FEATURE ARTICLES

Effect of New Technology on Information Transfer in the 1990s†

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Information transfer has been and will continue to be affected by developments in information technology. Active areas of research and development today are optical disks, telecommunications, natural language processing, and expert systems. Some of the current and anticipated developments in these areas are described. The impact of these advances on the information-transfer process is explored from the viewpoint of a large industrial generator and user of chemical information.

INTRODUCTION

New developments in technology continue to affect the methods and practices of information transfer. Activities that were once considered only remotely possible are commonplace today. There is every reason to believe that this evolution will continue in the future. The extent of these changes in information-transfer technology and the effects they will have on the practitioners need to be addressed.

In this paper an attempt will be made to identify those technological developments that will become practical and widely used in the next 10 years. The effect of these developments on information transfer will then be explored. All these remarks are presented from the perspective of a large industrial organization and the experiences derived from many years of serving the information needs of a large chemical corporation.

DEVELOPMENTS IN TECHNOLOGY

Many areas of technology could be explored, but for the purposes of this paper we have focused on three of them: optical disks, communications, and expert systems. There are a number of developments that appear to be on the verge of fruition in these areas that will have a significant impact on information transfer in the near future.

(A) Optical Disks. (1) Current Status. The best known, most widely available, and most standardized of the optical disk technologies is the Compact Disk Read Only Memory (CDROM). Also available, though not as prevalent, is the Write Once Read Many (WORM) disk. Under development are the erasable disks, Compact Disk Read Only Programmable Memory (CDPROM), that allow copying from the optical disk to a magnetic disk, and the Compact Disk—Interactive (CD-I), which places audio and video on a disk as well as text and graphics.[27]

Most of the CDROMS now available on the market contain copies of databases such as portions of *Chemical Abstracts*, Compendex, and *Psychological Abstracts*.[17]

A few WORMs are also on the market, but they are not standardized.

(2) Emerging Standards. Standards are necessary to allow interchangeability of equipment and wider use.

A group of major developers in the optical disk world formed what has become known as the "High Sierra" group. In June of 1986 they announced a data format standard for CDROM. These standards specify the encoding format that determines the size of a disk (5.25 in.) and the amount of data stored (550 MB), so that a standard reader interface is possible.[32] The National Information Standards Organization (NISO) is expected to approve these standards with few modifications by July 1987.[20]

These present hardware standards are well enough accepted so that most CDROMs can be read by any microcomputer-based optical reader. However, agreement has not been reached on standards for how the information stored on the CDROM is formated and organized for retrieval. This has implications for the search software used to retrieve data stored on CDROM. From a user's point of view, it means that for every application produced by a different vendor, the user must learn a different search language.

The de facto standards for CDROM have made some interesting new developments possible. Microsoft has announced an extension to MS-DOS that will allow any computer running DOS to access a CDROM formated to the High Sierra standards. Microsoft has also announced a general reference CDROM product called Bookshelf, which is a memory-resident PC reference containing a dictionary, thesaurus, book of quotations, etc. and is accessible from within popular word processors. Another interesting application is the interface between Lotus 1-2-3 and financial databases marketed on CDROM.[1,20]

Although WORMs are being marketed, the industry leaders are divided into two camps over formating standards. This controversy could delay the acceptance of the single industry standard that is necessary for market growth of WORM drives.[7]

(3) Write/Erase Capability. The capability to both read and write on optical disks will greatly enhance their attractiveness. This will allow the more widespread use and development of specialized packages at reasonable costs.

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Erasable optical disks are on the horizon. Optimem, a Xerox subsidiary, is working on a 5.25-in. erasable disk capable of storing 500 MB. It has reached the testing stage and is due to be marketed in 1988. Verbatim Corp. is working on an erasable optical disk to replace magnetic disks that sells in the range of $30–35.[36] Toshiba announced in December 1986 the development of an erasable direct-read-after-write (DRAW) optical disk. Sony will introduce a 130 mm disk system using high-capacity erasable optical disks in the fall of 1987. Full-scale production of Sony's disks will begin in 1988 (announcement March 30, 1987).[3]

(4) Economics. Three thousand CDROM drives were sold and installed by the end of 1985.[2] In January of 1987, the estimate was 15 000 installed drives, and by 1990, the projections are as high as 2.5 million sold with revenues of $500 million.[19]

Note that this does not include any speculation about the write once (WORM) drives or the write–erase drives.

(a) Disk Manufacture Costs. Manufacturing costs continue to go down. As techniques for reproduction become more available, large-volume production of materials will be possible, making lower costs possible. Today, costs for creating a master disk (by 3M) are about $8000. The 3M Co. expects that price to drop.[20] Replication costs, depending on quantity, range from $30/disk for under 100 copies to $6/disk for over 5000 copies.

(b) Hardware Costs. As standards become established, either formally or through use, connection with existing equipment will become easier and use will increase. This will permit manufacture of larger quantities and will reduce costs. Current costs for WORM drives range from $10 000 to $40 000. CDROM drives can be obtained for as little as $1000 or even lower in large quantities.[4]

(B) Communications. Information-exchange requirements are increasingly complex. We depend on a complex configuration of micros, minis, mainframes, protocol converters, local area networks, wide-area networks, broad band communications, and more, to get our jobs done. It is becoming apparent that one of the main topics in the information world today is the data link—the desired characteristics of which are speed, accuracy, generality, and transparency. Many organizations are addressing these issues.

(1) Increases in Speed and Data Integrity. Increased transmission speeds without the loss of data integrity will allow increased use of telecommunications for the transfer of information.

The development of "value-added" digital networks such as Telenet and Tymnet, which provide fast digital communications, have already provided a standard for increased transmission speed and data integrity.

The proposed Integrated Services Digital Network (ISDN) should provide much faster transmission rates (160 000 baud)[12,26] with very high data integrity.[33] This network is slated to become a worldwide digital standard. However, the more popular belief seems to be that there will be many interconnecting ISDNs rather than a single standard network.[26]

As more digital-based communications networks come into existence, transmissions will become cleaner and faster. All trends point eventually to all-digital networks, or, more likely, to a series of interfacing networks.

(2) Data Transmission Standards. Some progress is being made in establishing data transmission standards, but it is slow and arduous. The developments discussed in the next section will provide ways for circumventing incompatible standards to some extent.

Many standards are being proposed. The Comite Consultatif International Telephonique (CCITT) is very active in this arena. It is part of the United Nations' International Telecommunications Union and consists of 13 study groups and 160 member nations. The CCITT is the proponent of the ISDN.[26]

The International Organization for Standardization (ISO) established the Open Systems Interconnection (OSI) subcommittee. The task of this committee was "to develop a framework for the continuing development of standards for computer-to-computer communication".[11] The Corporation for Open Systems (COS), a group of representatives from major companies working with the ISO, has also been working on the open systems interconnection (OSI).[9] Many standards have been developed by the ISO.[10]

IBM has also proposed and implemented many standards. The new Series/2 PC's show a dedication to connectivity. Some of the IBM standards are Advanced Program-to-Program Communications (APPC) protocols that aid the micro to mainframe link, Systems Network Architecture (SNA) that is widely used to link major IBM computers, and the recently announced Systems Application Architecture (SAA).

AT&T has established the Information System Architecture (ISA). It is used with the UNIX operating system, which provides the skeleton for all AT&T products.

Unfortunately, this proliferation of standards has the effect of not having any standards at all. Each manufacturer has promoted its standards hoping to gain economic advantage. As a result, a large number of methods for communicating between computer systems must be considered and provided for if a network is to have any degree of coverage.

(3) Interfaces—Gateways. While all the committees ponder the brave new world of transparent, universal, fast, error-free connections to everything, the users have to survive in a complex world of incompatible layers of communications systems, hardware, and software. This has prompted the development of combinations of hardware and software systems that allow the connection of previously incompatible systems.

Third-party vendors are flourishing by selling tools to allow communication from one incompatible system to another. Various 327x emulator boards that allow an IBM PC to connect directly to an IBM mainframe are one example. Ungermann-Bass' NET/ONE telecommunications network is another. It can be used to connect PC's, IBM mainframes, DEC VAX's, and other systems. There are several products that link PC LAN's to VAX's in a direct way.

Communications software on a PC is the most commonly recognized interface. These packages allow a PC to emulate a terminal and enable communication with a mainframe or minicomputer as a minimum. More versatile packages provide help in interacting with the host computer. These high level "front-end" PC based communications packages are far from providing a transparent interface to multiple systems. The highly specialized ones provide help for only one or two vendors (Pro-search) or one database (Grateful Med). They do a good job of creating an almost "expert system" environment. Several good reviews on these types of systems are available.[13–15]

Bridges between vendors are becoming more common. The agreement between Pergamon and BRS to provide a window from one system into another is a good example. This is an agreement that will keep one organization from making unilateral changes to its system in such a way as to preclude access from the other system.

Gateways usually refer to a mainframe-based front-end package. These are menu-driven systems that provide a transparent interface to many different vendor systems at one time. CompuServe and Western Union's Infomaster are two services that access Telebase System's gateway to DIALOG, INFOLINE, Newsnet, BRS, Dow-Jones, NEXIS/LEXIS, etc. Telebase provides the gateway, and the front-end service provides the menu-driven search system. There are some questions about the quality of a search done through a mul-

tilayer menu system like this, but there is no literature comparing and evaluating both the products and the results of searches conducted by using them.

(4) Computer-Assisted Publishing. (a) Manuscript Preparation. Advances in merging graphics, tables, and text allow for the use of computers in every aspect of manuscript preparation. Most large publishers have installed systems that allow computer editing, page layouts, and composition of their publications. Recent developments are making this capability available on microcomputers, allowing individuals to have the same tools as publishing houses with systems such as Pagemaker and Ventura. However, each system is tailored to the particular computer system, and no standards have evolved.

(b) Document Transfer. The development of standards will allow for the electronic transfer of entire documents and manuscripts. Some efforts have been made to allow for such transfers. This ties in with connecting incompatible systems. Many communications programs can transmit in ASCII. Since most computer systems are able to handle these standard data formats, electronic preparation and transmission of manuscripts are already possible.

There are definite trends toward more common data formats and software that can translate from and to many different formats. For instance, Linkware can take data from a mainframe and tailor it to specific PC applications, such as Lotus spreadsheet formats. IBM applications can transfer in Document Content Architecture (DCA) among themselves, retaining more data integrity than with ASCII. However, there are still too many different formats, and a universally accepted standard will be needed before document transfers can be done routinely across a variety of systems.

(c) Editorial and Publishing Processes. As indicated earlier, computer systems are used extensively in the editorial and publishing process. Most of these systems are specialized stand-alone systems that have been developed to meet the needs of the particular publisher. Some common systems are emerging in the newspaper industry, but journal publishers have pretty much developed their own.

The widespread use of word-processing tools has prompted some publishers to seek ways of interfacing the products from word processors to the internal publishing systems. This would allow authors to submit manuscripts in electronic form and reduce the time and effort required to keyboard manuscripts.

The American Chemical Society has started a trial in which each of its journals is requesting submission of one or two manuscripts in electronic form in 1987. This trial is viewed as a step to gain experience in this process.

(5) Electronic Mail. The development of networks and standards will allow the transmission of messages of any size and form, making electronic mail a reality. The number of available electronic mail systems has increased dramatically. Some of the largest are CompuServe EasyPlex (275 000 users), Western Union Easylink (130 000 users), Dialcom (British Telecom, 100 000 users), and OnTyme (McDonnell Douglas, 85 000 users).[5] The current annual market is $375 million, with projected revenues to top $1 billion by 1990.[5]

At present, not many electronic mail systems link to each other, often requiring users to check several different mail systems, and all require separate login procedures. The CCITT is developing standards that would enable electronic mail systems to be compatible.

(C) Expert Systems. An expert system applies artificial intelligence reasoning and problem solving techniques to knowledge encoded about a specific problem area, simulating the application of human expertise. The effectiveness of expert systems comes from the amount of knowledge provided to them. There are several areas where expert systems are being used that will directly impact information systems.[31]

(1) System Design and Configuration. Very interesting applications of expert systems are those that assist in the design and configuration of information systems. These include the selection of hardware, software, telecommunications, etc. This application computes the power and cooling needs of a system and provides an integrated site plan for a computer configuration. Digital Equipment Corp. routinely uses this system when configuring new systems or considering major upgrades.[25] Other manufacturers are also using or considering such systems.

(2) Language Translation and Analysis. Significant advances in computer treatment and analysis of natural language have been made.[34,37] Some systems are now being used to analyze text for grammatical construction and to suggest corrections and modifications that should be made.[16,18]

(3) End-User Applications. Expert systems will assist end users by serving as front ends that will help in the selection of particular sources, development of search strategies, and organization of the resulting information. Some such systems are now being reported.[28] Some systems provide a way by which queries to databases can be developed using natural language, thus precluding the need for familiarity with the specialized language of the searching programs.[6,22]

Other systems have been developed that facilitate full-text searching, taking into consideration some of the characteristics of natural language.[29] Others are constructed in such a way that actual retrieval of information is possible. One such system, Answerman, provides access to information in standard reference books.[35] Another provides information and trouble-shooting assistance with chromatography systems.[23]

Finally, there are systems that attempt to extract concepts from natural language and thus provide conceptual retrieval.[30] This area of artificial intelligence has seen a significant revival in the past few years, and many more exciting and new developments will be forthcoming from such efforts.

EFFECTS ON INFORMATION TRANSFER

A variety of technological developments have been described. In most instances, the application of this technology is evident. However, it is appropriate to look at the various segments operating in the process of transferring information to see how some of these developments will affect the process.

(A) Information Generation. The generators of chemical information are, in most instances, the scientists who produce new information through the research and development process. They are, of course, also the primary end users of chemical information. However, we shall restrict our discussion at this time to the effect of new technology on the scientist as the generator of information.

(1) Data Acquisition and Analysis. The ability to interface instruments to information gathering devices allows for the reasonably easy generation of vast amounts of data. The availability of expert systems for the design of experiments will also facilitate the generation process. Once large volumes of data have been obtained, communication with other systems allows the use of a variety of techniques for the analysis of the data.

Communication and interfacing technology will allow bringing together different types of data from varied locations and experiments. This will permit the scientist to synthesize information from multiple sources.

Systems are now becoming available that contain the means for connecting to other established but complementary database management systems. Some vendors have reached mutual agreements that require both parties to maintain the ability to communicate and transfer data between their systems. This assures the user of the long-term stability of the systems and will foster their use.

(2) Manuscript Preparation. Direct preparation of manuscripts and reports will become widespread. The ability to merge text, graphics, and tables allows for complete preparation of computer-readable manuscripts. There are already some packages available, such as CHEMTEXT from Molecular Design, Ltd. Some publishers now accept manuscripts in this form, thus expediting the typesetting process.

(3) Dissemination. Once manuscripts are available in computer-readable form, their dissemination is facilitated. Through electronic mail networks, colleagues will be able to exchange their latest results and obtain rapid feedback. Lists of ongoing work will acquaint scientists with workers in similar fields with the latest developments.

(B) Primary Publishing. The availability of manuscripts in electronic form will bring benefits and challenges to the producer of the primary literature. It will facilitate the job but will also make circumventing of the publishing process easier. The availability of complete manuscripts in electronic form will permit their wide distribution over computer networks to interested parties. At what point does such dissemination of information become publication? Journal editors will have to make decisions as to what constitutes prior disclosure.

(1) Editing and Publishing. Developments in the analysis of natural language will bring elements of automation to the grammatical editing of manuscripts. Electronic mail will facilitate communication among editors, reviewers, and authors, allowing for more rapid processing of manuscripts.

Many of the benefits of automating the actual publishing process through the use of photocomposition systems have already been realized. This capability will continue to be enhanced as the handling of graphical information becomes easier.

(2) Distribution. It is doubtful that the printed book or journal will disappear in the next decade, but an increased reliance on electronic information will occur. Information will not only become available directly in databases for scanning and searching, but collections of information will become available on optical disks. Availability of optical disks will allow large amounts of archival data to be available at desktop work stations and will facilitate downloading and extraction for private use.[8,24]

(C) Secondary Publishing. (1) Indexing and Abstracting. Most of the large indexing and abstracting services have long ago applied the latest technology to their processes. This allows them to keep up with the volume of information being generated and to maintain satisfactory timeliness. Some of the developments that will have an impact on this process are those in the area of natural language processing.[21] Techniques for automatic abstracting and indexing will continue to develop, and increasing use of these developments will be made, although complete reliance on automatic processing will not occur within the next decade.

Availability of manuscripts in electronic form will continue to speed up the time between original publication and appearance in the secondary literature.

(2) Distribution. The large volume of information associated with secondary publishing services makes them prime candidates for the use of optical disks. Indexes and abstract journals will be produced in this medium and will thus be readily available for a variety of uses.

(D) Tertiary Publishing. Tertiary publishing has been characterized as the collection of data to produce derivative works, such as handbooks, tables, and other such collections. The availability of increasingly more complete information in electronic form will create opportunities for assembling specialized collections of data. It will be easier to locate and extract such information. Once extracted, providing access to such collections will be facilitated by the availability of optical disks and easy electronic access to databases.

(E) Database Vending. Making large collections of information available for direct access and manipulation will continue to be a viable enterprise. Access to these collections will become easier, increasing their use.

The availability of tools to facilitate searching and access of databases will provide the encouragement for many to enter this business. Publishers will see this as an opportunity to obtain revenue directly from the end user. The traditional database vendor will be hard pressed to provide value-added features to maintain a share of the market.

(1) Packaging. Databases and collections of databases will be made available in a variety of manners. Optical disks will be used to provide general data and to bring together selected databases in unique combinations to meet the needs of specific users. There will be a tendency for greater distribution, but at the same time, improvements in communication technology will also facilitate central access.

(2) Accessing. The ability to communicate from one system to another will allow vendors to specialize, promoting associations of vendors with dissimilar but complementary resources. It will no longer be important to know where the data are, as the software can easily route requests from one system to another. Some of this facility is now built into the Messenger software provided by STN International. The user no longer needs to know which node in the network to access in order to obtain certain information. All one has to do is request the information, and the connection is made automatically.

Expert systems that provide assistance in developing search strategies will make it easier to access the information offered by database vendors. This should increase the use of such resources and will increase the efficiency of searches.

(F) Information Centers and Information Professionals. (1) Increased Availability. The challenge to the information professional will be the significantly larger number of alternatives available. There will be many more databases and methods for accessing them. Decisions will have to be made as to whether a database should be obtained and used internally, using optical disks, for example, or whether access from a vendor is equally satisfactory. Searching and access will be made easier through front-end programs. However, an understanding of the databases being accessed will still be necessary in order to develop adequate strategies and ensure accurate retrieval.

The number of services available will increase, and thus an understanding of the differences between services will be necessary. There will be greater economic differences, and economics will play an important part in the selection process.

(2) Specialized Services. The information center will be in a much better position to offer specialized services than before. It will be possible to download information easily and to develop collections of information designed to meet the specific needs of the information center's users. Internal information networks providing data storage, retrieval, access to internal and external literature, data analysis programs, and even electronic mail will be the norm in most industrial information centers.

(G) End User. As more information becomes available and access to it becomes easier, we will see an increasing number of end users directly involved in many of the phases of information transfer. Front-end programs will allow the scientist to set up databases for the storage of data for subsequent analysis. From this database the scientist will be able to assemble a manuscript for publication and dissemination.

Front-end programs will also allow the end user to access the external information easily, resulting in increased demand

for individual access. Increased downloading of information from existing databases to feed specialized individual and group files will also occur.

The end user will not entirely do without the services offered by an information center or an information professional, but the user will become more self-sufficient in the information-transfer process. The information specialist will be called upon to provide training and assistance in developing search strategies. As more end users become capable of satisfying most of their information needs directly, the information specialist will become more and more involved in complex and difficult projects. More expertise, both in subject matter and in information technology, will be required for information specialists to maintain their ability to serve the user community.

ISSUES OF CONCERN

(A) Copyright. As it becomes easier to access and distribute information, protecting the ownership rights of information will become more difficult. Unless suitable mechanisms can be found to recompense the investor for the efforts and risk taken to provide information, the viability of the information-transfer system will be jeopardized.

(B) Security. Security is of particular concern to the industrial organization. The need for integrated information systems that bring together external and internal information is evident. However, careful thought and much effort will have to be devoted to maintaining the integrity of proprietary information.

(C) Data Reliability. Technology not only makes accessing information easier, but it also makes generating information and putting it into circulation easier. Although the easy and quick dissemination of manuscripts can be seen as a significant advancement, no assurance can be given that the data reported are consistent or reliable. Problems exist today in obtaining reliable data in spite of the rather elaborate review processes used by most reputable primary publishers.

Many issues must be considered when large amounts of data are made available to a wide variety of users. Concerns are raised about liability for conclusions that may be drawn from information provided through these systems, particularly if the data are not totally reliable.

CONCLUSION

The accelerated pace at which new technological developments appear will continue in the years to come, resulting in more information becoming available. It will be easier to access, and the relative costs of retrieving the information will also be less. End users will become more proficient at and interested in obtaining their own information. The information specialist will need to acquire many new skills to span a much larger area of expertise. By meeting these challenges, information specialists will ensure that they retain a primary role in the information-transfer process. The decade of the nineties promises to be an exciting and interesting time for those of us involved in information transfer. We will have many new tools and will face many new challenges.

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