Appendixes

Appendix A

The Technology of Office Automation

Business is now faced with the problem of controlling 400 billion documents, a number that is increasing at the rate of 72 billion per year. [1] Fortunately, technology is providing the means of electronically storing billions of characters on a single device and moving data at the rate of millions of characters per second. This appendix describes the technologies that are in use in offices, those that may be applied in offices during the remainder of this century, and how they may affect office operations.

Information is ephemeral. It must be available when and where it is needed; too late, it maybe useless. The goal in applying information technology is to deliver information to the end user on time and at the lowest possible cost. Information technology eliminates distance as a significant factor in determining the degree of operational control that managers can exert over operations. It reduces the time required to analyze large volumes of data and makes the resulting information available to those who need it for decisionmaking.

Overview of Appendix

This appendix describes the technologies for information processing and telecommunication in the office. First, a taxonomy of the functions of the office is presented, followed by a description of relationships between the functions and the technologies that are now available or could be available in the future. Following that is a more detailed description of the technologies and the options for employing them.

A Systemic View of the Office

The following functions comprise the set of major office activities:

- data gathering,
- data organization and storage,
- data access and retrieval,
- data processing, and
- communication of results.

[1] C. E White, (' " USTA and AT&T, "*Telecommunications*, April 1985, p. 44.

Data Gathering

Information flows into an office from the internal accounting systems of the organization, customers and prospective customers, government agencies, suppliers, trade groups, and other sources. Intraorganizational data flows constitute a significant portion of the total, Data, once received, must be put into a form suitable for processing, Some has to be transcribed from one medium to another. For example, an order that is received by telephone has to be recorded on an order form. On the other hand, automatic readers in supermarkets capture all the data needed for inventory control as a by-product of the checkout procedure.

Traditionally, the process of transcribing data from one medium to another has constituted a significant portion of the work. I.arge numbers of people worked at typewriters transcribing manuscript and at keypunch machines transcribing information from documents to punched cards. Modern technology is reducing the need for transcription. Professionals now create text that clericals edit and format rather than transcribe. Scanners are included in materials-handling systems to capture data in a form processable by machine.

Data Organization and Storage

Data is useful only if it is organized in a way that makes it identifiable and accessible. Offices have used multipart forms and files housed in cabinets for organizing and storing data. Modern technologies for data storage and organization range from large-scale computers that are capable of handling hundreds of millions of records, as in the case of the Social Security Administration, to small data bases containing a few dozen records that are stored on personal computers. Copying machines reduce the need for multipart forms because additional copies can be made on demand. Telecommunication lets responsibility for organizing and storing data be assigned to those responsible for gathering it. Or all of an organization's data can be gathered in one central location. In either case, all who require access can have it immediately regardless of their physical location,

A shared database reduces the problems of keeping multiple copies of data synchronized. But not all data in an office is meant to be shared. Much

consists of working documents useful only to specific individuals.

Data Access and Retrieval

The third function provided by an office is data access and retrieval. Implicit in this function is making all who may need data aware of its existence and denying access to it by others. In a paper based office, one of the means of assuring awareness of data is to provide potential users with "information" copies of documents. Others who need data must then seek out one of the existing copies and its accessibility to those not authorized to have it is implicitly limited. On the other hand, errors in data are often discovered after documents have been distributed, and corrective information has to be sent to all who have copies so that all are operating from a common base of information. This goal is difficult to attain.

Paper-based files may be less than satisfactory because of the time that it takes to move physical documents from point to point. Advanced technologies do not constrain the accessibility of data to those in a specific geographic area and thus reduce some of the limits on office operations.

It is most efficient to access only those data of interest. In the past, the user had to obtain one or more documents and sort through them for specific data of interest. With the aid of modern technology, the user can identify and retrieve specific data elements that are needed.

Data Processing

The tools for data analysis range from hand-drawn graphs depicting relationships between and among data elements through programs run on the most powerful computers. Nonnumeric data is assembled in tabular formats for study and analysis.

The speed at which humans can process data is limited regardless of whether they are performing numerical calculations, preparing charts and tables, or creating text. It is unreasonable to expect an individual to even attempt some computations. But modern information technology provides powerful tools, ranging from systems that will retrieve and order data to user specifications, to those that routinely prepare reports representing thousands of individual data items. The trend is to reduce the need for professional data processing personnel by providing users with easy to use tools having great analytical power.

In addition to automating traditional data reduction and reporting tasks, modern technology puts new capabilities in the hands of users. Word processors make it easy to alter text and combine or refine documents. Computer-based models can be used to explore the consequences of decision alternatives. These range in complexity from comparatively simple spread sheets to econometric and process simulation models that involve the interaction of hundreds of variables. Decision-support systems can provide insight into the consistency or interaction of judgments made by the decisionmaker.

Experience over the last 30 years shows that users constantly find new and previously unforeseen ways to employ this technology effectively. As the number of users has increased, the technology has evolved to require decreasing degrees of technical sophistication from the user. Innovative applications will thus continue to emerge.

Communication of the Results

Another function of an office is the delivery of information. Traditionally, it has been delivered either orally or in hard copy. Preparation of hard copy requires considerable effort, and transporting it requires time. Orally transmitted information is ephemeral and difficult to capture; transcription is required if an enduring record is to be created.

Modern technology lets the user specify the format in which information is delivered. It can be presented for viewing on a display screen but can be easily replicated. Telecommunication has largely neutralized distance as a factor. Many users can work from a common database eliminating the problem of inconsistent data.

Users and Providers

The trend in applications of advanced technology in the office is toward direct involvement of the user with minimal technical training. The technologies to support these systems comprise two relatively distinct classes. The first consists of centralized data processing equipment that is used to prepare printed reports as well as provide for direct user interaction through terminal devices. The second includes a variety of stand alone devices, microcomputers and word processors that are under the direct control of the end users.

The user seeks a functional capability rather than a specific technology. From this perspective, the terminal tied to a central computing facility can be the functional equivalent of a personal computer. However, from the systems point of view of managing the information resources of an organization, the alternative technologies can have quite different implications. For example, in an office served by a centralized facility, both the reporting needs of the organization and the needs of users for selective access can be supported from a common, shared database. On the other hand, coordinating the activities of users of personal computers who each define and structure data resources differently, may present a considerable problem for management.

Complicating this problem is the fact that the technology is not neatly divided into centralized processors and individual workstations. There are hybrids of these technologies. Microcomputers can be linked to central facilities to retrieve data that can then be processed at the user's location, Alternatively, networks of microcomputers permit the sharing and interchange of information. Thus, one of the effects of the emerging technologies is that the functional characteristics of an office system can be defined almost independently of the technologies used to implement those functions. Furthermore, while the end product of a system may be achieved through alternative means, the internal structure of a system can have significant implications for the operations of an organization, its employees, and its management,

Technology consists of tools and the knowledge of how to use them. Computers and telecommunication networks are virtually valueless to those who do not have a clear understanding of how they fit into the office environment and the benefits that can be derived from them. Systems put in place without such understanding have often failed to meet the needs of users. These failures represent a waste of significant resources and, in many cases, result in the creation of barriers to future introductions of technology.

Equipment Providers

The providers of technologies for the office come from three distinct heritages. First, there are the suppliers of the kinds of equipment that have been in offices for decades—typewriters, calculators, copying machines, etc. They have traditionally assumed a comparatively rigid division of tasks among office workers. Secretaries type; professionals use paper and pencil. They are accustomed to selling to office managers who buy equipment as though it were standardized, like paper clips and forms.

Computer manufacturers comprise the second class of equipment suppliers. They are most comfortable dealing with professional technicians and have had little contact with other office workers. While programmers and analysts were interposed between the computers and the end users, sellers of computer systems did not find it necessary to structure their products to be understandable by nontechnical people. Technicians were assumed to know the strengths and limitations of the equipment and to take the steps necessary to ensure its operability and the integrity of the work it supported. Data processors, for example, know the importance of creating backup copies of data; office managers often do not.

The third group of providers of technology to the office are telecommunication specialists, Their traditional role was to place telephones where needed and keep them in repair. Organizations with significant communication requirements worked with the providers of telephone service to establish private networks when such steps were economically justified. Data communication facilities were generally separate from voice services. Additional circuits were obtained for facsimile and video transmission as required.

The divestiture by AT&T of its operating companies and the emergence of a variety of competitors has complicated the job of the telecommunications manager. There has also been a marked increase in data traffic and in requirements that voice, data, and other traffic share telecommunication facilities. This has required that telecommunication mangers become heavily involved in the design, development, and operation of information processing systems. They must now work closely with technologies that are often unfamiliar,

In the past, the office manager, telecommunication manager, and data processing manager have been able to operate more or less independently. Each had a constituency of users able to maintain a marked level of distinction between the three classes of support services. Now there is a need for greater interaction, a need that will increase with time.

Equipment and service providers from each of the three sectors have moved into areas served by the others. Computer manufacturers offer word processing systems; some word processors now have the same capabilities as small to midrange computer systems. All offer telecommunications equipment, and telecommunication providers are

beginning to offer processing services. From the point of view of the user, this competition is probably beneficial, but each kind of provider may have difficulty in understanding the nuances of new markets. For exampIe, the firm that has been successful in providing word processing equipment may not grasp all of the operational ramifications of expanding its line to include capabilities normally associated with data processing.

The Merger of Telecommunication and Information Processing

In 1956, AT&T, in a consent decree, agreed that it would not build data processing machines for sale on the open market. In the mid-1970s, it offered for sale a terminal that had some processing capabilities; and the question of whether that violated the 1956 consent decree led to an inquiry by the Federal Communications Commission, called Computer Enquiry II. One of the purposes of this proceeding was to establish a line of demarcation between telecommunication and data processing equipment and services. The final report sidestepped the issue; it failed to differentiate between telecommunication and data processing, but defined a set of basic telephone services that could be offered by AT&T and enhanced services that could be offered through an arm's length subsidiary. This put to rest the assertion that telecommunication and data processing services and equipment could be differentiated. The interaction of the two technologies has changed the fundamental character of both.

One result is the ability to deliver information processing services directly to the end user through a variety of system configurations, Terminals can be connected to a central processing facility through either the conventional switched telephone network (dial-up service) or through a dedicated network "owned"[2] by the user organization. In this configuration, all processing takes place at the central site. A variation of this substitutes computers for the terminals so that some of the processing is done at the user location and some at the central location.

[2]An "owned" network, more often than not, will make use of circuits that are leased from a common carrier and dedicated for the use of the lessee. In some cases, organizations *wilf* build and operate their own telecommunication facilities that may include such diverse components as ground stations for use with satellite transponders, microwave towers, and fiber-optic cable. The balance between leased and owned facilities is struck by each organization to be consistent with the cost schedules for the alternatives and other, noneconomic consideration (e.g., the organization makes the judgment that it does not want the problem of operating a satellite Earth station).

Alternatively, a communication network may include only small computers under the direct control of end users, using the network facilities to access data wherever it is located. Processing functions are controlled by the end users with, possibly, some coordination activities being the responsibility of a central data processing function.

Telecommunication facilities can be designed so that they perform processing functions as well as provide a conduit for moving information. For example, the network can convert codes used by one type of equipment to a format usable by another so that the two can exchange data. Network switches can route data between locations on the basis of address information that constitutes part of the message, They can also combine information from a number of incoming messages into another that is sent to a specified destination,

Advanced telecommunication equipment available for offices can select the lowest cost alternative for routing each call, with some calls routed over one of the public long distance services and others over the organization's private network. Some equipment can combine voice with data traffic on a common internal network. Computers that comprise an office local area network function as the switches for the network while at the same time providing its data processing capabilities.

Broad Trends in Telecommunication and Information Processing Technologies

The foundation of new office technologies is the integrated circuit. The equivalent of hundreds of thousands of transistors can be built on a silicon wafer with an area of a fraction of an inch. Although many argue that the limits of silicon-based chip technology are being approached, the component density of chips can continue to increase at least in the short run. Alternative technologies are likely to become a factor in the market in the 1990s. Gallium arsenide, for example, offers potential advantages in speed relative to silicon oxide technology, and may provide a foundation for new materials that are more optimal than silicon for microelectronic circuits. Chips that have circuit components distributed in three dimensions rather than two are likely to be on the market in the relatively near term, with improved performance to price ratios relative to those now available.

Increasing the number of components that can be built into a single integrated circuit, by reducing the physical size of a circuit increases its speed

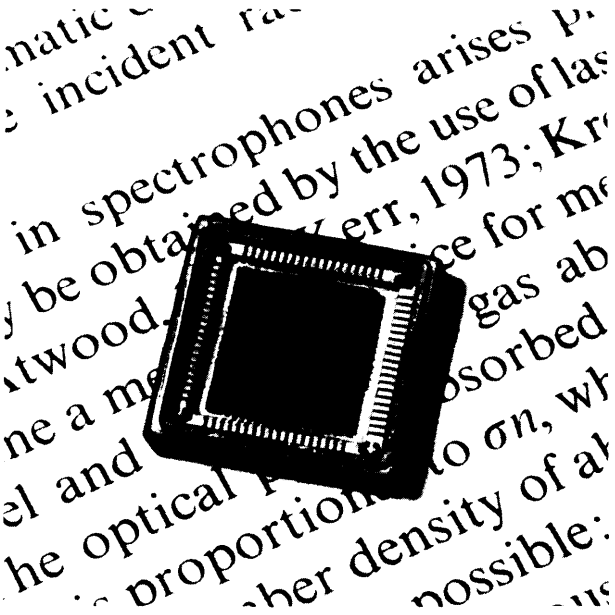

Photo credit Bell Labs

One of the continuing trends over the last several decades has been the reduction in the size of the microprocessor. This shows a very large-scale integrated memory management chip.

and hence the computational power of devices. As production volumes grow, the prices of chips fall. Generally, this is translated into increased performance to cost ratios for equipment. Fewer chips are required for end-user devices, again lowering the cost to build them and reducing the cost of maintenance.

Thus, the cost of office equipment will continue to decrease, but they will not go to zero; the bottoming of prices is likely in the next few years. Beyond that, the benefits of technological improvements are likely to be in the form of improved performance at relatively stable prices.[3]

Optics[4] may provide an alternative to electronics as the basis for the operations of computing and communication devices. Already, fiber optic conductors are being deployed widely in telecommunication networks. They offer advantages over copper wire, microwave and coaxial cable technologies in the form of reduced physical size, elimination of interference between messages carried over conductors in a common cable, and increased security (because fiber optic circuits are more difficult to tap). The use of optical devices in switching and storage devices is still a subject of basic research and is not likely to be a significant factor in the market in the near term. Such devices, if perfected, could offer advantages over microelectronics in that they could be less susceptible to electrical and magnetic fields generated by office machinery, In addition, since they would not emit electromagnetic radiation that can be detected and decoded, they would provide more data security.

Because the prices of computer components are expected to continue to decrease, it is possible that functions now performed by software maybe built into the hardware. For example, one of the most popular spread-sheet programs is now built into a portable lap-top computer and operates as if it had been loaded as a diskette. On larger systems, complex programs such as language processors, database systems and communication processors may be included in machine hardware.

A logical extension of this concept is the development of limited function machines dedicated to a specific task or a narrowly defined set of related tasks. Familiar examples of dedicated devices include stand-alone word processors and hand-held calculators.

But running counter to the trend of building increased capabilities into the hardware is the recent emergence of reduced instruction set computers (RISC).[5] These computers have 50 or so instructions in their repertoire rather than the well over 100 found in conventional machines. By processing a few types of instructions very quickly, RISCs can in theory outperform those with more complex instruction sets. A greater burden is placed on software designers to optimize their designs in light of the attributes of the machines. RISCs have gained some degree of commercial acceptance, because tests have shown that in some applications they can outperform conventional computers. However, all of the reasons for this improved performance are not fully understood. Changes in conventional computers that would use some of the coding techniques and architectural features found in RISCs may yield significant improvements in their performance.

[3] This statement has to be taken with a grain of salt. In the early 1970s a calculator with four functions, memory, and square root sold for something over $100. In the last year, a major manufacturer of electronic equipment gave away such a calculator as part of a promotional campaign. This adds some credibility to the argument that equipment could become a "throw-away provided at no cost to the user who buys some package of services.

[4] Computers and communication devices can be built of components that manipulate light waves just as microelectronic devices and conventional communication network components manipulate electrical currents.

[5] "RISCs—Reduced Instruction-Set Computers—Make Leap," *Systems and Software,* December 1984, pp. 81 ff.

The users of office automation are less interested in the nuances of the technologies used to implement systems than they are in the functional characteristics of those systems. Just as most automobiles are bought to provide transportation, not as a hobby for the amateur mechanic, most users of office systems want specific tasks performed and care little about the inner workings of the computer. Designs of newer office systems are generally moving in the direction of insulating the user from the specifics of the underlying technologies.

Many of the application programs now commonly used in offices are accompanied by thick jargon-laden manuals purporting to inform the user how to obtain the promised benefits from a package. Some of the newer systems, on the other hand, are self explanatory and are accompanied by minimal amounts of paper documents. In the long run, information processing systems will, like the automobile, evolve to the point where the user can operate them with only minimal understanding of their underlying technical structure.

As the capabilities of applications and hence their complexity increase, total development costs for office systems have tended to rise. However, emphasis is moving from systems tailored to meet needs of specific organizations to those having sufficient generality to meet diverse needs. Because these generalized capabilities can be sold in volume and development costs can be spread over large user communities, their price should fall.

These tendencies toward lower priced microelectronic circuitry and systems designed to minimize requirement for technical expertise, together with the merger of telecommunication and information processing imply:

- a broad and increasing choice among technological options for accomplishing information-handling objectives;
- a strong movement toward distributed data access and data handling, usually superimposed on rather than superseding centralized automatic data processing;
- more and more capture of data at the point of origin, with decreasing need for repeat keyboarding and centralized data entry; and
- unlimited capability for communication, between devices, between organizations, and between locations.

Managers will have the freedom to define organizational policies and objectives with more alternatives for implementing them. This creates a greater need for analysis to make good selections. Both for the designer and user of office systems there may have to be a significant rethinking of the way an office operates if the potential benefits of the technologies are to be realized.

Trends in Specific Technologies

From a functional perspective, information processing and telecommunication technologies can be grouped into five broad categories: 1) processors, 2) input technologies, 3) storage, 4) communication, and 5) software. Trends in each of these areas will be discussed in the sections that follow.

Processors

The Microcomputer.–The microcomputer that is becoming ubiquitous in many offices is the smallest of computers, followed by, in increasing order of size, minicomputers, mainframes and supercomputers. These constitute a continuum of capabilities, with considerable overlaps at the boundaries between classes. A large microcomputer may have roughly the same capacity as a small minicomputer.

Conceptually, given enough time, any computer can perform all of the computational tasks that can be envisioned. They all operate on the same principles. Realistically, however, large computers are necessary to perform tasks that require the manipulation of large databases and extensive computations. A large computer can also simultaneously support many small tasks each of which could be handled alone by a smaller computer. Thus, one alternative for offices is to provide all processing support from one or more large computers with many terminals.

Generally, microcomputers are designed to be used by a single individual and to perform one task at a time. In 1985, a microcomputer for use in the office can be purchased without a printer for $1,500 to $3,500. A printer, depending on the quality of the output desired, can be bought for an additional $300 to $2,000.

Microcomputers capable of supporting multiple tasks and several users simultaneously are coming on the market. Programs that allow two or more programs to be active simultaneously are available. Networking microcomputers has become possible using programs and hardware components purchased off the shelf. A variety of generalized spread-sheet, word processing, accounting and utility packages are available from both computer manufacturers and third-party suppliers. Thus, office workers will have under their direct control computer power that until very recently was found

only in corporate data centers. At present they need to develop the expertise to modify existing procedures and design new ones to take full advantage of the available capabilities. But this could lead to a significant redistribution of function and power between data processing groups and end users.

Stand-Alone Word Processors. -Stand-alone word processors are microcomputers whose hardware and software configuration has been optimized for word processing. As other software, such as data management and spreadsheet programs, are made available for them, the dedicated word processor becomes indistinguishable from a general purpose microcomputer. But as yet, with a few exceptions, the manufacturers of word processors have not significantly broadened the application packages for these machines.

Electronic Typewriters. –Electronic typewriters have limited word processing capabilities built into the circuitry of the machine. The repertoire of the machine is fixed and the purchaser does not have the option of either expanding or modifying the capabilities.

Integrated Office Workstations.–Integrated office workstations are now being developed that combine a personal computer, telephone, and modem in one desk-top device, providing a voice, text, and data terminal that can communicate with other computers. First generation versions are now coming on the market, Whether this market will develop probably depends on how integrated workstations compare in price with enhanced versions of conventional personal computers. The end that is sought through integrated workstations is usually to allow files and documents in preparation to be shared and passed between coworkers, or between professionals and support personnel. However, some designers speak of the need for a "multifunctional electronic office automation system compact enough to fit into a relatively small office area" and including in one unit an electronic typewriter, personal computer, word processor, laser printer, copier, electronic mailer, filer, telephone, modem, and facsimile machine.[6] Many users are likely to create their own integrated workstations through add-ens, modifications, and software packages. Ultimately integration will come about in a different way; it will result from the fact that almost all information will routinely be available in digitized form.

Minicomputers. -Minicomputers trace their lineage to the requirements of scientists for low cost computers for laboratories. They were the earliest means of providing end-user computing. However, they were delivered with little if any software, and it was the responsibility of the users to do whatever was required to get useful work out of them.

Minicomputers have, however, evolved to achieve many of the characteristics of mainframes. They support large amounts of data storage and permit multiple users simultaneous access. Often, minicomputer installations are run by a data processing manager supported by a small group of programmers, The principle advantage of minicomputers is that they offer the midsize organization considerable power at a cost significantly below that of a mainframe. Generalized applications for accounting, inventory control, and other applications are available to avoid the cost of developing custom software. The equipment is self diagnosing so that much of the required maintenance can be handled by replacing failed components from an inventory of spares.

Most minicomputers offer office-oriented software such as word processing and can support networks of terminals in addition to supporting conventional data processing services. Some are in direct competition with the shared-logic' systems sold by the office machine manufacturers. Some firms that entered the market as office machine providers have expanded their product lines to include shared-logic systems with a significant range of data processing capabilities. Some of these systems fit at the top of the range of microcomputers while others can be classed with minicomputers, However, all computers that offer users the opportunity to share resources, whether they are labeled shared-logic word processors or general purpose minicomputers, create new problems for managers who must allocate the shared resources among competing demands and at the same time protect the integrity of the organization's data.[8]

Mainframe or Large-Scale Computers.–Mainframe or large-scale computers are normally associated with data centers and/or data processing departments. They are capable of supporting a large number of users simultaneously, providing them access to large databases and libraries of com-

[6] John Vacca, "Key to Automated Systems Lies in Miniaturization, " *The Office*, February 1985, p. 66.

[7] A shared-logic word processor uses a central computer to support a number of word-processing terminals. Many are, in reality, minicomputers that are limited only by the software that is available to support them.

[8] "The problems of resource allocation and system integrity exist in the microcomputer/stand-alone word processor environment as well. But, they change in substance and magnitude in shared resource systems.

puter programs. Although these computers are capable of supporting routine office operations such as word processing and small database systems, they are not much used for such limited applications.

Where processing capabilities are distributed among many devices in an information processing network, large-scale computers may function primarily as repositories for data and programs that are to be shared throughout the organization. Data and programs can then be communicated from the mainframe to a small computer for processing. Drawing from databases stored on mainframe computers ensures that all users will have a common base of information, but new problems of coordinating data input and updating activities are created. Generally, office work does not challenge the computational capabilities of mainframe computers, but as applications that include voice and pattern recognition become available, greater processing capabilities may be required.

Supercomputers. -Supercomputers are very high performance machines with capabilities approaching 100 million instructions per second. These systems are being delivered to universities, government agencies, and a few private companies who have particularly intense computational requirements. Machines in this class as yet so far exceed the requirements of the office that they are not found in conventional data processing centers.

The laws of physics limit the computational speeds of conventional computers. Therefore, the supercomputers are structured to perform many operations in parallel rather than sequentially. Problems must be described in terms that make it possible to take advantage of parallel processing. Descriptions of office operations with this in mind have not been accomplished. Potential office applications for supercomputers that come immediately to mind include the processing of voice input by pattern recognition.

The range of processor capabilities now available more than covers the range of office needs. Moreover, technological developments are likely to proceed at a pace sufficiently rapid to stay ahead of the ability of office applications to challenge them. More importantly, users of office automation will be able to acquire processing capabilities appropriate to their needs and as those needs increase, expand those capabilities incrementally. Even the smallest users are likely to be able to enjoy the benefits of the technologies.

Data Capture Devices

The Keyboard.-The keyboard is likely to remain the dominant data input device at least through the remainder of this century, augmented by the mouse, wand, touchscreen and other devices for specialized tasks.[9] But this assumption, while it is perhaps the most obvious one, can certainly be questioned. In fact, the most important question about office automation, from the standpoint of effects on future employment, may well be the outlook for input technology, especially optical character recognition.

OCR.–State-of-the-art optical character recognition (OCR) devices can now read typed, printed, and some hand-printed material in a limited number of fonts.[10] *Some* OCR equipment can automatically feed about 75 pages into the reading device; recognize characters in 23 different fonts, whether in 10 or 12 pitch or proportionately spaced; read the material into the computer's memory at the rate of one page every 15 seconds; and format the text. The claimed error rate is one per 300,000 characters. Such systems are now being offered for prices under $12,000.

OCR can already input a typed document into word processing 40 to 50 times faster than a typist can rekey board it.[11] It can capture data from order forms, application blanks, ticket stubs, etc. Publishers are beginning to instruct authors to use specific fonts on their typewriters or computer printers to avoid the need for retyping. Banks are now introducing Automatic Teller Machines that will accept, read, and cash a check.

Within a decade OCR may be able to read all standard fonts, and have some capability to recognize, isolate, and read or copy specific bits of information. It will be much more difficult to de-

[9]The mouse is a palm-sized device, used with some computers, that when moved over a table surface positions a cross-hair curser on the VDT, using mechanical, mechanical analog, opto-mechanical, optical, and hybrid sensors. Touch-sensitive screens allow direct positioning of a cursor on a screen through touch; one approach surrounds the screen with infrared light-emitting diodes and sensors, the other places a resistive or capacitative layer on the screen that acts as a pressure-sensitive switch. While these kinds of input are swifter than keyboarding instructions, they have limited uses in most offices.

[10]With OCR, a page is scanned with light. White, or background, portions reflect the light and inked portions absorb it. The resulting image is recognized, digitalized, and fed into a circuit. There are two approaches to character recognition-matrix matching (the character is gridded and compared to templates) and shape analysis (features of the character are abstracted and used for identification). The latter is most useful where characters are less predictable, as with handwriting.

[11]E. Polizzano, *The Office*, February 1985, p. 75.

velop OCR devices that can read handwritten material except in very limited, constrained form.

During this early stage of office automation, some offices are using OCR to deal with the problem of incompatibility of equipment. Advanced OCR systems can take the hard copy printout from one computer or word processor and forward it into incompatible systems without rekey boarding. *[2] In another current application, time-sensitive forms for reporting hours worked are marked by the worker with a felt tip pen, collected or "batched" and fed into a scanner, which checks them for length and completeness, flags errors, accepts only data thus checked, and stores it for further processing. OCR systems are now being used for processing subscriptions, proxy cards, surveys, orders, sales call reports, piecework payroll data, utility meter-reading, tax bills, and tax payments.

OCR print elements are readily available now for office printers. If OCR reading capability becomes a standard component or add-on to standard office computers, printed and typed documents coming from outside the organization can be entered without rekey boarding. The possibility of transferring information from one medium to another (e. g., from a printed page to a computerized data bank) without a second keyboarding, or capturing data at the point of origin (directly from a ticket agent in the field, from a customer's order, or from business correspondence) rather than sending it to the receiver's central ADP unit could greatly reduce the volume of secondary data entry that is now done. If OCR can be improved so that it can read handwriting, the potential for labor-saving is even greater.

Optical character recognition technology has not been widely introduced into offices in the past because of relatively poor performance and high costs. Software has been a particular bottleneck. But performance is now rapidly improving.

In principle, combining OCR with facsimile technology (FAX, or electronic transmission of images from hard copy to hard copy) is attractive since OCR involves substantial data compression. This would allow FAX transmission to consist of intermixed ASCII code and digitized image bits. For this purpose, OCR will have to handle graphics, which it cannot do yet,

With the present rate of OCR development, by the end of this decade today's volume of manual data entry could be reduced by a significant amount, with a much greater reduction by the end of the century. The amount of data that is collected and used is of course steadily increasing, and likely to increase still more if the cost of data-handling decreases. Nevertheless, since more and more of the data will be digitized from the beginning, or can be captured with only one keyboarding at one point early in its processing, the amount of manual data entry to be done is likely to decline steadily.

OCR is a technology for translating hard copy into machine readable form. But as time goes by more and more data will be digitized from the beginning, and be translated into hard copy only when a paper version is needed.

Machines can read a variety of formats to capture information. Optical wands can read bar codes and alphanumeric characters printed in suitable formats. The scanner used in supermarket checkout lines and wand readers used in retail stores to gather inventory data are examples, Mark sense document readers have been used in a wide variety of applications for years. In some applications, the IRS Form 1040 EZ, for example, computers can read manually printed characters. Cash registers and a variety of machines can be connected to computers so that data capture becomes a by-product of operations such as recording the details of a sale.

Speech Recognition Input Technology .–Speech Recognition Input Technology (SR) could in theory mean that data need not be keyboarded even once. This technology is however likely to develop much more slowly than OCR. 13 State-of-the-art, commercially available SR technology can recognize from several hundred to 5,000 different words, spoken by a single individual for whom the device has been programmed. However, for most SR systems the words must be spoken clearly and with a pause between them, and there is still an unacceptably high error rate. Vocabularies are still too limited to be very useful.

Speech recognition has been used in some environments with limited success. For example, baggage clerks at airports speak flight numbers for routing baggage through automated baggage handling equipment.

[2] Polizzano, Ibid., p 75.

[1] 'Speech creates variations in air pressure that are transduced into electrical signals that are then broken down into their component frequencies. In the processing system, words have to be time-aligned to compensate for tbe variations in their length when they are spoken. When a machine is "trained" for one speaker, he or she creates word templates to which the SR system matches words. In another approach the system extracts consonant and vowel features *and recognizes in*-variant relationships among them. This is aimed at allowing the system to accept voice input from any speaker, but at present it is difficult to reduce the error rate below 10 percent. Continuous speech recognition is also complicated by the fact that the acoustic properties of a word are modified by adjacent words and by its place in a sentence.

IBM and Kurzweil have demonstrated voice--activated typewriters that may represent steps on the road to viable machines for use in the office. It is conceivable that a commercially viable voice--activated typewriter will be marketed by the middle of the 1990s.

A few SR developers are now claiming to offer continuous speech recognition-that is, recognition of speech at a normal pace and rhythm, without artificial pauses; and the ability to accept voice signals from people for whom the equipment is not specially programmed. A vendor recently announced a possible breakthrough in SR technology-a digital filter chip integrated circuit that, when used in sets, is said to allow something approaching the sound processing capability of the human ear. It is to be combined eventually with artificial intelligence techniques to allow software to deal with such peculiarities of the English language as homophones (words that sound alike, such as "to," "two," and "too')[14]

If SR is improved so that it can recognize up to 10,000 or 15,000 words of continuous speech, from multiple speakers, it can be used to put data into a computer for memory or processing, thus automating many office functions—taking dictation for correspondence, dictating rough drafts of documents, accepting commands to the computer, recording observations as a worker reports on other activities, keeping minutes of meetings, and perhaps most importantly accepting customer's orders, complaints, or inquiries over a telephone. If it can eventually be combined with speech synthesis output technology, the computer might provide many basic customer services without human intervention or with very little human backup—for example, taking airplane or theatre reservations over the telephone.

Even by more conservative expectations, SR could make some of today's data-entry work unnecessary by the end of this decade. It is conceivable that OCR and SR together could displace a significant amount of data keyboarding during the 1990s.

A related technology, voice identification, may have some special uses in offices; for example, providing security for facilities or computers by identification of authorized users.

In general, technology will diminish the distinction between information that is machine processible and that which is not. The number of cases will increase where users will be willing to accept information displayed on a screen in lieu of having it printed on paper. Many people will find that using a computer keyboard or alternative data-entry device gives them more flexibility and is preferable to the traditional pad and pencil.

Storage

Conventional Storage Media. -From the time of the first computers, there was a very strong dichotomy between machine processable data and data that could be easily read and used by people. Punched cards, magnetic tape and disks and punched paper tape not readable by people were, and continue to be, the data-storage media. The computers that could read them were not readily accessible to users. This has changed to an extent as terminals and personal computers have become readily available.

Paper is a "people medium. " Together with microfilm it is the primary means of creating a permanent record and a primary way of transferring information between people, and also the primary means used by computers to convey their output to users. Paper and microfilm are not media that have been usable by computers for storing data for further processing.

The media used for storing data should support the delivery of data to the user's location. Therefore, a key element that distinguishes alternative data-storage media is the degree of portability it offers. A large capacity magnetic disk is permanently attached to a computer. If the data is to be transferred to another site, it must be transcribed to another medium. Magnetic tape and portable disks can be shipped without transcription, but are not efficient if only a limited amount of data is to be moved. Punched cards, on the other hand, are very efficient for moving limited amounts of data, especially if it can be put in the standard 80 character format.

Traditional data processing installations have always stored large amounts of data primarily on magnetic disk and tape. These media support databases that contain millions of pages of data. Disks are available in two broad classes. The first, capable of holding hundreds of millions of characters on a single unit, are the so called "hard" disks that are permanently attached to a computer. The large capacity disk with a system that permits the sharing of resources can put immense amounts of data within reach of the users on demand. A single large capacity disk drive can store well *over* half a trillion characters. Even the magnetic disks used with

[14] **Kurweil** Applied Intelligence, Inc.—a description of the new chip, KSC 2408, appeared in *Technology Watch*, vol. 5, Nos. 1&2, November-December 1984; and *Fortune*, Jan. 7, 1985.

microcomputers and the smallest minicomputers have on-line storage capacity that can approach 100 million characters.

The great volume of information that can be stored on one large-capacity disk creates some problems. A large number of people within an organization may need to access the data at one time. Getting access to a specific bit of data maybe slow. If the data is stored on or in a limited number of physical locations, the problem of contending for access will always arise. There may be technological ways to provide multiple access paths to the same surface (whether that be a disk, tape, or other object), but as will be discussed later, optical disks designed for small computers may make it practical to provide multiple copies of databases.

This however creates other problems. With many copies of the database there is no way for an organization, or user, to make sure that all copies are identical, or are properly updated and corrected. This can also raise legal, ethical, and psychological problems—e.g., questions about the ownership of information and willingness to share it. Choices about data-storage mechanisms will be a matter of costs and management priorities.

Floppy disks are generally used with microcomputers and have capacities that range in the hundreds of thousands of characters. These offer the advantages of low cost and high portability; they can even be sent through the mails. Three *sizes* of floppy disks are used with office systems—3.5 inches, 5,25 inches and 8 inches in diameter. The last are most often used with stand-alone word processors, the first and second by microcomputers. The 3.5 inch disk is just entering the market but may become the medium of choice. It is packaged in a hard case that protects it from inadvertent damage, and its capacity of about a half million characters far exceeds 360,000 character capacity of the most popular 5.25 inch floppy disks.

The portability of floppy disks can be in part illusory. Virtually every word processor using eight inch disks uses a disk-storage format that is incompatible with all others. The same is true for 5.25 inch disks that are used on microcomputers supported by the CP/M 80[15] operating system. If data and programs are to be transferred on disks between machines that use incompatible formats, a conversion process is required. There are businesses that specialize in offering conversion services in many major metropolitan areas. On the other hand, floppy disk compatibility does exist among office microcomputers that follow the DOS format used, for example, by the IBM/PC, and this format is becoming an industry standard for office microcomputers.

The storage medium used determines to an extent the degree of control managers have over the data resources. Permanently mounted (fixed) disks, can be reached only through a computer to which access can be tightly controlled. Magnetic tapes are stored in a controllable central facility. The task of controlling access to data stored on floppy disks is much more difficult.

In spite of talk of the paperless office, paper could be widely used as a medium for storing data in some future automated offices. For decades, the punched card has been valuable as a turn-around document, for example, inventory cards and checks printed on punched card that could be machine processed. Today, the punched card has disappeared from many applications. But technology is now available that can read data that is printed in a variety of formats. Packages can be imprinted with a machine readable bar code and credit cards with numbers in a scannable type font. In addition, standard fonts used by typewriters can be read by optical character readers.

Therefore the printed page can be used as an external storage device for data that will be processed by computers, because the cost of converting the printed image to the electrical signals processed by a machine is becoming relatively small. Operationally, however, devices that read printed pages are not likely to replace the magnetic disks and tapes that are used to store data since the character reading devices are much too slow for anything but capturing data inputs for office systems. Processing will continue to be performed using an electrical representation of the data, but much of the data may be captured initially by scanning.

From time-to-time there is heightened interest in the use of microform (microfilm or microfiche) technology in the office. It is often used for storing information where large volumes must be archived for an extended period. Financial institutions routinely microfilm all checks. Computer manufacturers distribute infrequently used documentation on microfiche. There are some systems that facilitate the retrieval of information from microform files by coupling a computer to the reading device. Microform systems have been proposed that would have information recorded as conventional images in one portion and as a machine processable hologram in another.

[15] "An operating system is a program for a computer that performs many of the overhead functions required to manage the machine, Among the services it provides are those needed to move data and programs between external storage and the main memory of the computer for processing.

Optical disk technology may provide a viable means for on-line retrieval and processing of the types of records that would now be stored in a microform retrieval device coupled to a computer. If so, microform may be permanently relegated to the task of preserving large volumes of infrequently accessed records.

Optical Disk Storage.–Optical disk storage can potentially provide 25 times the per-disk capacity of magnetic disks, at one-thirtieth of the cost. The equivalent of 250,000 typed pages can be stored on one disk.[16] A read-only disk already available in the United States carries the equivalent of 100,000 typewritten pages on a 4.7 inch diameter disk. A number of optical disks, making up a very large database, can be stacked and sorted and accessed like platters in a jukebox.

Optical disk storage is still in the development phase, but the development is moving rapidly and reaching the market faster than expected even a year ago. It is likely to have a major effect within this decade. Diode lasers are used for "writing" data on optical disks in digital form. The disks may be "read-only," which means that users cannot change them; or they may be "write-once," meaning that users can record but not wipe clean; or they may be erasable. Read-only disks are useful mostly for archiving.

At least 30 American companies are working on development of optical disks, but it was generally believed until recently that the Japanese held the lead in development of erasables. In March 1985, 3M Corporation announced that it would immediately begin producing (in small quantities) 51.25 inch erasable laser disks that will store the equivalent of 250,000 pages, the capacity of 25 magnetic hard disks of the same size. " They are designed for microcomputers, and will allow data to be moved and changed or erased just as on magnetic disks. This will let personal computers perform many tasks that until now could only be done on a minicomputer or mainframe.

Because optical disks have such a large capacity it becomes reasonable to use them for storing images as well as alphabetic and numerical data. This capability will make it possible to organize, process, and present data more effectively than is possible when image and textual data must be stored separately.

Image Processing.–Image processing capability will be readily available as part of, or an add-on to, small business computers in the near future; it is already available from some vendors. It will allow drawings, photographs, maps, and other forms of graphic information to be scanned, stored, incorporated into databases, copied, or rearranged. It will allow parts of these images to be removed, added to, switched to a new location, or otherwise modified. Image processing has many uses in a general office, such as in presentations and facilities planning, and it will be very important in some specialized offices such as those in the real estate industry, marketing, and advertising. It should be noted that for the unscrupulous, image processing can be a tool for counterfeiting, misrepresentation, and fraud.

Special-Purpose Terminals.–With falling hardware prices, it is reasonable to expect the development of special purpose terminals. Some are already used, for example, to gather inventory data through either a hand held keyboard or an optical wand. Pocket-sized terminals with a key pad and small display screen, that can be easily connected to a telephone, may become available soon.

Portable computers that maintain memories when the power is turned off can be used to gather data to be transferred at a later time to another computer, either directly or over the telephone lines, In this way, a traveler can, while on an airplane, create a document to be transferred to the main office system for further processing and archiving.

Personal Storage Devices. -Machine-readable and updatable data storage devices exist that can be personally carried or attached to an article in transit. Included among these are the familiar credit card magnetic stripe technology[18] and the "smart" card that contains a microprocessor and memory. [19]

[16] In early 1985 a draft of this report said, correctly, that the best commercially available optical disk (read only) stored 1 billion bytes or the equivalent of 40,000 pages. By June that statement was incorrect, This is an example of how rapidly events are moving in this field.
"Brian Dumali, "Here Comes the Erasable Laser Disc, " *Fortune*, Mar. 4, 1985, p. 100.

"The fare card used on the Washington, DC, subway system provides one example of what can be done with magnetic stripe technology. When the card is purchased, the purchase value is recorded on the stripe, Then, whenever the user enters the system, the station of origin is recorded. At the destination, the fare is computed based on the recorded data and the value of the card decremented appropriately. Similar cards could be used to capture and store data for office applications where very low data volumes are involved and the connection of computers by telephone is unwarranted.

[19] A Canadian company has designed a hospital information system around the smart card. When the patient enters the hospital, a card is created. Then the card moves with the patient and as each service and product is dispensed, the memory of the card is updated using a device built into a microcomputer. When the patient is discharged, the data that has been captured during the hospital stay is retrieved and a bill is prepared. It is conceivable that the "smart" card, originally designed for executing financial transactions, could find significant application as a data capture and storage medium in a number of office applications that range from systems for providing security to those that require capturing transaction data.

Communication

In the present context, communication includes all technologies that are used to transmit data between people, people and computers, and computers.

Telecommunication Networks.–The backbone of office telecommunication is the switched telephone network. It was designed to handle voice communication passing between individuals, and still functions primarily in this mode. However, data comprises a growing portion of the traffic.

For many organizations, the switched telephone network consists of two relatively distinct parts. First is the conventional and ubiquitous interorganizational component, the dial telephone service. No operator intervention is required even for many international calls. Credit card calls can be initiated using the 10 key TouchTone[tm], and some pay stations are now being equipped with devices for reading billing information from the magnetic stripe on the back of a credit card.

The repertoire of services available from the switched telephone network will expand over the remainder of the century unless legal or regulatory constraints are imposed. Simple services such as call waiting, call forwarding and three party conferencing are already offered in many areas. Some code conversion services offerings by local operating telephone companies were recently approved that would translate the signals from one type of computer or terminal to a format understandable by another. Such services will be valuable to offices that until now had to provide code translation through their own systems. Not all businesses are prepared to deal with the code conversion problem and the detailed technical questions of interchange.

The future is likely to see such services as voice message storage offered through the switched telephone network. Virtually all telephone traffic, including voice, will be transmitted digitally. Organizations will no longer have to maintain separate networks for voice and data communication. It will also be technologically possible to deliver processing services through the network, including the routing of messages based on their information content. For example, the interchange of financial transactions (now accomplished by financial institutions) could be a service of the switched telephone network, and this could include data processing such as the accumulation and reduction of transaction data and following the enroute status of shipments.

The opportunity for offering an increasingly large variety of telecommunication services through the switched telephone network derives from the fact that much of the switching capacity now in place is provided through computers. Eventually, all switching will be done by computers. Already, much of the traffic between major switching centers is transmitted digitally; and customers are able to subscribe to on-site digital transmission services. They are then able to mix digitized voice and data traffic. Much attention is now being given worldwide to the concept of an integrated service digital network (ISDN) that would make digital transmission of all data, voice, video, and facsimile traffic universally possible over a common network.

For some years, 1ong distance telecommunication services have been offered by competing providers. However, since the divestiture by AT&T of its operating companies in 1984, the choices have become significantly more complex. Organizations now have the option of using either the switched telephone service or operating their own telecommunication networks, Most often, a private network is assembled using circuits and support facilities leased from telecommunication providers, some combination of the local telephone company, and one or more providers of long distance services. However, some organizations choose to build and operate telecommunication networks that include privately owned facilities as well as capacity leased from common carriers. Alternatives include leasing of transponders on satellites, the building of microwave systems and the construction of conventional telephone circuits. One problem is that large users of telecommunication services often find it in their interest to by-pass public utilities, depriving them of significant revenues.

A variety of providers offer business telecommunication services. Third-party operators either build facilities or lease them from another carrier and use them to offer services to those who cannot justify developing private networks. Packet switching is used to obtain the high rates of utilization that are needed to justify third-party networks. Messages are broken into data packets that are individually routed to their destination and reassembled to constitute the original message, Network operators can bill users on the basis of traffic volume rather than time and distance, because the packet switching technique levels the load across the available network facilities rather than allowing it to concentrate on the paths be-

tween points with the highest volumes of traffic flow.

Many localities are wired for cable television, and many of the newer systems are capable of two-way communication. Because television requires a broad channel, cable systems can handle large data volumes. In some areas, such as New York, cable operators find it profitable to make some of their capacity available for transmitting voice and data.

In congested areas, not all telecommunication options are available. For example, in New York City it has become very difficult to build private microwave facilities because buildings often obstruct the proposed path for the signals and facilities already in place cause electromagnetic interference that cannot be neutralized. Routing communication to a central antenna "farm" located in an area relatively free of these obstructions (the teleport concept) provides one alternative for neutralizing this problem. In some cities the cable tunnels beneath the streets are so congested that there is no room to run additional cables. Fiber optic circuits provide potential relief from this problem because they provide substantial increases incapacity in significantly less space than conventional cables.

Mobile Communications.— For local communications, offices also have the option of using mobile telephone services. The most common are the "beeper" services available in many areas. A person is alerted to a call by an audible tone generated in response to a signal sent by the service operator and received by a carried device. Some devices can visually display a message, eliminating the need to telephone the office for information.

Telephones in cars have been available for years, but the technology severely limited the number that could be used within a geographic area. A new technology, cellular radio, has eliminated this limitation on the number of mobile telephones. In addition, the quality of the service with the cellular system is significantly better. Companies requiring constant telephonic communication with people in the field can now have such service at relatively affordable rates. In the future, cellular radio may also provide an alternative for delivering fixed point telecommunication services to rural and remote sites more economically than is possible with conventional telephone lines. Potentially, this technology could also permit the transmission of data to and from mobile terminals, but not all of the problems posed by this application have yet been resolved. [20]

PBX and Local Networks.—Managers of offices are now faced with complex telecommunication choices. A few years ago, arranging for telecommunication services required only a call to the local telephone company and everything was taken care of, Today users can tailor services to their needs and shop for providers who can offer the required services most economically. However, the user organization has to devote more resources to analyzing the costs and benefits of alternative telecommunication services. To an extent, the settlement of the antitrust suit negotiated between AT&T and the Department of Justice has led to this increase in complexity. However, even without the divestiture, advances in technology were increasing the options available to users.

Adding to the telecommunication options available to managers are other technologies available for in-office communication. At the lowest level are electronic replacements for the 1920s plug switchboard to permit intraoffice communication as well as connection with the external network. Modern private branch exchanges (PBXs) can provide a variety of services, including the ability to forward calls from one office to another and to automatically transfer calls to another number once a predefined number of rings have gone unanswered. PBXs can be programmed to record voice messages and to select from the alternative services available the most economical routing for each call as it is placed. Some provide for the sharing of internal telecommunication circuits for both data and voice, giving the user organization the benefit of a shared internal network.

Another alternative for use within an organization is a variety of local area network (LAN) technologies. These provide high-speed data communication for a variety of office machines, including data-storage devices,[21] printers, word processors, gateways to external telecommunication networks and professional workstations. Several technol-

[20] Cellular radio operates using a number of low-power transceivers; computers are used to assign traffic to the one of many antennas that is best able to communicate with the mobile unit. As the mobile unit moves from cell to cell, traffic is handed from one antenna to another. This handoff procedure could introduce discontinuities in the signal that offer no problems for voice communication but could present problems for data transmissions.

[21] "Most often disks that can be used to store data of interest to a number of individuals and/or organizational elements and shared by a number of workstations,

ogies for implementing LANs are in use; [22] and this diversity of incompatible technologies using a variety of LAN architectures may present problems. But most LANs include the ability to carry on communications over the switched telephone network, so that the switched network becomes a common facility over which dissimilar LANs are able to communicate.

To an extent, modern PBX and LAN technologies are competitive. Both provide the ability to switch data at relatively high speed between office machines. On the other hand, LANs will be useful for voice transmission only to the extent that the telephone instruments that are connected to them can send and receive signals in a digital format.

An interesting variant in telecommunication lies somewhere between the public switched network and intra-office communications facilities; this is the smart building with which some realtors are experimenting. These buildings are wired for telecommunications and data processing services so that multiple tenants can use technologies available in the past only to large organizations. A smart building may provide outlets that permit all tenants to connect terminals to a common word or data processing facility. Other outlets may be used for telephone connections to a common PBX that routes calls within the building or complex without using the public switched telephone network, or routes external calls using the most economical service. High-cost facilities like laser printers and reprographic facilities can be shared.

Once digital information has to be transmitted more than a quarter mile over conventional telephone circuits, an instrument called a modulator/demodulator (modem) is required, to convert digital signals used by the computers to or from an analog signal that can be handled by the switched telephone network.[23] Commonly available modems are capable of transmitting or receiving 30 or 120 characters per second over the standard switched telephone network. Modems capable of handling 240 characters per second are becoming widely available. Speeds of 480 and 960 characters per second can be achieved by some premium instruments.

Higher speeds require the use of circuits that are dedicated to a specific customer. These may be leased from a common carrier or built as a private venture. Commonly, these lines are rated at 19.6 and 56 Kb,[24] The highest capacity lines are called T1 carriers and are rated at 1.544 Mb. [25] Satellite transponders have capacities on the order of 6 Mb.

Interactive communication that involves people usually will not challenge the capacity of a circuit capable of handling 30 characters per second. Higher speed circuits are needed only when large amounts of data are to be transferred directly between computers.

However, there are technologies for multiplexing many signals over a common line. Thus, many slow-speed conversations can be combined to take advantage of the economies attainable when high-speed circuits are used. A company with offices in two major cities may find it useful to provide one high-speed circuit between the two points. Some of the private lines can use the capabilities of a PBX to connect with any number in the remote city through the local switched telephone network, thus bypassing the long distance dial-up network and its toll charges. This reduces the revenues to the long-distance carriers, and, indirectly, revenues to the local-operating companies.

Communication Terminals.-The most ubiquitous communication terminal in the office is the telephone, basically an instrument for accomplishing voice communication between two people. However, computers have been programmed to accept the tones created by a TouchTone™ telephone and respond to them using computer generated voice. When a customer enters the long string of numbers required to use long-distance services provided by other than AT&T, the data (access code and number dialed) is received and processed by a computer. Telephone bill paying also uses the common telephone as a data terminal.

The telephone is suddenly a rapidly evolving instrument. Display screens are being added that let the user view a number from an electronic directory before instructing the telephone to dial it automatically, Telephone handsets are being added to data terminals so that the user can communicate voice and data interchangeably over a common circuit. When coupled with the PBX, the office telephone becomes a versatile, multifunction commu-

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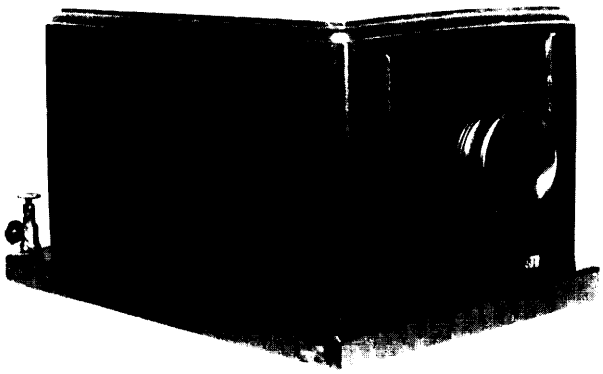
Alternative transmission techniques include broadband and baseband signaling The technologies for managing traffic include token-ring passing and collision detection and retransmission in the event of a collision between messages.

Actually, a digital signal can only be transmitted a few hundred feet without a modem. However, limited distance modems, low cost models with limited capabilities, can be used for distances under a quarter mile.

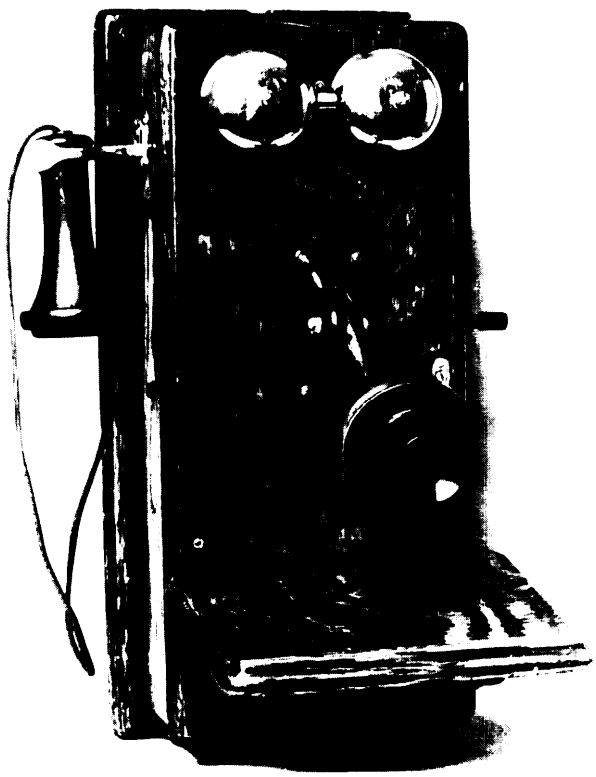
[24] Kb is kilobits per second or 1,000 bits per second A character transmitted at these speeds normally requires the transmission of eight bits.

[25] Mb is millions of bits per second

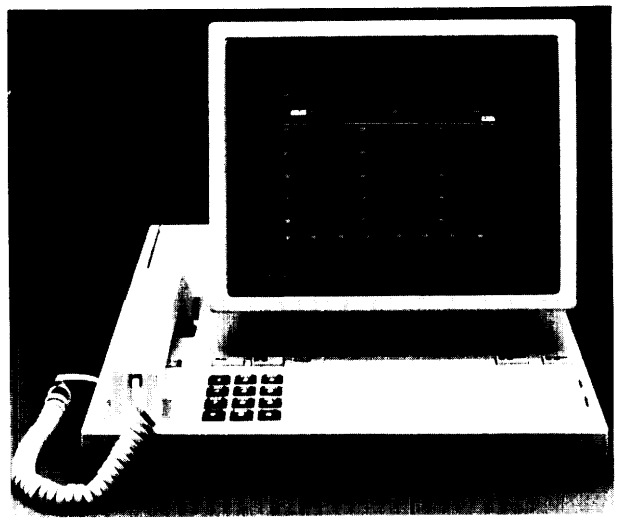


Photos Courtesy of Bell Labs

In 1877, the first commercial telephone was leased to a Boston banker. The round, camera-like opening on this box instrument served as transmitter and receiver.



This example of a 1907 Magneto wall set was in use from the late 1890s through the 1930s.



By the 1980s, the telephone and display monitor were integrated. This terminal can access files from other computers and perform a full range of telephone management and message functions.

nication instrument for the office. AT&T divestiture has forced businesses to decide whether to buy or lease the telephones in their offices. The increased variety of options has forced decision-makers to carefully match service requirements with alternative capabilities.

People now communicate with computers, and computers communicate with computers. It will become more and more common for computers in one organization routinely to interchange information with computers of another with little human intervention. For example, a computer can determine that an inventory level has fallen too low and send a replenishment order to the supplier's machine. Alternatively, payments can be queued in a computer that is instructed to contact the computer in a financial institution and order the funds transferred at the optimal time for the debtor organization.

The most common way for an individual to communicate with a computer is by means of a terminal that uses a typewriter keyboard for entry and either an electronic display or a printer for output. The terminal, in its simplest form, captures input from the keyboard, transmits it over the telecommunication line, receives data from the computer,

and displays it either on paper or a screen. This kind of terminal has no processing capabilities. With these "dumb" terminals, the user depends on a central system for all computational support.

Increasingly, however, the terminals used to communicate with computers will have significant processing capabilities in their own right. Some will have printers attached to them directly, but in the office, printing will increasingly be done by printers shared among the terminals that comprise a network,

Teleconferencing.– Information processing and telecommunication technologies can be used to substitute, at least in part, for face-to-face meetings of individuals. Two broad classes of teleconferencing are computer conferencing and videoconferencing, both insensitive to distance. A computer conference is also insensitive to time, in that people participate independently on their own schedules.

A computer conference is conducted by providing all of the conferees access through their terminals to a distant computer on which are recorded their contributions to the conference and from which they are able to retrieve the comments of the other participants. The conference may take place over an extended period, and each individual contributes at times that are personally convenient. Conferees sometimes are allowed to make their contributions anonymously or using a pseudonym, in order to encourage them to be more frank than they would be in a face-to-face meeting. Computer conferencing permits the users to ponder their thoughts rather than react to the dynamics of the group. This can be either an advantage or a disadvantage; the body language and other forms of nonverbal communication that occur in a face-to-face meeting are absent.

Videoconferencing permits conferees at widely separated locations to both see and hear one another via a television link. Several levels of videoconferencing are now available. One provides only for the transmission of stop frame pictures where the image seen by the viewers changes only every several seconds rather than continuously. At the high end of the spectrum is full-motion color video transmission that provides a level of quality at least as good as commercial broadcast television. As one moves to higher quality of service, however, costs 'increase markedly.

Some corporations and at least one common carrier have installed videoconferencing facilities. At best, success as measured by market growth has been marginal. Although this technology has been heralded for some time as a way of reducing travel costs, it has not been well accepted. Some people may like travel because it is a break in the day-to-day routine.

Display and Printing

The primary means of presenting information to users is by means of a display screen. The standard display screen now in use is the cathode ray tube, a specialized version of the television picture tube. There has been considerable controversy regarding whether prolonged exposure to the radiation from cathode ray tubes has long-term implications for the health of the user. (See chapter 5.) The question may well become mute as new display technologies become available that are more attractive, take up less room, and do not depend on high-energy beams[26] to generate the display. Liquid crystal displays are used on most of the lap computers now and plasma displays appear to be just over the horizon. A by-product of this display technology will be the flat screen that can hang on the wall, taking up no more room than a photograph or painting.

Display technology has improved so that it is possible to create finely defined images on a terminal screen. Color displays can cost three times the price of a monochrome monitor; some specialized office users find the benefits worth the additional cost.

Electronic Document Preparation.- The printing of documents may increasingly take place only at the last step in the document creation process. Documents will be created and transmitted from point-to-point electronically because of the delays incurred in sending paper.

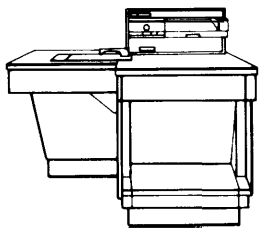
The trend is toward rapid convergence of printing, copying, and typesetting technology. They may also incorporate color sensing and image processing in designing and modifying output.

Multibin, multicolor, jetspray and laser printers are already becoming common in offices and are likely to increase in capability and decrease in costs for several years. Reprography (copying) technology is also becoming more sophisticated; print quality is improving and speed is increasing. Some of the capabilities already in the market or likely to be available soon are the ability to store and

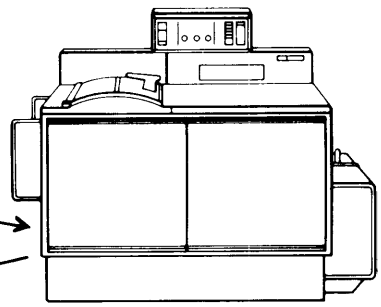
[26]The display on a cathode-ray tube is created by a stream of high-speed electrons that strike a phosphor on t he face of the screen and cause it to luminesce. At least some of the electrons continue past the face of the tube for some distance before losing their energy. It is the' electrons that continue past the screen face that give rise to concerns about radiation hazard from cat hode-ray-tube d i splays.

25 Years of Xerography in the Office

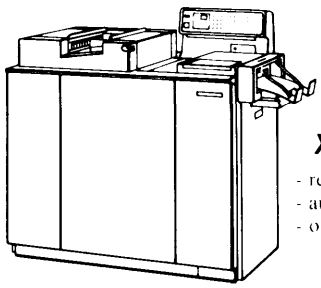
The use of xerographic technology to aid in office communication began with a slow-speed copier - the Xerox 914. Now 25 years later, xerography is used in (1) desk-top copiers, (2) multi-function machines that incorporate enlargement, reduction, and 2 sided copying into stapled sets, and (3) electronic printers that merge text, graphics, and scanned input.



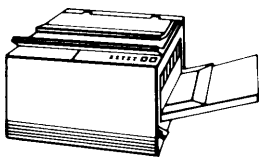
Xerox 914 (1959)
- first xerographic office copier
- 7 copies per minute



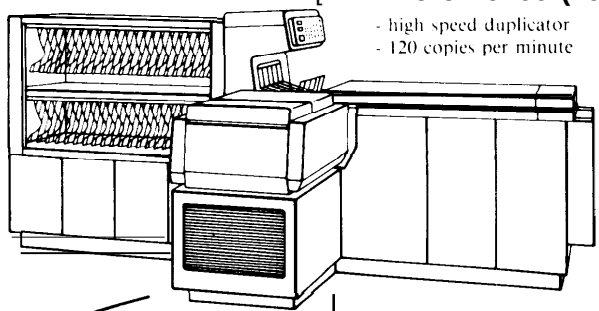
Xerox 7000 (1969)
- 60 copies per minute
- first reduction optics
- sorters



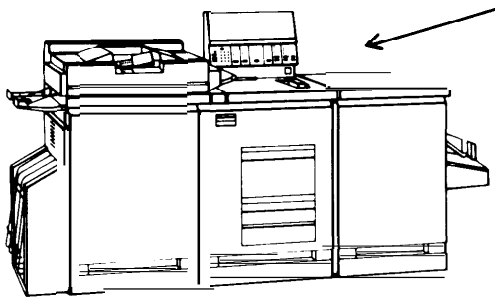
Xerox 5600 (1979)
- recirculating document handler
- automatic 2-sided copying
- on-line stapling



Xerox 1020 (1983)
- 3 × speed of 914
- 1/7 × size of 914



Xerox 9200 (1974)
- high speed duplicator
- 120 copies per minute



Xerox 1090 (1985)

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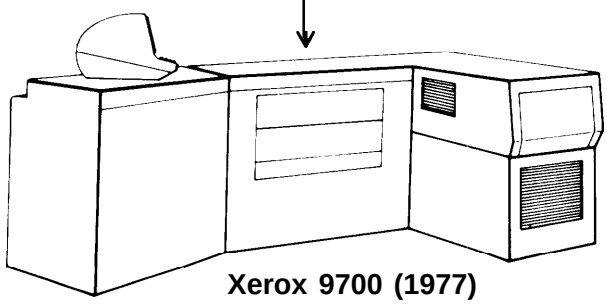

Xerox 9700 (1977)
- computer printing
- word processor printing
- text and graphics integrated

Credit Xerox Corp

use form overlays, to assemble a composite image with parts taken from many sources, and to automatically size an image to fit the space available.

As these technologies improve, it is likely that many organizations will do their printing of forms and documents as they are needed. The cost savings that are possible by reducing the warehousing of documents is large, and this is augmented by savings from reduced waste (no stocks of unused documents and obsolete forms to be disposed of), and reduction of labor time spent in ordering, unpacking, storing, etc. An additional benefit of on-demand printing is the ability to provide only those sections of a document or report that a specific user needs.

Documents that are electronically stored and transmitted will be complete with diagrams and illustrations properly inserted in the text. A major company has already demonstrated a printing device that will combine pictures that have been stored in a digital format with text on a single page. Optical storage, because of its large capacity, will be a key element in making this possible. Relatively small offices will be able to create documents that will give the impression of having been typeset.

Software

Software, broadly defined, includes all of the procedures, documents and computer programs for office computer technologies. This discussion focuses primarily on computer programs, Much attention has been directed toward software packages for microcomputers, but as has been pointed out, the combination of terminals and telecommunication capabilities has made it possible for office workers to interact directly with centrally operated computers. Therefore, the software that runs on larger machines is of as much interest to the office worker as that which runs on the smaller computers.

Software technology consists of two components. The more obvious is the ability to implement and operate computer programs that perform the operations necessary to produce the results needed by the end users, Second, and less obvious, is the knowledge needed to design the computer programs and related procedures. This requires the involvement of the user in the design of information processing and telecommunication systems, or full benefits of the technologies will not be realized.

Much of the software being developed today is designed to minimize the technical knowledge required of the users. At the same time, systems are coming that will be able to accommodate comparatively unstructured demands. The need for most users to develop programming skills or use the services of a trained programmer is diminishing.

Early applications of advanced technologies were for highly structured procedures such as payroll, general-ledger accounting and the processing of financial transactions. They were operated by highly trained specialists and did not have to be designed to be used directly by large numbers of technologically unsophisticated people. As the capabilities of applications software to accommodate comparatively unstructured demands for information have increased, much of the focus has shifted to the organization of data and the means of making it accessible to large and diverse user communities. To date, designers of automated systems have viewed applications in the light of the traditional computers that execute programs one step at a time, sequentially. Not all of the machines of the future will execute processes sequentially. Newer architectures now being developed to meet the needs of the scientific community for unheard of volumes of computations emphasize parallel processing to achieve these capabilities. Supercomputers are not used in today's offices, but for some industries they may be the business machines of tomorrow. At some point there will have to be a reexamination of the techniques used to design office-oriented systems to make it possible to realize some of the benefits of parallel processing.

During the early 1970s, much attention was given to the concept of an integrated management information system (MIS) that would meet all of the needs for information of an organization. Some organizations undertook the development of such systems; none were particularly successful. But information systems to meet the more limited objectives of specific organizational elements have been quite successful, These range from complex systems designed to serve large numbers of users to personal-information systems for individuals.

One of the challenges for software and system engineering is to establish effective mechanisms for interchanging information between automated systems while preserving the integrity and security of all of the involved data, processing, and communication resources.

Some tools to aid systems engineers already exist. Structured approaches to system design that emphasize the analysis of functional relationships have been in use for some time. Rapid prototyping is a newer concept that is meeting with a measure of success. In this technique, demonstrations that show the intended user samples of system

output and the procedures used for entering data are developed. The rapid prototype does not include implementation of the internal processes that will comprise the system. It presents only the facade that can be evaluated by the user in light of the requirements the proposed system is intended to meet, just as a wind-tunnel model is used as a tool for defining the external shape of an aircraft.

Two classes of software are used with modern computers. The first, support software, creates an operating environment that provides functions of value to all users, including resource scheduling and input/output services. The second, end-user software, includes application programs for specific users, ranging from spread-sheet processors run on a microcomputer to complex, tailored analytical programs that require the services of a very large mainframe.

Support Software. -Support software, in this context, includes language processors, utility programs, database systems and other software resources that are shared by all users of a computer system.[27] The software creates an environment within which a computer user operates. To an extent, a common operating system is created for computers that are, in reality, quite different from one another.

On large systems that are shared by multiple users, operating systems manage the resources on the computer, scheduling them for use by specific applications .28 An application is permitted to become active on a computer system once it has moved to the front of the line and all of the data it requires can be made available to it. The operating system on a computer shared among multiple users also keeps the various users from interfering with one another. On smaller systems that only support a single user at a time, the operating system lets the user move easily from one application to another and relieves him/her of some of the routine tasks that would otherwise be required. For example, a user can establish a series of commands to perform often repeated multistep tasks, and they will be executed automatically under the control of the operating system.

All operating systems, regardless of the size of the computer, provide input and output services for all applications. The operating system takes the data that is used by an application and translates it into a form suitable for driving the physical input and output devices.

Generally, the computer manufacturer designs and implements the operating system.[29] In the past, each manufacturer used a proprietary system, and this made it difficult for users to move from one brand of equipment to another. Today the trend is to standardize operating systems. For the microcomputers most commonly found in offices, MS-DOS is a defacto standard, although competitors exist and some are in relatively widespread use (e.g., CP/M). The UNIX operating system developed by Bell Labs is becoming a competing standard, available on a spectrum of hardware ranging from microcomputers to large-scale mainframes. However, although UNIX is the focus of substantial attention it is not as yet an established standard, and in fact may never become one. Competing systems are likely to continue to be a significant factor in the industry at least into the 1990s.

Standardization of operating systems would offer the user several potential benefits. The first is portability of application programs. An application written to an operating system standard, in theory, can be run on any computer for which that operating system is available with little or no modification. In this sense, the operating system can mask differences among machines from users, and competing computers take on the attributes of commodities not differentiable from one another in the eyes of the users. Second, third-party suppliers of generalized software will tend to prepare products for use with a standard or widely accepted operating system in order to have the largest possible base of potential customers. Thus, using a system for which a standard operating system is available ensures the user of a large and varied supply of software packages from which to choose. This availability of generalized packages, in turn, tends to reduce the need for expensive development of software tailored to needs of a specific organization.

Programming languages, or, more precisely, processors[30] for programming languages, are another

[27] One could argue that the generalized packages such as word processor and spreadsheet programs so widely used on microcomputers should be included in the category of support software. However, for the purposes of this analysis, because they are oriented to use by individuals on personal computers, not to be shared by a number of users of a shared computer system, these types of programs will be discussed as end-user software.

[28] Some installations may determine that all short jobs will run before long ones. Others may determine that some work, regardless of the demands it places on computer resources, will receive a higher priority than all others.

[29] In the early days of microcomputers, some third-parties created operating systems that were offered in competition with those created by the manufacturer. This practice is not widespread, but competing operating systems are still available for some of the most popular microcomputers.

[30] Language processors accept computer programs written by users and translate them into a form that is understandable as a set of instructions to a computer.

set of support software. COBOL and FORTRAN have been the two languages used most heavily for management information systems. BASIC is the language most widely available on microcomputers, but the common BASIC interpreter that is supplied with most microcomputers is not suited for very large application systems.

From time to time, new languages appear and receive some degree of acceptance before disappearing. ALGOL was one of these. It made some headway in Europe in the 1960s but was not accepted in the United States. The current crop of computer languages includes ADA, C, and PASCAL, among others. Whether they will be able to demonstrate real staying power remains to be determined.

In order to use programming languages of this type, the user must develop a degree of technical skill. First, the syntax or rules of the language must be mastered. Second, skill must be developed in describing a task at the fine level of detail that must be specified in a computer program. Most casual users of computers are more concerned with their tasks in the office than with developing the skills required to write computer programs. Rather, when the need to develop a program materializes, office workers turn to professional computer technicians.

The tendency today is to minimize the need for any user to develop computer programs, The general assumption is that most of the needs of end users, office workers in particular, can be met by program packages available on the open market. At the time it announced a major new product, one of the major producers of microcomputers made no language processor available; in fact, computers developed by suppliers of office machines are often delivered without a language processor.

The computer languages used for application systems continue to evolve, and languages available in the future, whether or not they have familiar names like COBOL, will be different from those available today. Software engineers have recognized some of the limitations of existing language structures and are developing new ones to overcome the deficiency. One approach is the development of object-oriented languages that focus on the manipulation of processes and the entities manipulated by those processes rather than the definition of procedures."

As this evolution continues, it is possible that comparatively few people will be engaged in the task of application programming as it is understood today. Rather, the language capabilities may evolve to the point where it is no longer reasonable to make a distinction between the language that is used to describe a process to a computer and the application program that is delivering information to the end user.

Support software also includes a variety of programs that are really applications, but fill needs for such a large portion of the user community that they are properly included under the heading of support software. Within this group are housekeeping programs that are used to create copies of files, prepare diskettes for use, and check copies to see that they are accurate. Some utilities also permit modification of existing data; for example, a utility could be used to change all occurrences of the word "green" to "blue." Others permit the user to select from a database some records that meet specified criteria.

Database management systems also fit in the category of generalized support software. These software systems are used to organize, store, and access data so that it can be shared among many applications. This concept makes it possible to manage data as a corporate resource and decouple specific applications from the databases that they use. The difficulty of modifying both application programs and the databases is thus markedly reduced. Changes in the data bases do not necessarily require corresponding changes in the applications that use them nor do changes in applications necessarily demand changes in the databases.

Some database management systems are designed to be used in conjunction with a generalized programming language such as COBOL, Hence, they are of value only to those with programming skills. Others provide the end user with a generalized query language that can be used to specify the criteria to be met by data retrieved in response to an inquiry. These query languages in general do not have the versatility that is found in general-purpose programming languages, but they let a user have access to data without the intervention of a programmer. Many of the data-management systems sold for microcomputers follow the model of the query languages used with generalized database management systems initially developed for mainframes.

End-User Software. -End-user software consists of the application programs that deliver information to users. With mainframe and minicomputers, end-user software consisted of a relatively well defined class of programs designed to meet the needs of a user community. Such applications still exist

"See a series of articles in the May 1985, issue of *Byte Magazine*, p. 151, discussing Small Talk, an object-oriented language developed by the Xerox Corp.

and the development of new application systems will continue, but the class of end-user software is no longer so precisely defined. Now a variety of generalized application packages such as Lotus 1-2-3° meet the needs of broad classes of users.

The development of software to meet the needs of specific users is expensive. The user organization not only incurs the cost of developing the software, but must also maintain it. Maintenance includes correcting errors as they are discovered and making modifications to operational programs as requirements change. A mature data processing organization is likely to devote as much as 80 percent of its programming resources to the maintenance of operational applications, leaving only 20 percent for the development of new applications. Many organizations are discovering that their requirements for data processing services are not as unique as they once thought, and are turning to packaged application programs. This trend is most clearly evident at the low end of the hardware spectrum where thousands of programs are being marketed.

There are two broad classes of generalized end-user application programs. One consists of modeling or decision aids oriented to fairly narrow categories of problems; the other includes applications of general interest.

Application systems designed to run on computers of all sizes have been developed for sets of problems to which a common methodology can be applied, such as packages for econometricians,[32] engineering specialties, statisticians, accounting, inventory control, and system-management packages. These applications are not designed for nonspecialists; users are expected to understand the underlying disciplinary concepts on which they are based. The command structures are oriented to the jargon of the professional. For the person not trained in the discipline, they are not "user friendly. "

The second class of generalized user applications consists of programs designed to meet needs common to most offices, such as data processing, spreadsheet, and graphics packages. "Thought processors' facilitate the creation of outlines and, thus, help the user organize ideas. "Desk organizers" let the user make notes or maintain a calendar and an automated telephone index. Programs that let users create personal databases, make inquiries against the data, and prepare summary reports are also available.

These programs are designed to be used by people with limited understanding of the technologies. Many are menu driven; the user only has to select an operation from a list on the screen. Most cannot be operated without sometime referring to voluminous, usually poorly written manuals or documentation; but the number that require only simple documentation is growing. For some of the more popular programs, dozens of texts explaining their operation to the user have been written and are widely available in bookstores.[33]

Some packages, because of their popularity, have become de facto standards of a sort. For example, word processors and spreadsheet programs will sometimes note that they are able to accept data from one or more other widely used spreadsheet programs.

Series of spreadsheets and word processing programs are available, designed so that their command structure is consistent, thus minimizing the learning time required to use each program. Also, the programs in a series are designed to facilitate the passage of data between them, e.g., a table from a spreadsheet is easily included in a document being prepared using the word processor.

Integrated, multifunction programs are also being marketed. While some of these have been reasonably well accepted in the market, each one of these programs has both its strong points and weaknesses. For example, the spreadsheet capabilities may be powerful but the word-processing functions weak. Often, integrated packages require complex command structures that are difficult to learn. There is some question whether it is more advisable to acquire a number of single-function programs that can pass data between and among themselves or to obtain a single, integrated multifunction package.

Instructions and owners' manuals, which the industry persists in calling by the intimidating name "documentation, " have been a major hurdle for beginning computer users; they are often incomprehensible to the novice. But competition for the small computer software market will sooner or later force software vendors to concentrate on ease of use, and to emphasize usability, training, customer service, and software maintenance in order to build and keep a share of the market.

[32] "Econometric programs, for example, include procedures for estimating the parameters of an econometric model, access to data useful in building economic models, and the means for exercising models once they have been built.

[33] "'Another explanation for the popularity of the texts for some programs is that they are being used in lieu of manuals by those with pirated copies of the software.

The management information system concept that has been developing over the last two decades is already evolving into the broader conceptual framework of information resources management, a field that seeks to understand the overall requirements of an organization for information and to provide the means for meeting them. Decision-support applications will comprise an important element within information resources management. These applications will range from comparatively simple models such as pro forma financial statements in the spread-sheet format to comprehensive models of both the internal operations of an organization and its interactions with the environment. Models for marketing and production management are already in use and will become increasingly commonplace even for small firms.

Much attention is now being given to expert systems. Some expert systems are being used, but they are generally rudimentary; and the ability of expert systems to deal with some of the more complex problems faced by knowledge workers may be slow to materialize.

Expert systems attempt to capture the problem-solving knowledge and methodologies used by people who have demonstrated abilities significantly above those of the large majority of the professionals working in a specific area. Specialized technicians, called knowledge engineers, interview experts and attempt to define in a format processable by computers, a series of rules of thumb that will emulate the experts. Users are then asked to provide the parameters of a problem, and the expert system returns an analysis that is intended to approximate the results that would be arrived at by the experts whose knowledge was used to structure the decision rules. In theory, if there is a sufficient gap between the abilities of top experts and the journeymen who would use the systems, expert systems should significantly improve the performance of the journeymen.

To date, expert systems have found some application in law, medicine, and insurance underwriting. Development work in other areas, including the management of emergency preparedness and financial services, is underway. The results of these efforts have so far been limited, but they offer considerable promise. An understanding of the process of building expert systems is developing and the computational power required to support them is available to many organizations.

Summary

System designers and users are only minimally constrained by the information processing and telecommunication technologies that are available. A wide variety of telecommunication services is also available. Capacity can be added in relatively small incremental steps so that users are not faced with unused capacity for extended periods.

Management can impose a strongly centralized structure or substantial decentralization of decisionmaking can be allowed. Regardless of the strategy, technicians have considerable latitude in implementing system designs that are optimal from the technical point of view while supporting whatever management philosophy is in place. For example, a centralized processing system can serve a decentralized decisionmaking structure as well as one that is highly centralized.

The processing and telecommunication technologies that are now available to the office put significant amounts of processing power in the hands of office workers and managers. The equipment used to deliver processing services ranges over a broad spectrum of capabilities, creating for office managers a wide range of options for configuring systems and designing the flow of work within an office. As the applications of the technologies become more widespread and the experience with them increases, they will have significant effects on virtually all aspects of office operations and the ways in which office workers interact with other elements of their own organizations and the outside environment.