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The Computer in the Home

Joel Moses

A visitor to an American home in the last decade of this century might note several scenes not present in today's homes. For example, while a six-year-old child might be seen playing with toys, these toys are different from those currently available because they are computer-controlled, and the child has programmed their actions. One toy is tracing a figure on a piece of paper spread on the floor. It is doing this without human intervention. The child is seen watching the pattern being drawn. If he decides that the figure is not to his liking, he walks over to a typewriter and keys his corrections to the program controlling the toy's movements.

In another part of the house two teenagers are seen playing Space-War, a game played on a TV-like screen, which may be thought of as an extension of Ping-Pong. In Space-War each side has a rocket with a number of missiles. The game is made more complex and interesting than Ping-Pong because the rockets move in curvilinear fashion owing to the presence of a gravitational field generated by a star depicted by a bright spot in the center of the screen.

Later one of the teenagers is seen reading a book. The pages of the book are displayed on the face of a hand-held screen, and are turned by pressing buttons on the console attached to the screen. On a nearby screen the other teenager is comparing his favorite baseball team's current batting statistics with statistics taken at a similar point in the schedule a year earlier. The father appears to be reading the newspaper on yet another screen. He uses the console to obtain more detailed information on a news item of particular interest to him. The mother is seen paying this month's telephone bill. No checks are visible. Rather, the bill is viewed on the

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screen, and various keys are punched on the console informing the bank to pay the telephone company the full amount.

This scenario indicates some of the computer-based services that could appear in the home in the next two decades. The implications of the widespread introduction of these services into the home are already the subject of some debate, and I shall therefore consider a number of the technical, social, and economic issues that must be resolved if the home computer becomes a reality. I shall emphasize the computer-based recreational hobbies and educational services over others like menu planning, income-tax aids, and computer programming, because although they will not be easily achieved, I believe they will have a great impact on the individual and his relationship to others.

I am assuming that the components of the home computer system are cast along fairly traditional lines. These are a central computer; a main fast memory for the computer; a larger-capacity but slower backup memory (such as a cassette); portable TV-like consoles with typewriterlike keyboard attachments; and a connection to an outside communication network, such as the telephone network, which permits the home computer to connect to central computers and their information storage and also to computers located at other homes. I shall assume that the cost of the basic system will be comparable to that of a color television set, with the monthly cost for using the network and its services comparable to today's telephone service cost.

The market for home computer systems has grown phenomenally in the past few years. Such systems have been sold largely to people who have made a hobby out of their home computers. My discussion will concentrate more on computer systems for the general populace which will have greater power and offer far more capabilities than any that are likely to be available in the next few years. At the same time, I do not wish to underestimate the impact of systems with significantly less power which could become widely available in the next five years. Electronic games are already bringing computer-based recreation into many homes, often without computers. Word-processing services in the home, such as those for editing papers, do not appear very far away, nor does use of the telephone network for computer-mediated transmission of letters (electronic mail) or payment of bills.

COMPUTER-BASED RECREATION

Visitors to university computer centers are often regaled with a variety of computer games. Currently popular computer-based games are Jotto, a word game, chess, and Space-War. Many thousands of attachments to TV sets for playing Ping-Pong-like games are expected to be sold this year for under $100. It is reasonably safe to assume that with the expected cost

reduction in computer hardware in the next two decades, a variety of computer-based games and related recreational services will be available in many homes.

There is a popular tendency to play down the importance to one's life of recreation that is not very demanding physically. Partly this is a carry-over of the Puritan ethic, a feeling that one must earn one's leisure time. Thus, while few deny the need for recreation, many act as if they feel that they should work hard at play as well as at work. In addition, one effect of television has been to degrade the creative aspects of recreation and overemphasize its purely entertaining aspects. One effect of computer-based recreation will likely be a deemphasis of the increasingly passive or exceedingly physical modes of leisure and the reintroduction of an older active and interactive mode.

The popular electronic Ping-Pong game is an example of a two-person game requiring some physical dexterity. Probably the most interesting such game is Space-War, invented in Cambridge, Massachusetts, around 1960. Space-War is a two-person game that utilizes a TV-like screen. Each player is given a spaceship which moves on the screen and which can be turned, sped up, or slowed down by moving knobs on a console. Each ship has a number of missiles which are used to shoot down the opponent's spaceship. The game is made more complex by introducing a star in the center of the screen which creates a gravitational pull, causing the ships to move in a curvilinear fashion. Ships that move off the top of the screen reappear at the bottom; those that leave from the right appear in the left part of the screen. The geometry of the space, which resembles that of a torus, also has its counterintuitive aspects. The game offers the players some unusual experiences, and they learn how to execute some of the same maneuvers required by spaceships.

Computer programs have played chess at a good amateur level since 1967. Though no current programs play at the level of a world champion, they can easily defeat over 90 percent of the amateurs in the country. Current programs possess two features that make them very useful in the home. For one, chess programs are forgiving. They let you take a bad move back without complaining. They do not gloat after they win or become very gloomy after a loss. For another, chess programs can be tuned so that they play just a little bit better or worse than their opponent, making it possible to let one's temperament dictate how often one loses to such a program. The author must admit to having lost several hundred matches to one of these programs over the last ten years.

There are certain drawbacks to current chess programs. They do not use well-defined plans for attack or defense. Rather, they tend to play a cautious game, waiting for the opponent to make a tactical mistake. They are also unable to describe the purpose of their moves or the strengths and

weaknesses of the opponent's moves, as a human tutor might. Such weaknesses present a challenge for designers of chess programs in the next decade.

One of the strengths of computers in a recreational environment is the great variety of things that can be done with the same basic system. One would not expect the emergence of a computer in the home to create a sudden and long-lasting chess or Space-War mania in the country, but one would expect a "Game of the Month" club to appear, along with increased playing of the classical games.

COMPUTER-BASED HOBBIES

Games are not likely to be the only recreational uses of computers in the home. Computer systems could also aid in various traditional projects in the home that often have a recreational component. For example, a computer system could help to design new dress patterns. Patterns might be used to guide a computer-controlled saw to cut wood for a chair, in an extension of the way in which machine tools are now guided in industrial applications. Nicholas Negroponte's essay, "The Return of the Sunday Painter," discusses how computers could permit people to "paint" on the surface of the screen (see chapter 2).

An era in which computer-based applications in the home were widely prevalent might make it possible for an individual who so chose to become expert in a wide array of activities, since with the help of computer systems he could reach a reasonable level of proficiency relatively quickly. In addition, those who shared a common interest might use the computer-communication network (which I shall discuss later) to form an electronic version of a club. A club for those interested in, say, Chinese pottery of the Ming dynasty might meet on the air on Wednesdays at 7:30 P.M. in order to view and discuss a particular vase.

One effect of the mass media in the past century has been to homogenize experience by providing everyone with the same TV shows or newspaper columns. The mass media also tend to reduce most individuals to insignificance by building up a few personalities to superhuman proportions. Computer-based hobbies can work to reverse this trend by allowing different individuals to specialize in different areas and build up their self-esteem by virtue of their proficiency.

COMPUTER-BASED EDUCATION IN THE HOME

One of the early predictions made about television was that it would have a great impact on education. It is fair to say that whatever positive impact the medium has had has been late in coming and not as great as its adherents had hoped for. Although proponents of the home computer risk falling

into a similar trap, I nevertheless believe that computers in the home will be of very great value in education.

One of the major differences between computers and television is that a computer and its associated hardware and software leads to an active rather than a passive involvement. It is argued by some, notably Professor Seymour Papert of MIT (see chapter 5), that the deepest educational experiences for a child occur as a result of working on projects of fairly long duration. In order to facilitate such projects and to channel them into educationally rewarding directions, Professor Papert's group has devised a number of "supertoys." One such toy, which looks like an inverted fruit bowl, is called a turtle and can be made to crawl on the floor under the control of the computer. It can be programmed by a seven-year-old child to draw various patterns, such as a circle or a human figure, on paper laid on the floor. If the figure being drawn is incorrect or not to the child's liking, he can modify the program and redraw the figure. Another turtle project is a simple program that causes the turtle to wind its way through a maze of boxes on the floor. Through such projects children can learn geometric skills and develop intuition and have a great deal of fun in the process. Another supertoy is a music box that can be programmed to repeat a set of notes with variations. Such a toy gives children who are not yet skilled in playing musical instruments an enjoyable way of making music on their own.

A more traditional form of computer-aided education is based on the concept of drill and practice. For example, a slide appears on the display screen saying that George Washington was the first president of the United States. A later slide asks who was the first president and gives five choices. If the child answers correctly, he advances to the next section; otherwise he repeats the section. Such programs are quite successful in certain situations, such as memorizing vocabulary.

The drill and practice form of computer-aided education has often been criticized. The kind of teaching program many of its critics would like to see is one that offers a conceptual understanding of the material being taught rather than one based on a script composed of multiple-choice questions. Unfortunately there are as yet few programs with this property. One example is the Sophie system, which teaches naval recruits how to repair electronic circuits. Remedying this lack of sophisticated software in the next two decades is a challenge for workers in the field of computer-aided education.

Computers are already in use in the nation's grade and high schools, most commonly in high schools, where they are used to teach ways of programming computers to solve mathematical problems. There are sizable efforts under way to introduce systems based on the drill and practice model, such as the PLATO system marketed by the Control Data Corpora-

tion. The penetration of computer-based education into the schools can be expected to increase in the next two decades. It is quite likely that the learning experience and the sheer enjoyment that children will derive from computer-based education in the home will speed up the introduction of such educational technology into the schools.

In addition to its value for children, computer-aided education in the home can be of value to adults as a means for obtaining continuing education, which is acquiring more and more importance in our society as the average age of the population rises. While many adults go to schools and colleges in the evenings and some take courses via television, there are many who are held back by the timing constraints imposed by these forms of education. The educational computer program in the home could presumably be run at any available time, and the computer system might even remind the student to continue a course if he had been avoiding it for a while.

AUTOMATIC CONTROL OF APPLIANCES IN THE HOME

Millions of families already have rudimentary forms of computers in their homes. Interestingly enough, most of the owners of these computers are unaware of their existence, because they are the forerunners of a generation of silent, invisible, and very cheap computers (microcomputers) which can be used to operate various appliances.

These rudimentary computers are the ones used to control electronic calculators. The function buttons of calculators provide such a simple language for getting a computer to solve a computational problem that the user is often not aware that he is programming a computer. It is the restricted nature of the service to be performed that makes the interaction with the computer so easy. Home appliances also perform well-defined services, and most of them can be expected to be controlled by computers in the next decade or two. At first the appliances will have independent microcomputers; later they may be linked to the central home computer. A computer-controlled range could regulate the heat in the oven quite carefully (say within 1° of the desired temperature). It could be made to turn on a back burner after the oven had been at 370°F for thirty minutes, for example. A washing machine might be able to accept a more complex description via push buttons of the range of fabrics in a particular load. It would then try to regulate the temperature and washing cycles so that all the clothes were properly washed.

Large buildings are already making use of small computers in order to optimize the consumption of energy. Such control of heating and cooling plants saves enough in energy costs to pay for the computer system after only a few months of use. Similar savings could be had in the home if temperature sensors throughout the house were connected to the home

computer. Such a computer could also be informed when people leave the home and when they are expected back and could have good plans for regulating heat and air conditioning at night.

The impact of computer control would be more revolutionary and controversial in the case of appliances such as automatic vacuum cleaners, which would clean wall-to-wall carpets and sweep under the furniture by themselves. Such vacuum cleaners would presumably use tactile sensors to locate the furniture and to avoid close contact with pets or babies. Similar appliances can be imagined for cooking in the kitchen or cleaning in the yard. Again it is likely that the wide range of services provided by such devices will have the greatest impact. Safety and cost factors will, of course, play a paramount role in determining their eventual usefulness. Michael Dertouzos discusses how related computer-controlled devices, largely outside the home, could produce custom-made apparel, such as shoes (see chapter 3).

COMMUNICATION AND HOME COMPUTERS

So far I have largely stressed "stand-alone" applications of the home computer—that is, they do not depend on a communications network. I believe that such applications will be the first to become available, and the current computer hobbyist and video games markets tend to confirm this view.

Coupling a home computer with a communications network will permit many new services and raise many new issues such as privacy and potential impact on existing services (for example, the Postal Service), along with a number of issues related to communications, government regulation, technological alternatives, and potential requirements for capital investment.

There are various alternatives to existing communication services, depending on the characteristics of the technology in use. The telephone network can currently be used to transmit digital information at rates from 10 characters per second to 960 characters per second. At the latter rate, the usual TV screen can be filled in under two seconds. A modem, the device that permits the encoding and decoding of the signals over the telephone lines, presently costs under $10 per character in the transmission rate. These costs can be expected to be reduced markedly with new electronic technologies and larger markets. For services such as electronic mail, the telephone network's transmission rates, especially at the high end of the scale, will present no problems. The problems arise when one considers transmission of books and especially of pictures. The transmission of different pictures into each home will force the use of technologies with broader bandwidths than those currently available for the telephone network.

Electronic Mail, News, and Related Services

Many people have noted a trade-off between doing a computation locally, for example at home, or doing it remotely and communicating the results. When the information changes rapidly, as in the case of news, there is no way to avoid some form of communication. The trade-off in such cases is between physical transportation of the information and electronic communication. There are two major information services to the home that are currently delivered by carriers rather than entirely by phone or radio and television. These are the mail and the newspaper. My concern here is with how these services could be delivered via a communication network and the home computer.

Let us consider the various classifications of mail. First, we shall remove parcel post from further consideration. If you send your aunt a sweater, she had better get that sweater rather than an electronic image of it. First-class mail is another story. Much of first-class mail to the home is composed of bills, and much of the mail sent out by homes consists of payment of such bills. Electronic communication can make a significant contribution here. Second-class mail is largely comprised of magazines. Magazines are facing grave financial crises because the cost of mailing them has risen so high. Much of the rest of the mail is so-called junk mail, which is advertising in one form or another. Mass advertising is in large part a gamble—the advertiser is betting that a certain percentage of the recipients will actually buy the product or service. This situation could stand some improvement as far as both parties are concerned. There remain personal letters and Christmas cards. The latter category accounts for a significant fraction of the mail, but one wonders whether an electronic reproduction of a card will be satisfactory to the sender or the recipient.

One scenario that can be considered for the automation of the distribution of bills goes as follows: The electric company sends the information in its bill to your home computer. When you decide to check on your electronic mail that day you see the bill's contents on your screen with all the usual information such as kilowatt-hours used. If you are satisfied with the bill you can press some buttons on the console and cause a message to be sent to your bank requesting it to pay the bill from your account. This process thus avoids the mailing of the bill, the writing of a check, and the mailing of the payment. If you are not satisfied with the bill you can send a reply to the electric company via the network stating the reason for nonpayment.

Let us consider the service in greater detail. Since the bill itself contains only a moderate amount of information, say a hundred words of text, the current telephone network is faster and probably no more expensive even today than the mails for this purpose. The idea of coupling the bank into

the process of paying bills over the network is an example of what is called an electronic funds transfer (EFT) system. An EFT system similar to the one just described for the home is used in certain retail transactions as well. The information on a sale, along with the buyer's account number and password, is fed to the bank automatically, causing the buyer's account to be reduced accordingly, after which a message is transmitted to the seller's bank to increase his account by the amount of the sale. The combined use of such a system in the home and in stores would drastically cut down on the volume of checks in circulation. Some banks already offer the simple half of this transaction—that is, one can call the bank and request it to pay the required amount to the sender of one of the usual monthly bills, such as the electric bill.

An extension of the electronic bill-paying service would allow one to send a typewritten or even handwritten message to a relative or friend on the network. Message sending has, in fact, been one of the most common uses of a major existing computer network, the government's ARPA network. Computer programs can make the job of addressing such electronic letters very convenient. Once the computer knows your mother's network address, then you may just write a letter to "Mom," and the proper addressing is done automatically. The letter can be expected to be in her mail file either the same day or the next. This mode of communication has many of the advantages of a telegram over a telephone call. The message will arrive even if your mother is on the phone or not home at all when you send the message. The recipient has a chance to look this message over quite carefully. If the communication network had sufficient bandwidth one might even be able to attach a doodle or a recent photograph to the message.

A potentially important use of message transmission is for transmission of identical messages to a group. The computer could keep the addresses of all your bridge club members. Then you need only send a message to "Bridge Club Members." This form of communication could substantially increase the number of groups one would be able to join. A side effect would be that one's mail would tend to increase, but since messages over the network would contain the name of the sender (telephone calls do not), one could direct the computer to ignore mail from unwanted senders.

Let us now consider the possibility of transmitting news over the network. The morning news could be transmitted overnight and stored in the computer's memory, to be read from the console in the morning. Although the amount of information to be transmitted is quite large (especially if one includes digitized photographs and diagrams), we might be able to get away with the current telephone's capacity, though a technology with a bigger bandwidth (like cable TV) might very well turn out to be preferable. The reason is that a single paper is being transmitted to many transcribers,

and the time available for transmission is hours rather than seconds.

One potential difference between electronic news and our current newspapers is the length and variety of the articles. The news stories need not be limited by current page size. Thus articles may be of greater length and contain more background information than at present. Furthermore it may be possible for subscribers to obtain news of particular interest to them by having the computer store stories containing certain key words in the title and ignore many others. The *Wall Street Journal* is already using a satellite to transmit news copy to various printing plants around the country. Many newspapers and magazines use computers to store copy, justify it, and prepare it for photocomposition. Thus electronic news in the home appears to be in line with the present evolution of this field. In fact, the BBC sends certain news information over the air which can be picked up by owners of television sets with special attachments.

Much of the income derived by newspapers comes from advertising. With the advent of a home computer network, advertisers may change their mode of operation, but the consequence of such a change for newspapers is entirely unclear. Advertisers currently use mass mailings and newspapers partly in the hope of getting a message to a customer at about the same time he or she wishes to buy a particular product or service. This aspect of advertising is a fairly inefficient process. Quite often the consumer does not receive the information he wants, and the advertiser reaches many people who are not interested in the message at that time. One possibility is to collect current advertising copy for a whole class of products, say groceries, in the memory of a central computer. Consumers would have access to this information in the home and might even be able to place an order at home in a manner similar to that of a Sears catalogue.

Magazines should be able to use the network in a manner quite similar to newspapers, with the possible difference that one might be able to pay for the right to read a single story or two rather than the whole magazine. The impact of a potential loss of advertising is likely to be consequential here also. Of course, there are now magazines such as *Consumer Reports* that are viable even though they do not accept any advertising at all.

Electronic mail will, of course, have a tremendous impact on the U.S. Postal Service. The Federal Communications Commission or Congress could forestall it by postponing the introduction of such a service until sufficiently many carriers and mail sorters have retired, but there may in fact be no need for such action since half the employees of the Postal Service are over fifty years of age.

THE ELECTRONIC LIBRARY IN THE HOME

The dream that one might be able to read any book in a large library such as the Library of Congress just by pressing the right keys on one's console

and reading the pages from a display screen has been around for quite a while. Presumably the texts of the books would be stored in digital form on some medium that can be read by a computer. The contents of a single page could be displayed on the TV-like screen; by pressing a button one could effectively flip pages. Ideally the contents of a new page would appear on the screen very quickly, say in under a second.

What would be required in order to make this dream a practical reality? Assuming a page of text contains 300 words on the average, or about 2,000 letters, it has about 10,000 bits of digital information. At 300 pages per book, the Library of Congress, with 20 million volumes, will thus contain about 10^{14} bits of textual material. By contrast, a single photograph has something on the order of a million bits (10^6) of digital information. But since the number of photographs is smaller than the number of pages of pure text, we can still estimate the capacity of the library at about 10^{14} bits. This is approximately one thousand times the capacity of the largest computer memories now available, so in order to make a copy of its contents available for use with the home computer, one would need to employ a new technology or a highly modified existing technology, such as video tape. Current business and scientific users of computers have only recently awakened to the value of a storage medium with just the properties required by a copy of a library (i.e., very high capacity, relatively slow access, relatively slow read-in rates, and no writing capability beyond the first time). Nevertheless, we cannot be reasonably certain that such a technology will be widely available in homes by the last decade of this century.

On the other hand, if a computer-readable copy of the library were kept in a central computer, thus sharing the memory costs among thousands of subscribers, the contents of a book could be transmitted a page at a time on demand over a communications network, such as the telephone network. However, at current telephone rates for digital information (between 10 and 960 characters per second), it would take about several seconds for a new page to appear on the screen, which may not be an acceptable rate for most purposes. And even if the system were clever enough to keep ahead of the reader, it would get bogged down transmitting a digitized picture, which would require several minutes at current rates.

Another possibility is that one could improve the transmission capacity of the telephone networks by improving the switching elements underground or even changing all the cables to use fiber optics. This would involve a multibillion-dollar capital investment and would take a decade or two to carry out over the whole country. One hesitates to speculate about such a possibility, in part because of the feeling that digging up the streets of our cities is such a large undertaking that the results would have to satisfy our needs for many decades to come.

There exists yet another communications technology that could possibly handle all the requirements—cable TV. With cable TV one might be able to transmit different books to hundreds or thousands of simultaneous readers in a given locality. There are various arguments advanced as to why cable TV has not got off the ground, such as difficulties with local regulatory bodies and lack of sufficient service to the community; the home computer could very well lead to the widespread use of cable TV. Satellites could potentially offer another broad-band technology suited to applications in the home.

But even supposing we could resolve the storage and communication problems in the next two decades, we would still face another technology that has had five hundred years to develop—the technology of bookmaking. Consider some of the characteristics of books: they are fairly small, lightweight, and very portable (imagine taking a TV-like console to read in bed), easily marked up (for the purpose of recalling previously read material), and possess high communications bandwidth (for maps, reproductions of paintings, and so on). For the technology of display consoles to achieve these characteristics in the laboratory stage is likely to require well over a decade, and even then some compromises will probably be unavoidable.

Another issue that would have to be confronted in a world of electronic home libraries is that of copyright. How would the rights of authors be protected? One could charge the readers a fee for each book they read from a central memory, but the payment to be obtained by publishers and authors for a copy of a full library sold to the home appears a more complex matter. The advent of a computer communication network with its potential for rapid access to articles and books will surely have a major impact on the publishing field.

COMPUTERIZED FACT RETRIEVAL

A special part of a library in the home is composed of reference books, such as encyclopedias, record books, and dictionaries. A user of reference material is usually after only a tiny fragment of the information contained in such volumes. Thus the total amount of information to be stored and the amount needed to be transmitted at any given time is not nearly as great as in the case of a full electronic home library, making it possible to avoid many of the problems associated with the latter. In fact, in the case of reference material, computers can potentially offer better service than consulting reference works in the library.

As in the case of the electronic home library, one might be able to purchase a full copy of the reference books in the form of a cassette tape or obtain the desired information through the telephone network. One advantage that the network approach possesses over both the home copy

and the present system is that the network could maintain up-to-date versions of the material. The centralized information could presumably be kept current with about the same manpower needed to keep reference books current, at the same time avoiding the delays entailed in publication and distribution of the volumes.

A more basic difficulty with reference works is that one cannot always determine how to find the information one seeks, no matter how well classified the volumes may be. A simple example of this type is that of finding the correct spelling of a word when an incorrect one is known (actually there now exists a book for just this purpose which contains many common misspellings). This is a situation in which computers could do very well, given an appropriate classification of the information and some capacity to conduct a dialogue in English within a narrow domain of interest. In particular, the misspelling situation could be handled by knowing the common misspellings, knowing heuristics for ways in which people tend to misspell, using some knowledge of phonetics, some trial and error, and so on. Furthermore, there would be no need to look up a word in a pocket-sized dictionary. The computer could store the information contained in the largest dictionaries, giving out as much detail as the user might request.

Another application of fact retrieval in which computers could perform better than standard reference volumes occurs in situations where one can store all occurrences of a particular class of events. Examples are stock sales and baseball games. Suppose you wanted to know how often your team won Sunday doubleheaders last season or the won-lost record of left-handers in Fenway Park. Such information could be compiled in a record book, but it is not likely to be if the question is of a nonstandard kind. A program could search the record of all games played by your team last year or all games ever played in Fenway Park and answer these questions with little difficulty. The problems of structuring information on financial transactions or baseball games is clearly within the state of the art, and an English-language question answering system, if sufficiently restricted in subject matter, should be within the state of the art in the next ten years. Such a natural-language program will, however, require a large memory for grammatical information, semantic word meanings, and the like. Terry Winograd discusses the general implications of such programs for the interactions between humans and computers (see chapter 4).

Fact retrieval services generalize into advice-giving services. One of the most often mentioned services for the home is a program that aids in the preparation of income taxes, such as helping the user to take as many legal deductions as are available to him. One advantage of such a service would be in unusual situations, where the program could point out exist-

ing tax rulings—something the local H. & R. Block representative is not likely to be able to do. The next two decades may also see homes containing programs that dispense legal or medical advice, such as antidotes to poisons found in household cleaning fluids, although most advice-giving programs will be slated for use by doctors and lawyers in their offices. There is much research at present on diagnostic and disease management tools for doctors. Examples are programs that recommend how much digitalis to give a patient or that determine which one of about a hundred different infections a patient seems to have.

OFFICES IN THE HOME

A relatively radical proposal for trading transportation for communication is the concept of the office in the home. Underlying this concept is the belief that many employees, especially those in white-collar jobs, could stay at home one or two days a week and still perform essentially the same duties that they now do via the network. An advantage claimed for this concept is that less travel to the office would mean a reduction in pollution and energy consumption. Such a system would demand an exceedingly close coupling of the office in the home with the regular office. Assuming that the person staying home is the proverbial paper shuffler, then the memos he or she would receive must be communicated to the home and back to the office at approximately the same rate as before. This places a strain on the network. If one were to allow interviews in the home office, then a picture-phone-like facility would be necessary as well. At this point it is difficult to imagine how such a concept would affect one's interactions with colleagues and other members of the family.

The office in the home would presumably use much of the same hardware, software, and communications technology that are likely to be used in the "automated office" in the coming decade. The automated office concept assumes a marked reduction of paper flow, since individuals will be able to read the required documents on the console. If a document needed to be printed, it would be done on copying machines directly attached to the network of consoles. Preparation of the documents themselves could be notably simplified by having powerful editing and text-justifying software in the console computer.

The office in the home concept can be of great importance to people who find it difficult to leave the home. Mothers with small children might be able to have part-time jobs at home by working at a computer console during their free minutes. People with certain emotional and physical problems which make it difficult for them to interact with other people outside the home may find that the computer network gives them an important outlet.

HARDWARE-SOFTWARE REQUIREMENTS

The basic hardware bottleneck in the introduction of sophisticated computer services in the home is likely to be the size of the main and backup memories. A computer with a main memory of about ten million bits will probably be satisfactory for most services. A reasonable guess for the sale price of the home computer is about $500, or the price of a color TV set. The current value of a medium-speed computer with the desired memory size is about $500,000, although cheaper and decidedly more expensive computer systems with such specifications are clearly available. Is there any reason to expect the cost of the system to be reduced by a factor of nearly one thousand in fixed dollars in the next two decades? The answer is yes if we extrapolate from the experience of the past two decades. It is an adage in the computer business that the cost of a given computation goes down by 30 percent every year. In fact, certain manufacturers appear to price their equipment accordingly. When extrapolated for twenty years, the 30 percent reduction rate yields a decrease of a factor of about a thousand. Noyce's essay on the physical limitations of large-scale integration (LSI) technology tends to support this expected reduction in the cost of hardware, but if it fails to materialize, one could always cut down on the services available in the home, or use lower performance systems, or use the network for various services that cannot be obtained at home.

The major reason for favoring a relatively powerful home computer is that a sizable software system will be needed for the support of natural-language interaction, for fact retrieval systems, and generally for the support of the wide variety of services I have described. Thus in addition to the hardware required and the communications requirements, one has to consider the cost and availability of software for performing the various services. Currently software costs are outstripping hardware costs in most computer installations. The computer in the home may provide a different experience. At present a particular piece of software may be used in anywhere from a single installation to approximately 50,000 installations, with a majority being used at fewer than a hundred installations. If we assume that software could be used in ten million homes, with the cost amortized over several years via a rental charge, then even a multibillion dollar software cost could be recouped.

One factor that will affect the cost of the home computer is whether the system is sold by a single company or several competing companies. If we assume that available services will continue to grow gradually, as they have already been doing in the recreation area, then the market will be competitive. This may require home owners to pay for a multiplicity of hardware systems, multiple versions of similar software, and so on. Com-

petition, of course, will likely produce some very good products, along with many mediocre ones, and possibly some undesirable ones. A gradual entry into the home may provide sufficient lead time for the basic research that needs to be done on issues like natural-language query systems. The argument for a more monopolistic market is based on the need for a large capital investment in software, hardware, and communications equipment in order to deliver good service from the start. On the other hand, we do not yet know which services are likely to be most useful, and a competitive market will point these out.

SOCIAL IMPACT OF HOME COMPUTERS

Some people maintain that the introduction of computer-based services in the home will only further the process of making us incompetent in areas in which we were previously competent, as the introduction of hand calculators may have done in the area of arithmetic. There are others who believe that the range of services potentially available through the home computer is not sufficiently interesting and useful to families and that few of them would purchase a system even if it were to cost as little as a color television set. It is hard to argue against such claims at this time. Data regarding the acceptance of relatively rudimentary recreational and educational services in homes in the next five to eight years should give us some information on these points. Others do not deny the value of services like computer-based education but argue that our understanding of the software issues involved in producing viable services are woefully insufficient. Thus they recommend that we wait until the services become very much better than they are now before unleashing them on the market. I have much sympathy with such a position, yet I wonder whether the market forces in our economy can be controlled sufficiently to make such an approach effective. Moreover, there is good reason to suppose that a child presented with bad educational material in the home will ignore it, given the choice.

A distinction must be made between the social impact of a home computer system that is not connected to a communications network and one that is. Some services such as electronic mail cannot exist without such a link, but there are many that can, such as recreation, education, device control, and fact retrieval.

The issue of privacy, so often raised in discussion of the social impact of computers, takes on slightly different forms in the home. If your home computer is not connected to a communications network, then the private information that you have placed in the computer's memory is physically located in your home. Thus unless electronic snooping becomes much more refined than it is now, a thief who wants to steal such information will be forced to commit a burglary. The deterrent in such a situation is the

same as in the usual case where someone breaks into your home and rifles your desk. Unfortunately our legal system has not yet determined a punishment that fits a crime like this. The punishment for breaking and entering may be insignificant when compared with the value to the individual of the information lost. Furthermore, the information you may have in your file at home may be truly private (such as love letters).

Most of the debate on privacy so far has dwelt on data bases that collect information like age and bank balance easily obtained from some other data base, such as a registry of births and deaths. Nevertheless, the potential for loss of information is considerably enhanced if the home computer is linked to a network. Even if we suppose that the links are such that the network cannot get information from the file at home that the user did not specifically transmit, we would still have the technical problem of enforcing such a restriction. If we wish to be able to keep private information in the memories of central computer networks, then the problems become much more acute. In spite of recent breakthroughs in the development of "unbreakable" encryption codes, in the long run we may want to have what John McCarthy has called a "Privacy Bill of Rights."

The government may play a major role in the operation of such a network of home computers. Licklider's essay, in fact, discusses a government-sponsored network, dubbed MULTINET, that would link home computers with various agencies of the government (chapter 6). Another way in which the government may be involved is in the area of regulation. Noll's essay on this subject (chapter 12) paints a bleak picture of past experience with regulated industries, yet he admits that it is unlikely that a national network of computers will escape regulation entirely. Several national policy commissions have already examined various issues such as privacy, electronic funds transfer, and copyrights. Though many laws and regulations have been proposed, the home computer field is still largely unregulated.

A large national network need not be established all at once. It could start in small communities and grow over time. This approach requires less capital in exchange for a reduced level of service. Some have proposed that the federal government sponsor a pilot experiment in which a community of, say, fifty thousand is linked via telephones to central computers. Some such experiment appears to be a good way of beginning the informal public policy debate over the home computer. An experiment with as few as 200 homes provided with a comprehensive home computer system and communications network could yield much insight into the technical and social problems that remain to be resolved, and especially which approaches and services should be avoided in the future.

The home computer will not arrive all at once. Various computer-based recreational, educational, and control services will appear in many homes

in the next ten years. Current systems composed of a black-and-white television set, a keyboard, and a microprocessor-based computer are already available for under $500. The coming decade will, one hopes, give us sufficient time to prepare for the impact of what may well turn out to be the most powerful technology to be introduced in this century, one that could profoundly affect our lives both as individuals and as members of families.

EDITORS' POSTSCRIPT

Most idealistic projections of the impact of computers on individuals are vulnerable to the criticism that similar projections were made about the telephone, radio, and television in previous decades. Such projections have not been fully borne out, a point raised by Weizenbaum's essay. At the same time, the reader should note that Moses makes relatively long-range projections extending fifteen or twenty years into the future. Thus, as McCarthy has pointed out in his critique, he tends to deemphasize the fact that many services, such as electronic mail, might become available in the next five to ten years, services that could have a noticeable impact on the home relatively quickly.