, and for making inquiries on other members of the Mailbox. The system consists of two workspaces and a single APL file. The user facilities mentioned reside in one workspace, which is accessed by people whenever they want to use the Mailbox. The other workspace is used only by the Mailbox stewards, who are responsible for enrolling, changing, and deleting enrollees, altering group membership, spooling and purging messages, and performing a variety of other maintenance activities. The file is a shared storage medium which contains Mailbox directories, status and control information, and the message database.

The development of the Mailbox involved meeting some fundamental design goals. Perhaps the most important of these was the goal of security. The system had to be secure, and maintain a high degree of message integrity at all times. Functionally, the main effect of this is that it is not possible for a user to read another user's mail: all messages are carefully protected, even from the Mailbox stewards. Furthermore, the failsafe file design ensures that the Mailbox remains completely intact in the event of a system crash or hardware failure. The package is well-guarded against both malicious and accidental attempts to compromise its integrity.

Program efficiency was another important design goal. This was complicated by the fact that the Mailbox originally had to run in 48K workspaces, so it could not enjoy the luxury of using storage-intensive algorithms to help achieve efficiency. The time-space trade-off was resolved by using complex file data structures and highly-efficient APL algorithms to manipulate them. In addition, algorithms are sometimes selected

dynamically in cases where the most efficient solution is dependent upon data or other non-fixed parameters.

Because the Mailbox was intended to be used by both experienced and untrained users, it was designed with a minimal number of "rules" to remember and two levels of input prompting. Advanced facilities such as Mailbox profiles and non-interactive conferencing are available for the more sophisticated users, but individuals who do not wish to use them need not even concern themselves with knowing about the features. The Mailbox is also fully documented in the user's manual, and a supplementary reference card.

The Mailbox design goals were considered in isolation of implementation difficulties. As a result, the requirements to fulfill these goals fell into two categories: those that could be met with facilities already available, and those that could not. Necessary facilities that were already available pertained to the system environment, notably the large time-sharing network, the SHARP APL File System, and the APL language itself. Required new facilities were not quite as straightforward, and occasionally resulted in modifications to the APL system. The potentially conflicting goals of security and efficiency, for example, led to the ability to "seal" a package and mask the names within it. The resulting encapsulation enabled one to make provable assertions that would have been difficult or impossible to sustain otherwise.

To keep the space consumed by the Mailbox to a minimum, sophisticated program compression techniques, now widely used to maintain other systems as well, were developed. One of the problems that program compression was designed to solve relates to comments within functions. Because APL is interpretive rather than compilation-driven, the image of a program that it executes is almost identical to what the user typed in. In particular, comments, which are normally removed during source-to-object code compilation in other languages, remain intact in running APL programs because there is no notion of object code. To reclaim this space, most comments are removed from the Mailbox prior to its installation. This results in an enormous space saving (over 65 percent), and a small reduction in program execution time as well. Other program optimizations that are performed further reduce the space requirements and increase efficiency.

A number of interesting problems arose during the internal design and implementation of the Mailbox. Many of these were direct results of the specifications and design goals of the system. A few general and specific problems are mentioned in the remainder of this section.

The installation of a new Mailbox, and the reinstallation of a later version of an extant one, had to be done cleanly and in such a way as to preserve the security of the Mailbox at all times. It was also important that people using the Mailbox at the time it was being reinstalled experience no interruption in service, nor indeed any indication that an installation was in progress. Users with privately-saved copies of the Mailbox are, however, automatically notified if the version of the Mailbox they are using has been superseded by a later release.

To protect the Mailbox against software, hardware, or malicious user error, an additional level of validity checking, called "paranoia checks" [Gold78], is performed. Paranoia checks are an extension of preliminary validation checks and semantic plausibility checks, both of which may legitimately encounter invalid or improper data. What sets paranoia checks apart is that they theoretically deal only with prevalidated data, and thus should never fail. The Mailbox uses frequent paranoia checks to guard

against possible user error or integrity exposure, and does not assume that a single level of nonredundant checks is adequate to ensure the validity of sensitive operations. Checks that fail are immediately logged for perusal by a Mailbox steward, and the concomitant operation aborted.

Because many users can be accessing the Mailbox simultaneously, multi-user interlocks were necessary to ensure that no unsynchronized file updates could occur in critical program sections. System-level queuing mechanisms provide the basic facilities necessary to properly sequence file updates and accesses; however, the Mailbox itself had to ensure no inconsistent data could result from updates that were aborted (through user interruption or system crash), or that were interrupted and then resumed. Two copies of each directory are used to guarantee that hardware failure or interruption during an update does not damage the Mailbox file, or lose any information within it. To avoid difficulties associated with restarting after an interruption, a general restart capability, called *GOON* (for "go on"), is provided. *GOON* always computes the correct restart point in whatever program is suspended. Because of critical section complications, this is frequently not the line number on which the interruption occurred. Implementing *GOON* required giving careful consideration to program topology, always making sure there **was** some point to restart at successfully.

Mailbox stewarding, such as the addition or deletion of enrollees or groups, had to be able to occur asynchronously to normal Mailbox usage, and transparently to it as well. To achieve this, a special signalling mechanism between the steward and Mailbox workspaces is used to cause all active Mailbox workspaces to be reinitialized whenever a steward has changed something. The reinitialization procedure happens invisibly to the Mailbox user. In addition, special steward-steward interlocks guard against problems that could arise from simultaneously-active stewards.

The requirements to handle a large number of enrollees and a large volume of mail (see the appendix to this paper for statistics) suggested the use of data compression techniques in both the file and the workspace. Further, to ensure continuous, smooth performance of the Mailbox, automatic "garbage collection" and capacity expansion facilities were built in. In fact, once a Mailbox has been installed, it requires no handholding at all to keep it running. In the event a problem should arise — or to make sure that none has — a Mailbox self-diagnosing capability can be run by the steward at any time, to precisely pinpoint an error or inconsistency in the system.

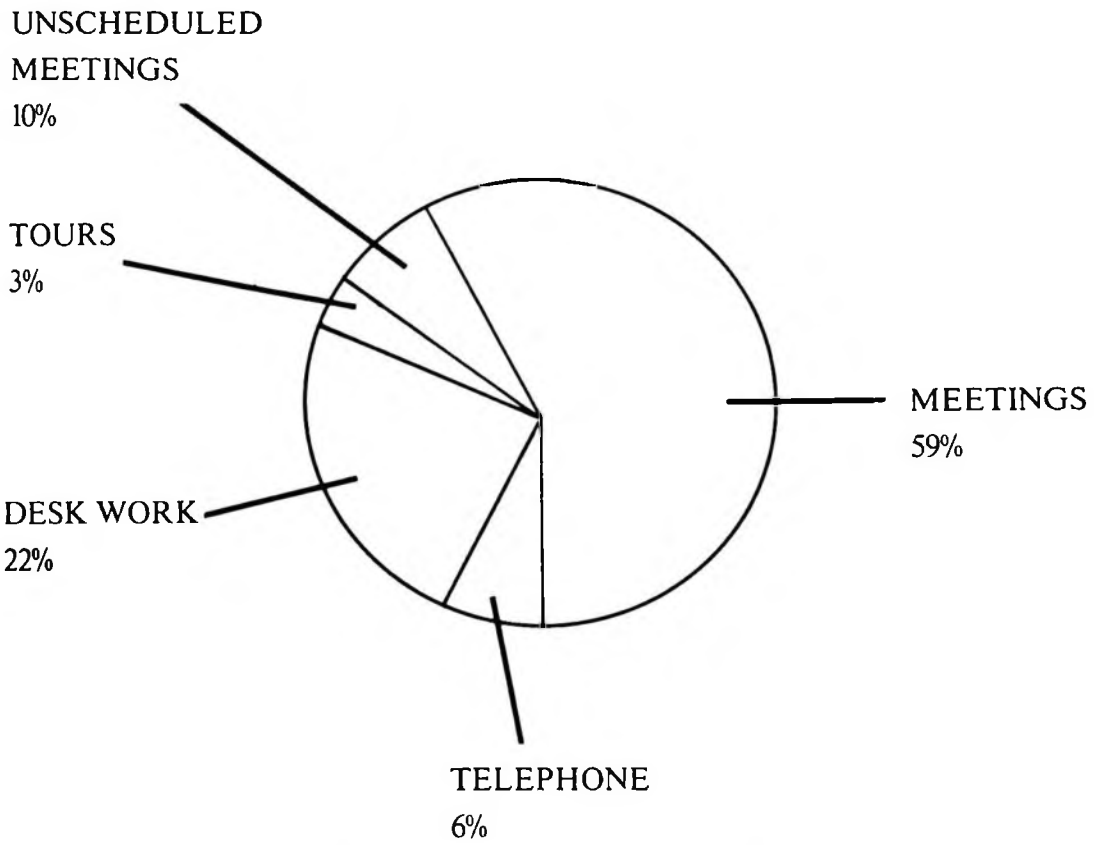
6. Economic and Other Benefits of the Mailbox

To analyze the economic payoffs offered by the Mailbox, it is necessary to first examine how it fits into the overall organizational picture. The decline in the rate of productivity growth of private business firms during recent years confirms the need to find ways to increase productivity in the office. Further, the size of the labour force which functions as information workers is expected to at least double during the ten year period beginning 1975, rising from approximately 20 percent of the total work force to over 40 percent. Combining this with the inflationary rise in the basic cost of labour leads to the conclusion that the cost of information processing by people in offices will increase by a factor of more than four. Electronic mail is a fundamental way in which this cost can be cut.

Non-clerical labour costs amount to 66 percent of the total labour costs for white-collar workers [Hark78], so this area is a natural one to examine for the greatest economic leverage. Non-clerical personnel can be divided into essentially two categories, managers

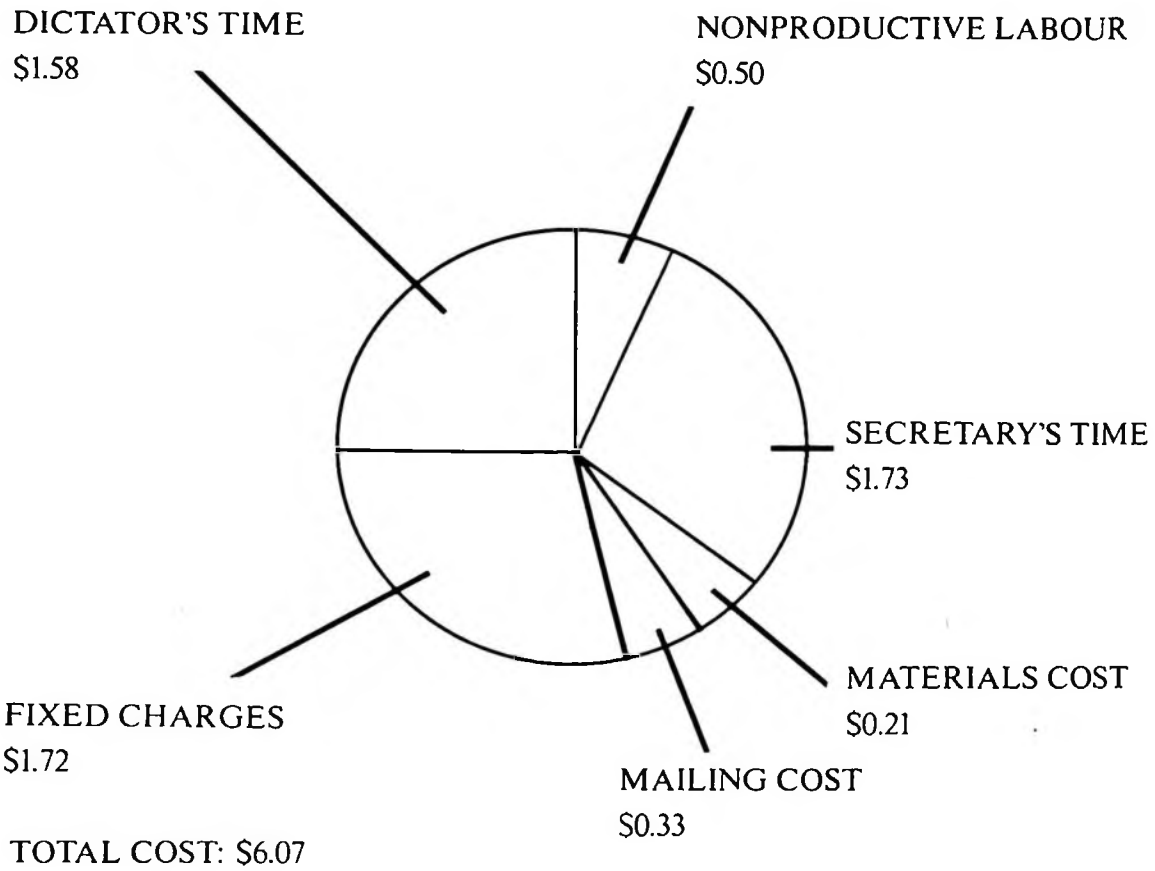
and professionals. Managerial activities have been summarized by several persons, and all results are in general agreement. In one of the most interesting and thorough of these studies, Mintzberg [Mint73] concluded that the typical manager's activities can be broken down into five generic categories (see Figure 3). Based on this managerial work distribution, oral communication (meetings and phone calls) amounts to 75 percent of managerial time. If one adds to this the portion of desk work that is involved with writing letters and memos, we find that nearly 95 percent of what a manager does is spent in communication of one sort or another.

Non-managerial professionals tend to spend slightly less time in communication, as one might anticipate. Studies by Bair [Bair74] and a composite study by Panko [Pank76] indicate that professionals spend 63 percent of their time in communication.



Distribution of Managerial Work

Figure 3



Cost of the Average Business Letter in 1980

Figure 4

Since managerial and professional communication gains have such high economic benefits, even small percentage increases in labour and cost savings can have a high impact. But most costs continue to rise at double-digit rates. The cost to dictate and mail the average business letter, for example, increased from just over $3 in 1970 to $6.07 in 1980, according to the Dartnell Institute of Business Research. The breakdown of the present expense to generate a business letter is shown in Figure 4.

Electronic mail offers an extremely viable and cost-effective alternative to escalating communications and labour costs, and decreasing productivity in the information sector. Analysis of the work-time expended in conventional communication compared with electronic mail shows a typical saving of nearly two hours per day [Uhli79] on an activity that already consumed six hours per day (75 percent of non-clerical time). This amounts to a 33 percent improvement in direct communication labour costs. The average hourly wage for non-clerical personnel is presently over $12 (based on Konkel [Konk76] and current inflation rates). Typical overhead and other related expenditures triple this figure to $36 per hour. On a day-to-day basis, this simple analysis shows a potential cost saving of approximately $72 per day for each managerial or professional employee, or $18,000 per year.

To put this into perspective, it costs roughly $1.00 to send a message of about 400 characters in the Mailbox. (The cost is independent of the number of recipients of the

message.) Message reception cost is proportional to the number of messages actually received, and is roughly $0.40 plus $0.10 per message. (These figures are based on CPU time consumed to send and receive mail in a private Mailbox containing 800 members.) In addition to this, there are initialization overhead costs of approximately $0.40 when the Mailbox is first accessed in a session. During a typical hour, the average user will send one Mailbox message and receive two. Assuming new sessions each hour, an hour's worth of communication would cost $2.00 in CPU time. Since editing or reformatting a message can increase the cost of sending, we shall assume a nominal cost of $3.00 per hour. This compares extremely favourably with other electronic mail or Telex/TWX-based systems (see, for example, [Barn78] and [Blea80]), particularly since the cost of sending messages in such systems is often proportional to the size and geographical distribution of the recipient list.

Using the hourly rate of $3.00 for computer communications, the daily cost would be $18 based on six hours of communication per day. Taking into account the projected minimum cost saving of $72 per day (two hours of non-clerical labour), the resultant overall savings from this brief analysis is $54 per non-clerical worker per day.

But cost effectiveness is not the whole picture. The Mailbox offers other advantages as well, both direct and indirect. Spatial and time difference factors of communication are minimized. On-line writing is accelerated; an author can compose at a much higher pace because he subconciously knows his wording can be modified using the immediately-available text editing facilities. The increased efficiency of communication increases a manager's span of control. For example, in one study conducted at Citibank [Uhli79], the span of control was observed to increase by 20 to 30 percent. This in turn can have a positive impact on managerial effectiveness.

The collaboration of groups of people is accelerated by the speed of communicating, in terms of both initial distribution and response feedback. Conversations can proceed more effectively, and with a multiplicity of contributions, without the need for physical collocation. The controlled pace which typifies collaborative discussions makes it feasible to increase groups from the classical limit of 8 to 10 participants, to upwards of 50 to 100 persons. Further, regardless of the size of the group, electronic mail reduces the inability or reticence of certain group members to participate in a discussion because of personality differences or shyness.

The use of the Mailbox results in changed communication modes. There is a lessened need to schedule meetings. There is also a marked decrease in the use of conventional mail, and in the use of the telephone — for both local and long distance calls. In addition, the decrease in interruptions which results from the use of electronic mail has the positive effect that working days are no longer "interrupt driven".

The Mailbox also brings flexibility in working hours and in work location. The working day and week are both extended arbitrarily due to the portability of terminals, which can be used wherever there is a telephone. This allows people to work creatively when they feel creative — even if this happens to be on a Saturday. Indeed, one survey conducted by the Yankee Group showed that 20 percent of electronic mail usage occurred outside normal business hours. Another timing-related impact is the instant availability of information. The computer can be used to drive a retrieval system which can store messages (or other documents) for an unlimited period of time. Typical systems permit retrieval based on any number of complex criteria including sender, recipients, date sent, keywords, text searching, and so on.

7. Conclusions

The Mailbox provides a facility whereby the right information can get to the right people, wherever they may be geographically, in a timely and cost-effective manner. With the declining rate of office productivity growth, the spiraling cost of non-clerical labour, and the rapidly decreasing cost of computers and information networks, the time has never been more ripe for the application of electronic mail to corporate communication.

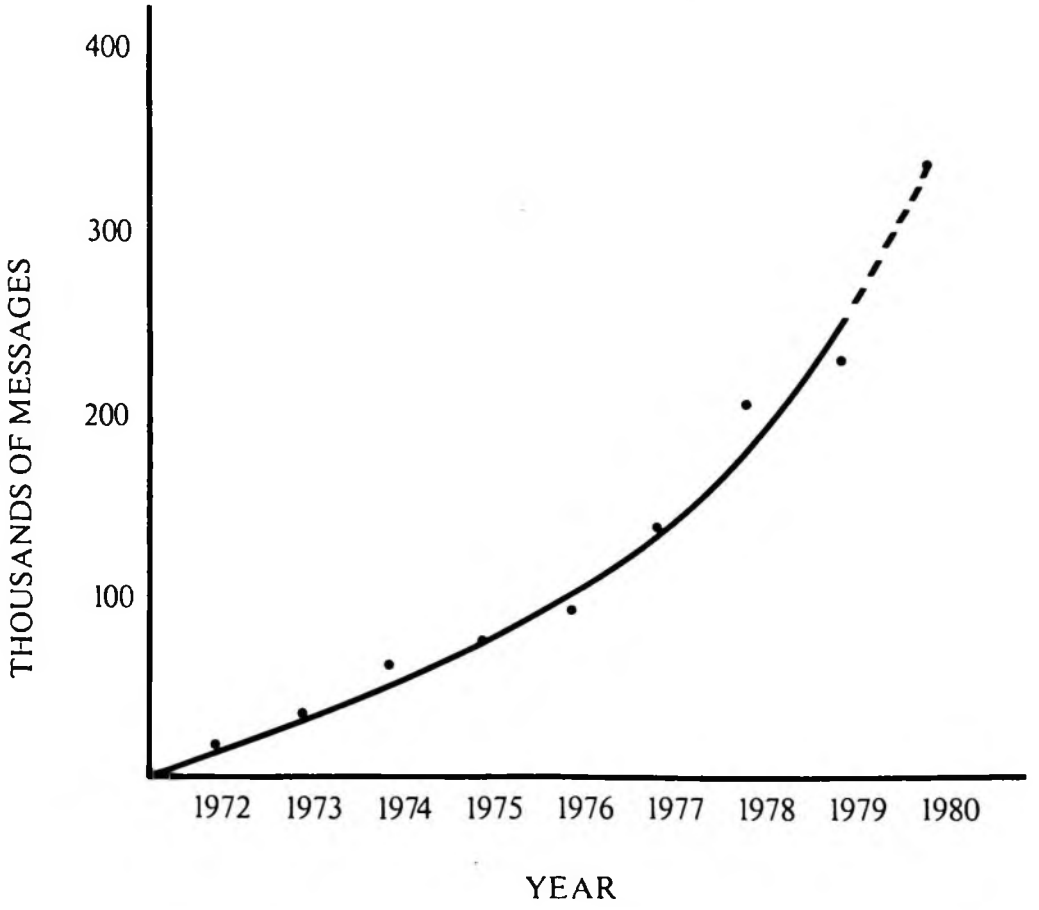
The Mailbox substitutes for many kinds of communication. When it is used in place of conventional mail services, delivery is instantaneous and mail awaits only the recipient's time to read it. When it is used in place of face-to-face dialogue or a telephone call, communication consumes far less time. People read about six times faster than they can talk, and thus are able to get the point across much more quickly with written communication. Mailbox messages also tend to be more succinct, since there is usually less non-task oriented information in them than a verbal conversation would graciously permit.

Managerial and professional personnel spend most of their time communicating with others, either verbally or in writing. As a result, even small impacts in their modes of communication can have a large economic benefit. While the use of the Mailbox is by no means advocated as a replacement for all other forms of communication (some tasks certainly require a verbal engagement), it has been found that the Mailbox has a profound positive impact on corporate communication patterns, often opening channels which did not previously exist.

Appendix: Statistical Information About the Mailbox

The Mailbox itself consists of two workspaces, and a supporting file which contains messages and user enrollment information (see the section entitled "Technical Aspects of the Mailbox" for more details). Because of the manner in which the workspaces and files are coupled, any number of independent Mailbox systems may be extant at a given time. Each Mailbox has its own set of workspaces and file, so that each may run different software if it desired to do so based on the community or organization it is serving.

There are presently about ten such Mailbox systems active, on the I.P. Sharp computers as well as on the computers of in-house customers. The first and largest of these is the I.P. Sharp Associates company and customer Mailbox, called 666 *BOX*. This appendix contains statistical usage information for this Mailbox **only**; the combined usage levels including the other Mailbox systems running similar or identical software would be much higher. Present usage levels quoted herein are based on figures collected by the Mailbox during the first two quarters of 1980.



Annual Growth of Message Traffic in the Primary Mailbox

Figure 5

Figure 5 illustrates the growth of message traffic in the primary Mailbox for years 1972 to present. The projected volume of mail in 1980 is some 338,000 messages in this mailbox alone, and nearly a half million messages in 1981. More than 1,000 messages are now sent on a typical working day.

Over the years, the number of members in the Mailbox has grown from twenty-five people to almost 2,000, more than half of whom are customers. About forty percent of those people have mail pending at any given instant. The average incoming message level for users with a nonzero number pending is about seven messages.

The instantaneous capacity of the Mailbox is presently about 3,500 messages. (This number grows automatically according to usage patterns of the system.) For 3,500 messages, there are typically over 36,000 recipients, for a mean of around ten recipients per message. Roughly fifty-eight percent of all messages are addressed to one recipient. Of the forty-two percent that are not, the average number of recipients per message is approximately twenty. The maximum number of recipients actually addressed during the sample period was around 220, although a wider distribution list would have been possible just as easily.

On the order of nine percent of all mail sent through the Mailbox goes to a single group (which may contain any number of members). About 8.5 percent of the mail goes to a single group **and** one explicitly addressed person, who may or may not be a member of the group. (This situation arises most frequently when a message is

addressed to an individual, and carbon-copied to a group.) The Mailbox presently contains some 400 groups, with an average enrollment of more than ten persons per group.

References

[Bair74] Bair, James H., "Evaluation and Analysis of an Augmented Knowledge Workshop", **Final Report for Phase I**, Rome Air Development Center, RADC-TR-74-79, April 1974.

[Barn78] Barna, Becky, "Electronic Messaging Can Make Cents", **Computer Decisions**, pp. 34-42, September 1978.

[Blea80] Bleackley, Beverley J., Special Article on Electronic Mail, **Computer Data**, pp. 30-31, February 1980.

[Druc74] Drucker, Peter F., **Management: Tasks, Responsibilities, Practices**, Harper and Row, New York, N.Y., 1974.

[Gold78] Goldsmith, Leslie H., **On the Security and Integrity of Programmed Systems**, Computer Systems Practice Unpublished Working Paper, Department of Electrical Engineering, University of Toronto, Toronto, Canada, November 1978.

[Gold80] Goldsmith, Leslie H., **The SHARP APL Messaging Processing Facility**, I.P. Sharp Associates Limited, Toronto, Canada, May 1980.

[Gott77] Gottheimer, Debra, "Mail the Postman Doesn't Carry", **Administrative Management**, pp. 37-50, March 1977.

[Grov79] Grove, George, "Information Management in the Office of the Future", **Management Review**, pp. 47-50, December 1979.

[Hark78] Harkness, Richard C., "Office Information Systems: An Overview and Agenda for Public Policy Research", **Telecommunications Policy**, June 1978.

[Konk76] Konkel, Gilbert J. and P.J. Peck, "Traditional Secretarial Cost Compared to Word Processing", **The Office**, pp. 67-68, February 1976.

[Mart73] Martin, James, **Design of Man-Computer Dialogues**, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1973.

[Mier80] Mier, Edwin E., "Tying Together Telephones and Typewriters", **Data Communications**, pp. 51-67, April 1980.

[Mint73] Mintzberg, Henry, **The Nature of Managerial Work**, Harper and Row, New York, N.Y., 1973.

[OEM80] **Office Equipment and Methods**, Special Article on Communicating Word Processors, p. 19, January 1980.

[Pank76] Panko, Raymond R., Presentation to the Seminar on the Augmented

Knowledge Workshop, Stanford Research Institute, Menlo Park, Ca., November 1976.

[Pott77] Potter, David A., "Software Objectives for the Administrative Network", International Data Corporation Executive Conference, Ft. Lauderdale, Fla., November 1977.

[Rowa78] Rowan, Roy, "Keeping the Clock from Running Out", **Fortune Magazine**, p. 76, November 1978.

[Uhli79] Uhlig, Ronald P., D.J. Farber, and J.H. Bair, **The Office of the Future**, vol. 1, International Council for Computer Communications. North-Holland Publishing Company, Amsterdam, The Netherlands, August 1979.