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Office Automation
and
Document Preparation

for the
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SUMMARY OF MAJOR RECOMMENDATIONS

* The University should undertake academic research into office automation.

* In implementing office automation, the University should concentrate on document-preparation systems.

* The University should not establish a centralized document-preparation service, nor undertake extensive development of document-preparation facilities.

* The University should not mandate standard document-preparation equipment, except perhaps for typesetters.

* The Computation Center should provide advice in system selection, furnish hardware and software interfaces for selected systems, and continue to support SCRIPT as the one central document-preparation service.

* The Administrative Data Processing organization should conduct studies, or assist in conducting studies, of administrative organizations contemplating the installation of document-preparation systems.

* Administrative managers and faculty members should be apprised of the current status and future potential of office automation.

* A University committee should oversee the implementation of office automation.

1 OVERVIEW

1.1 MODELS

Office automation can be described in terms of either of two essentially different models [1], the principal-support model and the service-oriented model. Under the principal-support model, the operation of an office is seen primarily as supporting the activities of one principal person. Although this person is usually described as a business executive or other manager, the conceptual model holds equally well for lawyer, stockbroker, or professor. Under the service-oriented model, the operation of an office is seen primarily as performing a set of tasks that collectively accomplish the goals of the office. The office may employ a large number of persons, perhaps issuing purchase orders or answering credit inquiries, or it may in fact be that of a principal or of his* secretary.

1.2 DISTINCTIONS

Hammer and Zisman [2] delineate several distinctions that are important in the study of office automation. The most crucial of these is between task and function. "A task is a narrowly focused activity, usually performed by a single worker. A function is an end to be realized by means of task performance. A given function may be implemented in different ways, by means of different task structures." Automating the performance of a task is thus very different from automating the implementation of a function, although the latter may be composed of instances of the former.

The term shadow function has recently become common. It refers to activities that are intended to lead to the performance of function, but turn out to be unproductive. One example is placing a telephone call to a person who cannot receive the call. Another is several persons waiting for one person who is late to a meeting.

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*The masculine pronoun is used in this report to refer to a male or a female person, without specification.

A second distinction drawn by Hammer and Zisman is between automation and mechanization. "In its strictest sense, automation means the use of technology as a substitute for human labor. ... automation can only be accomplished for a highly structured task. ... If ... an activity is not sufficiently structured to allow for its automation, it may nonetheless be subject to mechanization, which means providing human workers with improved tools for performing it." The mechanization of telephone dialling would not eliminate the shadow function previously cited. The redesign of a principal's activities, however, combined with automation of the task to which the telephone call was adjunct, could eliminate the shadow function. I shall follow prevailing practice in using "automation" in both senses; the context should make clear which sense is intended.

1.3 FACILITIES

Many technologies, devices, and approaches have been pressed into the service of office automation. For convenience, I have grouped the most widely discussed of them into four areas.

1.3.1 Document Preparation

Word processing systems are used to automate some of the functions of a typist and to provide more powerful mechanization than a typewriter. They offer the editing and formatting of documents from initial creation, through revisions, to final production. Keyboards, character display terminals, computers, printers, and typesetters are the chief devices encountered. Machines for copying and reproduction also belong in this category. The foregoing facilities are all widely available commercially today. Because of their immediate importance to universities, they are described in fuller detail in Section 3.

1.3.2 Records Management

Word processing systems are based on the storage and manipulation of documents in machine-readable form. The existence of the machine-readable

document, combined with relatively inexpensive mass storage devices for computers, makes electronic filing systems possible. Although there has been for a decade considerable emphasis on the electronic filing of data, there has been much less on the electronic filing of documents. This is due in large measure to the difficulties in describing, clustering, and identifying documents. Enough progress has been made in these areas, however, to warrant further efforts at implementation.

1.3.3 Communication

Electronic mail can be viewed as a clerical interface to a word processing facility. It also substitutes for the telephone in sending such common unidirectional messages as declarations, corrections, acknowledgements, and modifications to itineraries.

Computer mail combines a personal terminal with a store-and-forward message system. A portable terminal permits a travelling user to send and receive mail when away from his office.

Store-and-forward networks for audio messages do not appear to be economically feasible yet, but the facility is very attractive to many people. So is the integration of telephone and dictation equipment.

Facsimile transmission is now available in a variety of speeds and prices. It makes possible the electronic transmission of arbitrary written material, such as line and half-tone drawings, or even handwritten notes.

Teleconferencing is the use of long-distance closed-circuit video and audio to facilitate a meeting among persons at separate locations. Its greatest appeal is the saving of travel time and cost. Unlike the previously mentioned facilities, teleconferencing has little applicability for persons at a single geographical location.

1.3.4 Scheduling

One present application of an office computer is the maintenance of a personal calendar. Without added function, this hardly seems competitive with

a pocket appointment book. The addition of a reminder function, or mechanized "tickler" file, is a potential enhancement. More attractive yet is the maintenance of personal schedules for many members of an organization, coupled with a program that serves as a meeting scheduler.

2 OFFICE AUTOMATION IN THE UNIVERSITY

The impact of office automation on a university is twofold. Like any other large enterprise, the university is a potential beneficiary of new applications of technology. This is true, of course, for the normal business functions of the university, but it is even more so for its academic functions. Virtually every person holding an academic appointment can be viewed as a principal engaged in activities that can benefit from office automation with a principal-support orientation. The functional enhancement of the capabilities of individual teachers, researchers, and servants is independent of discipline and can ultimately modify substantially the work style of an entire institution. For those reasons it promises to bring a transformation of the university even greater than that wrought by the advent of the computer as a problem-solving tool.

The other role in which office automation impacts the university is as an object of study. Potentially another computer revolution, and certainly both a major influence on business organizations and a major application of computers, its nature, implementations, effects, and costs are appropriate subjects for research. Before considering university research in office automation further, I turn first to the issue of implementing office automation in the university.

2.1 IMPLEMENTATION

2.1.1 Service-Oriented

I have not attempted to assess the need for mechanization of office tasks, or for automation of office functions, in carrying out the routine procedures of this University. That such needs indeed exist is evident from the use of

office automation technology, particularly word processing systems, in many parts of the University. I see increasing interest not only in document editing and formatting, but also in typesetting. I am not aware of current interest in electronic mail, automated calendars, or other advanced functions. There is no call for the University to rush into large-scale automation of its business offices. Nevertheless, it is appropriate that its managers be aware of the potentials of applying modern technology to office practice. Many of the benefits of office system redesign come not from the introduction of computers, communications, or other technology, but from the very process of study and redesign. For this reason, it is normally not wise to acquire office automation devices without a prior review of the tasks and functions to be automated. It should be possible to count on the Administrative Data Processing staff for expertise in conducting such reviews.

2.1.2 Principal-Support

In carrying out the academic functions of the University, it is very likely that the scarcest resource is the time of individual faculty members. If that is so, then the greatest increase in productivity will ensue from office automation designed to support the individual faculty member in his activities. Although the cost for supporting staff and for students is lower, per person, than that for faculty members, the staff and students collectively constitute a substantial resource whose time could often be used more efficiently. Graduate students in particular face substantial opportunity costs of taking longer than necessary for research and writing.

The typical academic functions of a faculty member are highly unstructured, as opposed to that of a bookkeeper encumbering travel funds. These functions are therefore not susceptible to automation, in the strict sense, but many of the tools can be mechanized. The elimination of shadow function is a great help. The use of computer mail permits the nearly instantaneous sharing of information with colleagues in the "invisible college". Yet the biggest immediate payoff will come from the most mundane application of office automation, the preparation of documents.

Whereas in the paper-bound business office the document is a means to an end, to a professor the document is often an end in itself. Table 1 lists many of the types of documents commonly produced as part of the academic operation of a university. The six that appear in bold face are the end products of the research half of the academic enterprise. As such, they are much more central than the others, which serve primarily as means and as tools, rather than as products.

Recognition that those key documents constitute part of a university's product should enhance our concern for the process of their production. Every professor and every student should have available the time-saving resource of automated document preparation.

Table 1

ACADEMIC DOCUMENTS

Accreditation Requests	Examination Papers
Administrative Reports	Grant Applications
Articles	Job Opening Announcements
Bibliographies	Laboratory Reports
Books	Lecture Notes
Brochures	Letters of Recommendation
Catalogs	Minutes of Meetings
Commmittee Reports	Program Proposals
Contract Proposals	Progress Reports
Correspondence	**Research Papers**
Routine	Self-Study Reports
Special	Student Job Applications
Course Assignments	Supplementary Texts
Curricula Vitae	**Technical Reports**
Dissertations	Term Papers
Employment Resumes	**Theses**

2.2 RESEARCH

2.2.1 Issues

At least four groups of issues in office automation require investigation: organizational, behavioral, economic, and technological.

It is widely accepted that procedure manuals do not accurately describe the actual procedures, and that official organization charts often give insufficient clues to the real loci of decisions or to the most relevant relationships. One of the paradoxes of business system study is that the paper-based system permits easy understanding of an individual paper form, transaction, or task, but only limited comprehension of the system as a whole. In a fully automated system, on the other hand, the individual transaction may be virtually lost in a plethora of magnetically-encoded data, but the system itself is completely described by the computer algorithms. Because the system as a whole is now understandable, it is readily modifiable, and can serve as a vehicle for studies of organization.

The effect of office automation on the role of the manager is a vital organizational issue. One result that has been observed is an increase in the span of control of each manager. A major study of office automation at Citibank has been described by White [3]. Subsequent anecdotal reports claim a company-wide increase in average span of control from 6 to at least 6.5 directly supervised employees.

Behavioral and sociological issues include the intriguing notion that more and more of the work of a body corporate could be accomplished by persons working at home, where appropriate equipment would be installed. The effects on everything from family life to transportation patterns and communication requirements, to distribution of responsibility in an organization, could be very substantial. Just as the assembly line in industrial manufacturing created problems of personal responsibility and incentive, so does the automated office raise similar questions for tomorrow's office worker.

Economic issues of office automation range from assessing its costs and benefits in a single organization to the prediction and analysis of its impact on different sectors of the economy. Will the percentage of gross national

product devoted to communication rise higher than originally anticipated? Will intercity business travel be reduced?

The technological issues relate chiefly to design -- the design of devices, interfaces, filing and retrieval strategies, systems of hardware components, systems of programs. The problems encompass building better tools for the tasks currently performed, building tools that do not now exist, and building complete systems that involve a redesign of the functions performed by a principal or by an office staff.

2.2.2 Participating Units

Which academic units of this University should most appropriately consider research in one or more aspects of office automation? The two most centrally involved should be the School of Business Administration and the Department of Computer Science. Several business schools have substantial research in office automation now under way. Among them are the Graduate School of Business Administration at N.Y.U., the Sloan School at M.I.T., and the Wharton School at the University of Pennsylvania. Drawing on the technological strengths of the Research Triangle Area, our own business school is well positioned to investigate this important modern development in business practice.

I have not yet ascertained whether departments of computer science in other universities have tackled problems of office automation. A number, including those at Brown, Stanford, and Waterloo, have addressed the important subarea of document-preparation systems. With our experience in building and using interactive text editors, our accomplishments in interactive graphics and man-machine interface design, and our interests in natural language processing and in software engineering, we are well prepared to address the technological issues other than hardware development.

I can well imagine that several other academic units can find in office automation grist for their research mills. Those that come most readily to mind are Economics, Operations Research and Systems Analysis, Psychology, and Sociology. As a profession, journalism is one of the oldest and largest users of word-processing technology. The School of Journalism may be interested in application-oriented research therein.

3 DOCUMENT PREPARATION

3.1 FUNCTIONS

Interactive computer-based document-preparation systems permit a user to enter and modify a document by means of a keyboard, to view the material as he works, and ultimately to receive a copy of the document on some physical medium. Any document being prepared embodies two types of information, its body or content and its layout or format. In the use of a typewriter, no distinction is made between content and format. If, for example, a new paragraph is to begin at some point in a document, the typist will typically position the carriage to a new line, indent a few spaces, and continue typing words. If it later becomes necessary to change either the words or the paragraphing, the page must be re-typed.

In a computer-based system, on the other hand, it is simple and common to distinguish format information from content. The text that is processed by the computer then includes both document content and format control information, and each can be changed independently of the other. For example, it is possible to reset margin widths without re-keying the words of the document, and to change the words without re-keying the line length specification. The major functions performed by a document-preparation system are to create, edit, file, format, and print documents. Each will now be explored in turn.

Document creation is essentially the capture of key strokes, producing for each stroke or group of strokes a machine-readable representation within the computer system. Any subsequent manipulation of the document can be performed by a machine process that reads the computer representation and therefore does not require a repetition of the keying action. Three major advantages accrue. It is no longer necessary to key any material more than once, simply to accommodate a change in neighboring material, as in modifying a phrase or in changing tabular alignment. A resultant advantage is the saving in re-keying time. A second, very substantial advantage is that the absence of re-keying guarantees that no new errors will be introduced into unchanged material by re-keying. A third advantage is that further processing can occur at speeds not limited by that of human finger actions. Thus a professor can, with no

increase in calendar time, take a scholarly publication through several more drafts; or he can, in less calendar time and with sharply less secretary time, produce clean copy of a complex layout of technical material; or a doctoral student can have, within just hours of defending his dissertation, a completely reprinted document, embodying a host of minor improvements suggested by his committee, and ready for xerographic or offset reproduction.

Document editing is the insertion, deletion, and revision of text, both content and format. It really includes document creation as a special case, for creation is nothing more than insertion into a previously empty text. During creation or, more generally, during any editing, the system displays to the user the new material or changes he is making. Facilities for document revision vary among systems, but typically include moving a block of text from one location to another within a document, finding each occurrence of a given string of characters, and systematically replacing all occurrences of one character string by another. Thus a typist could save considerable effort in a long paper by keying "USPOD" many times and at the end requesting only once that each occurrence be replaced by "United States Post Office Department".

Document filing and retrieval by the system permit each of several users to keep one or more documents in the system, each user working on one of his documents at his convenience, provided that the system is available to him.

Document formatting provides control over margin settings, justification, hyphenation, paragraphing, pagination, centering, capitalization, underscoring, and a host of other functions that govern the physical appearance of the document. In some systems, the effect of format control is evident in the current display of whatever portion of the document is being worked on. Other systems perform the formatting as a step subsequent to and distinct from editing; in these the effect of format control often cannot be inspected prior to a trial printing.

Document printing can use any of several different media, depending on the desired end use. If the document is to be viewed by projection, it can be printed or exposed photographically on transparent stock. If it is to be reproduced in multiple copies, it can be prepared by typesetting or on a high-quality printer. If print quality is not a primary concern, the variety of acceptable printers becomes wider.

3.2 TECHNOLOGIES

Although work continues on voice input to machines, the current state of the art in recognizing natural language spoken by an arbitrary speaker accepts only words selected from a small vocabulary and pronounced separately. Original input of text will for some years have to come from the keyboard, which will often be part of a computer terminal. There is an alternative that is cheaper for large volumes of keying, but forgoes the interaction possible at a terminal. This is to use the keyboard of a typewriter equipped with a printing element that has a font designed for optical character reading (OCR). The savings in purchasing typewriters rather than terminals can be used to pay for an OCR reader. An optical reader that accepts arbitrary fonts has recently been developed, and may be suitable for entering old documents, without re-keying, into a computer-based system for further work.

Although printer-based terminals are still used, the almost universal technology for text display in document-preparation systems is the cathode-ray tube character display, or video terminal. Multiple colors are extremely useful for distinguishing portions of text, but they can be replaced at somewhat lower cost by such monochromatic effects as light-and-dark reversal, different intensity levels, shading, and blinking. Screen size varies, with page-size screens becoming very popular because of their ability to display a page of formatted document exactly as it will ultimately be printed.

Text editing is performed by computer programs. In those terminals that embody a microprocessor, a substantial portion of the editing can be performed within the terminal, although it is necessarily restricted to the portion of text currently held in the terminal before transmission to the host computer. Two essentially different types of editing programs are commonly encountered, line editors and character editors. In line editors, each line of text is identified by a line number stored with the text. The line number serves as an index for rapidly locating a portion of text; it is normally stripped off during final printing. In some systems, line length limitations impose constraints on arbitrary revision of text. Character editors treat the entire text as a single character string.

A line or character editor may or may not offer a context-locating facility. Such a facility is virtually mandatory for character editors, but may be omitted from line editors. The user of a line editor with no context facility needs to know the line numbers that correspond to different portions of his text. Character editors provide greater ease and flexibility in editing, but may spend substantial time in searches for a specified context.

Document filing generally uses digital recording on rotating magnetic surfaces. Systems with a large central computer use standard magnetic disk packs, which remain (often permanently mounted) at the computer site, and hold hundreds of millions of characters. Smaller systems typically offer one or two removable "floppy disks", or diskettes, which store up to perhaps 200,000 characters each. Some also offer one permanently mounted standard disk of higher capacity.

Formatting, like editing, is performed by computer program, and it is in formatting capability that different systems vary the most. Richness of formatting function is obtained at the cost of program execution time and especially of program storage space. Systems with small computers simply cannot offer the features available for a large one. A good example is hyphenation. Smaller systems often provide a hyphenation assist feature that displays, at the end of a formatted line, the first word that will not fit. The user can decide whether to defer the word to the next line or to hyphenate it, placing one portion on each line. In the latter event, the user decides where to insert the hyphen. A full-function formatter typically offers the optional provision of automatic hyphenation, using a program that applies syllabication rules and consults a dictionary of exceptions.

A formatter can not only govern the layout of the given document, but also produce certain derived documents automatically. These include a table of contents, an index, and a spelling dictionary.

The variety of output technologies is impressive. Modern typesetting offers a large assortment of type fonts and a great degree of control over character size and placement. Digital character generation, fiber optics, and laser light sources are all used to provide excellent character quality for typesetting. Photography and xerography can both be used to produce

projection transparencies. Impact and non-impact printers are distinguished by whether a print element makes physical contact with the paper. Balls, wheels, bars, drums, and chains are among the devices used to carry raised type in impact printers. Some print a character at a time; others, a line at a time. Speed, quality, and cost vary substantially. Some printers require expensive thermally sensitive paper. Among the non-impact technologies are the ink jet and laser xerography.

3.3 SYSTEMS

The spectrum of over-all system organizations is extensive, but three typical organizations are prominent: stand-alone, shared-logic, and general-purpose.

The stand-alone system incorporates a single work station with keyboard and display, a microcomputer with one or two diskettes, and a printer, usually a "daisy-wheel" impact printer. Selling for less than $15,000, the system is self-contained and does the job, but has considerable idle capacity. A single user can usually not keep a fifty character per second printer busy, and certainly cannot keep the computer busy.

The shared-logic system can be configured with several work stations, more than one printer (not necessarily identical), and a single microcomputer or minicomputer with diskettes and perhaps a system disk. More work can be accomplished per dollar than on a stand-alone system, but the investment can be substantially larger and the system must be shared.

The general-purpose system is an interactive computer utility, running on a large, fast computer accessed by remote terminals and offering a multiplicity of services, of which document preparation is only one. The power of the editing and formatting programs may be greater than for either of the dedicated systems previously characterized, and it is possible that a wider selection of output devices is available. The machine-readable copies of the documents are stored centrally, rather than at the user's location. Being a general-purpose system, it may or may not be easy to use for the specific application desired. Economies of scale, which were one motivation for the establishment of computer utilities, are less manifest now than they

were a decade ago. The economics of using such a system are difficult to characterize in general, because they are highly dependent on computer center pricing policies.

Rather than present a detailed analysis of the systems and devices that are available locally, I refer the reader to the excellent recent survey by Ragland [4].

3.4 COMMUNICATION FACILITIES

A given document may need to be edited by, or assembled from pieces written by, users of two or more different systems. One may be a university's centralized system and another a stand-alone, or systems of different vendors may be involved. The minimum communication requirement is an interchange standard for machine encoding of text. Programs to convert documents between the standard encoding and that of any given system must then be developed.

Given an interchange standard, direct electronic interconnection of systems greatly increases the speed with which collaboration can be accomplished. More importantly, it permits a single terminal to serve both for document preparation and for other uses, such as data-base interrogation or computer programming. Moreover, it also provides a basis upon which to build eventually a system for electronic mail. Another use of communication links is to permit the user to produce output on a device that is not part of his own system.

4 DISCUSSION AND RECOMMENDATIONS

4.1 RESEARCH

* The opportunities for, and importance of, academic research into the organizational, behavioral, economic, and technological aspects of office automation should be called forcefully to the attention of the Business School, the Computer Science department, and several other academic units.

4.2 IMPLEMENTATION

* For the next five years, the University should concentrate on providing extensive facilities for document preparation, rather than attempt to implement all forms of office automation.

* Multiple small systems offer advantages of availability, accessibility, rapid turnaround, privacy, specificity, and controllability. These are not offset by significant economies of scale due to centralization of office task performance. The University should therefore not establish an office automation service or word processing service modeled upon the existing computation centers.

* Because of widespread availability of a large assortment of suitable commercial document-preparation devices, programs, and systems, the University should not undertake extensive competing development.

* In discussing standardization of facilities, it is useful to distinguish between hard standardization and soft. Hard standardization is the restriction to specified vendors, systems, or configurations. Soft standardization is the negotiation of attractive prices for selected systems and the concentration of support efforts on those systems. The soft-standard systems become much easier to buy and use, but it is still possible for a user to depart from the standard.

* The University should not impose a hard standard for word processing systems. Not only is it probably too late to do so effectively; with decentralized, independent systems there is no technical need.

* The preceding recommendation notwithstanding, the University should nevertheless hard-standardize on typesetters. Reasons include the much smaller number needed than of work stations, word processing (WP) computers, or printers; the high unit cost; and the complexity of interfacing an arbitrary WP system to an arbitrary typesetter. The standard may well have to be the de facto standard defined by what we already have.

* Two or three of the commercially available systems are clearly superior to the other 20 or so. The Computation Center should determine their suitability for widespread campus use. The University should then support the negotiation of favorable State Contract prices for one or two technically attractive systems, perhaps with different balances of functions. These would be soft-standard systems.

* The Computation Center should remain current both in the state of the art and in evaluating commercially available document-preparation systems. It should prepare the necessary conversion programs and acquire the interfaces only for the soft-standard systems. It should also offer advice to organizations planning equipment acquisition.

* As a member of Harvard's Board of Overseers is reported to have once said, it is difficult to distinguish between what should be overseen and what should be overlooked. Because of the tremendous impact that office automation can and should have on the University, I recommend the creation of some mechanism for oversight and advice. Although these functions could be assigned to the Provost's Computer Advisory Committee, the admixture of non-computer issues suggests the establishment of a parallel committee. This group should formulate policy. For technical advice it can either establish technical panels as appropriate or consult the Computation Center.

* Because of the advantages of not straying too far from the soft-standard systems, and because of the exposure to financial loss due to ill-conceived systems, the acquisition of document preparation systems should require committee approval. An exception should be made for those below a certain cost or size, probably simply for all stand-alone systems.

4.3 SERVICE-ORIENTED USES

* Administrative managers throughout the University should be informed of the current status and future potential of service-oriented office automation. The Printing and Duplicating Department has already taken some initiative here.

* Equipment selection, acquisition, and operation should be the responsibility of the using organization. They should be preceded by a system study carried out either by, or with the assistance of, the Administrative Data Processing (ADP) establishment. No organization should expect to be able to use any component of an office automation system as a terminal connected to ADP facilities without ADP's prior approval.

4.4 PRINCIPAL-SUPPORT USES

* All faculty members and administrators in the University should be informed of the current status and future potential of principal-support office automation.

* Many individual users or units will not have enough volume of work to justify the acquisition of a local system. For them, for persons who already use computers for other purposes, and for those with special needs, a general-purpose document-preparation system will continue to be necessary. The Computation Center should continue to support SCRIPT for this purpose, and attempt to convert FORMAT and TEXT360 users either to SCRIPT or to local systems.

4.5 JURISDICTION

* The division of responsibility between the Computation Center and ADP should be re-examined with respect to document-preparation systems. Although there is no indication that the current division is causing any problems, there is a potential for unnecessary duplication of effort. The primary functions are maintaining currency, assessing client needs, providing hardware and software interfaces, and offering a general service. It is not clear that any of these must be done by two agents, except that the two existing sets of clients may have different sets of needs. Nor is it clear that the division into the existing customer spheres makes sense for the document-preparation application. Perhaps a division according to service-oriented v. principal-support should be defined and maintained.

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