MICROPROCESSOR BASED MEDIA

A Briefing on the Technologies, Applications, and Diffusion of Videotex, Teletext, Personal Computers Speech Synthesis and Speech Recognition, Communicating Word Processors, and Satellite Earth Terminals

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Preface

When the Canadian communications theorist Harold Innis described changes brought about in the ancient world as chipping hieroglyphs on stone was supplemented by writing on papayrus,[1] he described a transformative technology, one whose use had major social, economic, and cultural consequences, which for hundreds of years afterwards, could not even be visualized. The microprocessor -- the computer on a tiny silicon chip -- is a transformative technology.

In spite of scant data on the actual extent to which microprocessor-based technologies have diffused through the developed economies of the world, it is now clear that the rate of adoption is extremely rapid, at least an order of magnitude faster than the traditional time lag of fifty to one hundred years between the invention and the first commercial use of a new technology. The microprocessor was invented in 1971.

This work is intended to be a briefing manual for policy makers, executives involved in product and production planning, and others about new communications media emerging from microelectronics.

It identifies and describes the different technologies, products, commercial services, and field trials presently or soon available in the North American home and office.

It delineates the main applications of the new communications technologies, their costs, the major industrial players, and, to the extent that data exist, the penetration of services and products.

Although analysis is focused on North American developments, Japanese products are often discussed since they figure so prominently in these technologies.

Finally, despite most current futurist nonsense about computer terminals in rural villages and a generally bleak history of high technology in development, the work attempts to identify some areas in which the chip-based communications media may actually be useful in development and education in the Third World.

The Third World, developing countries, less developed countries - all of these terms conceal differences of a vast and tragic human scale. I don't suppose that the microelectronics technologies will have any direct effects in the most impoverished countries of the world. (There will be indirect industrial effects here arising from widespread adoption of the chip-based technologies in production in the developed economies). However in the so-called newly industrialized countries or NIC's, and in countries on the verge of joining this group, there is a much higher technological capability than is generally acknowledged, especially in the area of engineering and software,[2] and several NIC's are already producing silicon chips, mini-computers, microprocessors, and perhaps more importantly, writing their own computer software.

The "developed" economies of the west are characterized by planned obsolesence, the stimulation of continuous consumption and instantaneous gratification through advertising and through superfluous production of many varieties of virtually the same good; thus it should not surprise us that the new communications media like videotex and personal computers are being first used for matters like home shopping. More peculiar is the fact that the rate of inherent technological obsolescence in microelectronics and microelectronics-based products is even shorter than the planned obsolescence rate. Chip-based products typically have a product life of between eighteen months and two years, and not infrequently new products such as word processors, and telephone switching exchanges are technologically obsolete <u>before</u> they come onto the market.

The developed economies have generally tried to make money off of the Third World by selling prestige-laden, often useless technology. The main purpose of this work, then, is informative, to portray the communications technologies and their current applications, so that future decisions about their use may be made in an informed manner.

The work is based mainly on interviews and publications of manufacturers of original equipment, predominately in the Santa Clara Valley of northern California, and of international marketing and research firms concerned with the new communications media such as SRI International, The Institute for the Future, Frost and Sullivan, International Resource Development, and Butler Cox. It also relies on the science and technology section of the Economist, (which must appear at the top of a list of anyone who wishes to be informed in these areas), and on the computer trade publications.

The Microelectronics Base

The microelectronics industry has its origins in the mid-50's in the Santa Clara Valley of California (now called Silicon Valley). Starting with William Shockley, the inventor of the transistor, who left Stanford University to start the firm of Fairchild Semi-Conductor, this industry grew rapidly in a remarkable series of "spin-off" ventures in which employees left Fairchild and subsequent firms to start their own new ventures. A geneology of Silicon Valley firms is presented in the Appendix.[3]

The microprocessor on a silicon chip, invented in 1971, is a major technological shift. Microprocessors the size of a fingernail can be instructed or programmed to perform an infinite variety of tasks, can be used in any situation which presently utilizes information processing, and are rapidly facilitating entirely new communications technologies in developed countries such as telephone exchanges which switch both voice and data, communicating word processors, personal computers, cheap, portable satellite earth terminals, videotex and teletext, and speech synthesis and speech recognition systems - all of which will be described in this work. Throughout this work we will speak of <u>terminals</u>. These are any devices used to interact with computers and can vary from small, hand-held protable units with little keyboards, like The Sony Corporations's new portable word processor, to big terminals which ressemble an electric typewritter. Sometimes computer people use the term "intelligent terminal". All this means is that the terminal itself has a small computer (microprocessor) in it, and the person using it can write software and do programming at the terminal instead of merely passively receiving data from outside computers.

In the '40's electronic componetry was based upon electronic vacuum tubes to transmit currents of electrons. The first transistors - invented in 1947 - replaced these vacuum tubes and were incorporated into virtually all electronic componetry of the '50's. In transistors, the electrical current flows through solid materials called semi-conductors rather than through vacuum tubes.

Semi-conductors are peculiar devices, typically made of silicon (or glass), which, when mixed with minute quantities of other elements like phosphorous and boron, have properties halfway between conductors (like metals) and insulators (like rubber). Unlike electronic tubes, they don't wear out, require very little power to function, don't have to be heated to provide electricity and thus don't have to be air conditioned to function.

Integrated circuits, invented in 1959, use transistors as a basic building block They combine large numbers of transistors and other devices on the same single chip of silicon so that they can perform as a complete electrical system. We may think of each of the thousands of transistors on a silicon chip as an electrical gate. If the gate is open, current flows, and if the gate is closed, current does not flow. Each gate can represent one or zero (depending on whether it is open or closed), and this in fact is how computers process information, in digital form.

In addition to silicon, manufacturers are beginning to make chips out of a material called gallium arsenide - a compound of a metal called gallium and metallic arsenide. Its main advantage is that electrons can move through it thirty times faster than through silicon.

By the mid-'60's electronic componetry was fully transistorized, and since the late '50's miniaturization has proceeded so rapidly that the number of transistors on a single piece of silicon has roughly doubled each year.

Today's semi-conductor firm regularly produces a piece of silicon the size of a fingernail containing 100,000 transistors, and experimental chips have already been produced carrying more than 1,000,000 transistors.

The most sophisticated integrated circuit is the microprocessor. Microprocessors contain, on a single tiny chip of silicon, the central processing unit or brain of a large computer - that part of the computer that performs the arithmetic and logical functions. These microprocessors are used in conjunction with memory chips - chips which store the data - and input and output chips - used to control the data in and out of the central processing unit. There are two common types of memory chips, random access memories (RAMs) and read only memories (ROMs).

Random access memories are memory chips in which one can instantly find any information stored on them, regardless of location. One does not have to go through the stored information sequentially, item by item to find something. In other words, the access time to get the information is independent of where on the chip it's located.

Read only memories on the other hand are memory chips in which the information is "blown" in by the manufacturer during production and can't be changed by someone programming it. One can only read data out of a ROM but not write data into it.

In mid-1980 a new chip, illustrative of the input/output chip, came widely onto the market - the analogic/digital chip. This chip lends both eyes and ears to a microprocessor and converts analogic data (or continuously varying data like voice, sound and light patterns) into discrete digital data (the computer talk of 1 or 0). Each time a microprocessor is used to control a production process, an analogic/digital chip is needed to convert voltage and current produced by sensors into the digital talk that the microprocessor can understand. As we shall see, these chips are also being used now in consumer products such as for monitoring and control of water temperature, instrument settings in cars, and in the new communications products, such as solid-state speech recognition.

It is expected that within a few years, microprocessors will account for almost a quarter of all world sales of integrated circuits.[4]

Development Costs - Software

Although mass production of chips is cheap once they have been designed and developed, the actual development costs of chip technology are extremely high. Intel, a California manufacturer of microprocessors, has estimated that their development costs for a single microprocessor, the 8086, was 200 million dollars. The main development costs however are for writing the instructions to tell the microprocessors what to do. These instructions are called software.

On a world level the capacity to write computer software is growing only by about 18% per year, while the demand for new software applications is growing at more than double this rate. Various responses to this situation are being tried, such as the use of "higher level" computer languages - which enable the programmer to write software more rapidly and in natural languages more resembling French or English - or "structural programming" - which breaks down programming tasks so that they can be better shared. Some manufacturers even wire standard programmes into the computer chips and thus in a sense "mass produce" software. There are also software packets or packages pre-written programmes into which the user can insert his or her own data. There are now software packets for everything from statistics to industrial process control to small business applications. But none of these solutions has dealt with the problem that much programming is essentially a very creative act and is almost impossible to structure, and all software writing is extremely labour-intensive. But to understand future software needs, we must understand a distinction between types of chips - specifically the difference between custom and standard chips. Here it should also be noted that a number of manufacturers such as Diablo, Quantel Corporation, and Micro-Data Systems are attempting to provide self-programming computers, computers which write their own software. Much routine programming can be itself automated, and it is thought that this automation will ultimately vastly decrease the world software scarcity. However, even if much microprocessor programming is eventually automated, programming will still remain a labour intensive activity because someone will obviously have to programme the self-programming computers.

Custom versus Standard Chips

The first microprocessors, invented at Intel in 1971, were "4 bit" microprocessors - meaning they could accept instructions only in units spelled out in 4 digit words. They were incorporated into very simple applications like toys, games, and traffic controls. In the same year, Intel came out with the 8 bit microprocessor, capable of understanding instructions in words of 8 digits. These were used in more sophisticated applications such as word processors. By 1976 Texas Instruments came up with the first 16 bit microprocessor.

With Intel's recent 32 bit microprocessor chip, called the 8800, microprocessor technology has moved into its fourth generation. (National Semi-Conductor, another American manufacturer has also been developing a 32 bit microprocessor, and a third firm, Motorola is still 1 to 2 years away.)

But each time the computing power of the microprocessors has doubled, the applications costs have gone up astronomically. It has been estimated that an average cost of developing merely one application for a 16 bit microprocessor is three to five million dollars. A typical customer must design both the computer board containing the microprocessor and all the support chips such as the memory chips and input and output chips. Intel has estimated that the development of applications for the 8800 are ten times more expensive than for the 16 bit generation of microprocessors. But most customers in the advanced technologies simply do not have the computer sophistication to incorporate microprocessors into their end products. This incorporation involves designing how the microprocessors will interact with the input/output chips and memory chips, or the system's architecture, and the actual software or instructions which tell the product what to do and which is hand-wired into its architecture. As a result of this, the big firms are increasingly producing custom chips for specific applications.

Many of the standard, programmable chips such as the 8800 run on "higher level" computer languages - which enable a programmer to write software faster and in codes that more resemble English than earlier computer programming languages. Since the 8800 contains more than 100,000 logical gates or transistors, it can be used in situations in which there is a massive amount of data traffic, such as managing extremely large computerized libraries of information, keeping track of salaries in supermarkets and banks, and for the recognition of speech and visual patterns.

Custom chips then are chips which are tailor made for individual users who need them in comparatively small quantities. In general, a custom chip does not have to be programmed at all. The large manufacturers do not like to make customized chips because their marketing strategy is basically to make large numbers of standard chips and force down the unit cost.

These big firms have assumed that their standardized microprocessors may be adapted to a large number of specialized applications by being programmed. But these programming applications are proving very expensive. Although computers themselves are being used in the design of custom chips, it still requires about 100 man years to design a single custom chip free of faults, and computerized work stations used to design custom chips still cost about $200,000.

Although presently only about 5 to 10% of production involves custom chips, by the end of the '80's one third to half of all chip production will be customized.

A World Scarcity of Chips

Present costs of manufacturing chips are so expensive now that America's top semi-conductor manufacturers have had waiting lists of up to a year. Also, due to the trends in customization discussed in the last section, many large users of chips now have their own in-house facilities; for example, National Cash Register buys custom chips to make electronic cash registers which can automatically keep track of store inventory (by means of a microprocessor-readable code of lines on each item) and even do automatic ordering for storehouses. They now have their own in-house chip production. The same for General Electric, which has been running into production problems because of their own inexperience and has been forced to buy chips from the equipment manufacturers. (In 1980 IBM, the largest computer company in the world, purchased more than 30 million, 16 bit RAM's on the open market. Also the chip industry is simply not making enough profit to finance its own growth, and venture capital firms are beginning to put money not into chip manufacture but into firms which apply the chips in new uses. It seems fairly clear that the first countries to be deprived of chips when they need them will be the less developed countries which are dependent upon the mulinational suppliers.

Advances in Production Techniques

The basic problem in microelectronics technology is to cheaply imprint several hundred chips comprising thousands of electrical circuits onto thin wafers of silicon or gallium arsenide. The equipment now used for this is called a projection printer (supplied mainly by the American firms Cannon and Perkin Elmer). A lens projects an image onto the wafer, and there is no physical contact between the negative (or photomask) and the wafer itself. The wafers are coated with photosensitive material, and light, projected through the mask, transfers the patterns of the circuit designs onto the wafers. Acids are then used to etch the pattern into the wafer.

Over 60% of the chips thus produced are always defective, but it is thought that continuing advances in production technology will bring down the defection rate to under 10%.

Many firms such as Intel, Texas Instruments and IBM have all concentrated on making standard, low cost microprocessor components and letting the customers themselves perform the software. Intel has focused on simplifying a customer's programming work by assembling an "off-the-shelf" microprocessor system with various combinations of chips which the customers can simply plug into products. One compromise between mass production and customization is the gate array chip.

Gate array chips are chips in which identical arrays of logical components are manufactured in bulk but are not yet connected to each other. They are later connected to give the chips special characteristics the designer and user desires. Although several California firms such as VLSI Technology and Silicon Systems are presently manufacturing gate array chips, in late 1980 IBM announced new faster and cheaper methods of making such chips.

In this process designers first use computers to generate the masks or patterns and to transfer circuit designs onto the silicon chips. (The use of computer aids may cut the design time for the mask from 6 weeks down to a single day.) Masks are used to make "master slice" wafers comprised of hundreds of unconnected gate arrays. Later the circuit designer decides precisely how he wants to interconnect the gate arrays for a customized chip. The design for the circuit is shot into a design computer connected to a second computer which drives an electron beam lithography machine. This machine wires up the different bits of chip for their specialized function; use of this electron beam machine has significantly reduced production time.

The 16 Bit Microprocessor

Although there are already many commerical applications of more sophisticated microprocessors, at the beginning of the '80's the 16-bit microprocessor is the most prevalent. Although sales of these microprocessors presently comprise under 20% of almost a billion dollar market a year, by 1990 they are anticipated to comprise roughly half of a six billion dollar market.[5]

Sixteen bit microprocessors are extremely important for control of industrial processes and comprise the basic building block in future office equipment such as communicating word processors and private automatic branch telephone exchanges.

Here again there are two strategies, one followed by IBM, Texas Instruments and Intel, to produce a basic programmable microprocessor accompanied by comparatively cheap software packets which adapt it to particular uses, the other strategy being to custom make chips for individual users and to totally elimiate the need for any post-manufacturing programming.

Future Developments - Very Large Scale Integration

The main competition between American and Japanese chip makers is focusing around the 64 bit memory chip. These new memory chips can store almost 66,000 items of information, four times as many as 16 bit memories. However, there are real production problems with these new memory chips, and the number of fault-free chips as a proportion of total chips produced has varied from 5% down to no useable chips whatsoever! To circumvent this problem of very low yields in production of the new memory chips, firms like Intel,IBM and Bell Laboratories are building spare parts or redundancy into the memory chips. When they are tested, faulty cells are automatically deactivated and circuits are rerouted to extra fault-free chips.

From 1970 to 1980 the number of memory cells or transistors which one was able to put on a single silicon chip rose from 1,000 to 64,000. Where will it end? How small will maufacturers be able to go?

Here we are interested in both technical and economic considerations required to make VLSI chips. At present, line width on silicon chips averages from two to two and one half millionths of a meter, and each time that the width of a line is decreased 10 times, there is a hundred-fold increase in the number of circuits that can be put on an individual chip. But any chip having over 100,000 circuits may require up to 2 days to test! Also a lot more wiring is needed to connect them to peripherals and to one another.

During the '70's then the number of memory cells or logical gates on a chip was doubled every year. However, according to the most optimistic predictions, during the '80's the doubling of the number of functions per chip will occur approximately only once every two years. Since the 64 bit RAM only became a product in 1979, the semi-conductor industry is no longer operating according to the famous Moore curve (which plots chip density against time and says the number of functions double yearly).

In 1980 two Japanese firms (Matsushita and NEC) announced designs to place 256,000 transistors on a chip of silicon, and in fact the Japanese have recently concluded a four year VSLI programme to develop integrated circuits. Five Japanese firms (Nippon Electric, Toshiba, Hitachi, Fujitsu and Mistubishi Electric) have spent about 400 million dollars on research into tracing very fine circuits onto chips with electron beam machines, and electron beams are now being used to draw circuits on chips finer than the 64 bit RAM's now on the market. Hitachi has an electron beam machine which now can draw a line only .75 microns (millionths of a meter) wide. Fujitsu has a machine which can draw a line .5 microns wide, and Toshiba has been able to reduce the width of beams to .3 microns!

With this background about the technology and industrial trends of custom chip production, programmable microprocessors and their software, let us now turn to a description of the new communications media which they are facilitating.

Videotex and Teletext

Videotex, the two-way T.V. technology through which viewers can easily call information from computers, is presently being developed by almost every industrialized country in the world. It is a low cost method of selecting, transmitting and retrieving information by using a modified T.V. set plus any two-way transmission means such as the phone line, two-way cable, or fibre optics. Using a simple key pad (which is similar to a remote control T.V. selector) or an entire typewriter-like keyboard, viewers can call information from computerized data banks to a modified T.V., which has the capacity to decode and display it.

In addition to information retrieval, videotex can also be used for all-digital written messaging and for interactive services such as home banking and shopping. With mass production it is expected that the microelectronics needed to convert a normal T.V. into a videotex receiver will add only about $100 to the T.V. cost.

The major difference between videotex and all other forms of encoding information - chipping on stone, writing on paper, tape casette recording, or whatever - is that videotex is interactive. A home or business viewer may easily search information stored in a computer by means of key words. Thus if one wanted to retrieve all information stored in a computer on growing jojoba beans, one would type the key word "jojoba" into the videotex T.V.-like terminal. All textural paragraphs in the information pertaining to jojoba could be printed out on the T.V. screen.

Of course one can only search in this way if an entire typewriter keyboard is available to type the key words. Many videotex systems have only simple keypads to search information according to "tree logic". Grassroots, a commercial videotex service for Canadian farmers later discussed in great detail, is illustrative of searching by tree logic. We quote from their brochure. "The Grassroots information bank is arranged like a large pyramid. Each screen-full of information is called the page. At the tip of the pyramid is the general index page that lists a number of subjects such as weather, commodities, market information and so one. Using the simple key pad you select a specific subject, say, weather and move down one level of the pyramid to another subject index that lists the kinds of information available about that particular subject. For the weather it may be such things as this afternoon's local forecast, regional weather, soil moisture content, and so on. Once again, using the key pad, you select a specific area of the subject you're interested in, perhaps the local forecast. Pushing the right key on the key pad, you move down one more level and see an index that offers the local forecast for a list of Manitoba crop districts. Select your crop district and push its number on the key pad. Once again, you move another level down the pyramid and now you see, on the screen, the information you are looking for; in this case, a detailed forecast for your immediate area complete with map showing temperature, wind direction, rainfront, etc."[6]

A videotex system with a search capability by key word is much better than one with a simple keypad. Tree structure or branching logic is quite an incomplete and slow way of looking for information, and videotex systems with only keypad search capability by branching logic cannot be used for computer-aided learning.

Teletext looks just like videotex, but unlike videotex, it's not two-way, in the sense that viewers cannot request information but can only get what has been sent.

Teletext services continuously broadcast information such as news and weather which the user can intercept and display on a modified T.V. These systems are a lot cheaper than videotex, and there is no limit to the number of people who can the service at any one time (as there is with videotex).

In North America teletext is mainly used for things like weather, news, sports and to provide subtitling for the deaf superimposed over a normal T.V. programme.

With teletext, information is sent as part of a broadcast T.V. signal (either over the air or by a T.V. cable). Pages of information are constantly transmitted, and the user "framegrabs" and displays them on the T.V. set. If teletext is broadcast over the air like T.V., it is usually inserted into the so-called "vertical blanking interval" of T.V. transmission. (This is the part of one's T.V. screen which is blank when it's rolling up or down). Teletext is also a lot less expensive to install compared to videotex, but it is one way and cannot include any interactive services.

It is generally conceived that about 200 pages of information is the maximum number that can be placed into the vertical blanking interval; however, if a full T.V. channel instead of the vertical blanking interval is used for teletext information, up to 10,000 pages may be cycled constantly with rapid retrieval of a few seconds by the receiver. One can thus see that if teletext systems are big enough, they appear to be interactive from the viewer's perspective.

One current new use of teletext is that of Time-Life Incorporated, which plans to distribute 24 teletext magazines via satellite.

Another new videotex-like service in North America is computer shopping. Comp-U-Card of American Incorporated, is an electronic shopping service. Comp-U-Card personnel receive phone requests for products and search for minimum prices in several states by computer terminals. It has about 1.5 million members which shop from home by phone. Comp-U-Card will, for example, find one the minimum price of, say, a colour T.V. set to be delivered to the door. In December of 1980, the Times-Mirrors Satellite Program Co. formed a joint venture with Comp-U-Card for the purpose of T.V. home shopping using Telidon, the Canadian videotex technology, and owners of home computers, for about a year and a half now, have been able to search Comp-U-Star Shopping by home computer. Also Warner Amex, in conjunction with Compuserve, an Ohio computer service company announced home shopping by computer in early 1981.[7]

So far the biggest barrier to the diffusion of computer shopping has been the lack in North America of two-way cable television. Right now most existing cable only goes in one direction.

Present and future usages of videotex include interactive transactions such as telesoftware, (sending software over the phone lines), financial transfers and reservations, interactive consumer and business services, computer-aided instructional programmes and electronic mail and messaging. In fact, many of these services are now provided by such U.S. firms as The Source and Compuserve.

Although there are already several commerical videotex services and dozens of videotex trials in North America, its actual widespread use is still uncertain and is being inhibited by the interaction between videotex terminal makers and information providers - companies which provide information content for the various videotex services. Thus, people simply won't buy the videotex decoder necessary to convert the T.V. so that they can receive videotex and teletext information at current prices of $250 to $500 without a wide range of information being available. However, the information providers won't create content to put into videotex systems until there is a market for it.

It is probably quite myopic to see videotex technology in terms of its current uses, since it is so new. Ther is also no reason to assume tht the current applications of videotex will ultimately be the important ones, for it is usually the case that when a new technology is introduced, its first applications often replicate those of existing technology. Thus, teletext and videotex are often thought of merely as variants of electronic publishing.

Many North American newspapers have converted from mechanical preparation, editing and printing of information to computerisation of these processes. Editors, sitting at T.V.-like terminals, write and edit articles directly on a computer screen. The articles are then transformed into digital form and printed by an optical laser printer. But each time information is put into digital form, it is quite easy to store it for retrieval. It is thus natural that newspapers, which increasingly have information in digital form, are becoming information providers in videotex trials. But to view videotex merely as electronic publishing is analogous to the Hutterites, a US religious group who don't believe in the use of mechanical transportation, using two mules to pull a tractor. Transformative technologies changed the structure of industry so radically that we cannot visualize now what they will be like. It should also be remembered that in Philadelphia in the 1890's when the telephone was first invented, the finest business minds of the age got together and said, what possibly could we do with it?

Alternate Delivery Means for Videotex and Teletext

Coaxial cable television (CATV) is another means, beside the phone lines, of transmitting videotex and teletext messages. Compared to the phone lines, CATV can carry more information in a specific time since it has a much greater bandwidth and a faster response time, and its picture qualities are better.

About 50% of home televisions in Canada are wired with cable with only about 20% of US homes wired with a forecast of approximately 50% of North American homes by mid-decade.

Almost all cable that now exists in North America is one-way only, but according to a 1972 Federal Communications Commission (FCC) directive, all new cable laid has to be upgradable to two-way. It is thought that approximately 70% of existing US cable is upgradable.

Although some North American cable companies are offering such services as telesoftware and home computing via cable in addition to T.V., the most advanced with two-way cable are the Japanese. At Tama - New Town, the Japanese have been conducting experimental cable services since 1976. In this project sponsored by the Japanese telephone companies experimental services have been made available to 500 households - including pay T.V., facsimile transmission, still-picture requests and retransmission of T.V signals. The Japanese also have a two-way cable T.V. experiment underway which utilizes optical fibres for transmission at Higashi-Ikoma, New Town. The experimental services are basically the same as those at Tama. however, they also include a videotex service.

Another means of delivering videotex and teletext signals are fibre optics cables, consisting of tiny glass rods. Such rods can handle 1,000 times the capacity of existing cables and are not affected by electromagnetic fields.

Electrical signals are first converted into light pulses and then shot down the rods and reconverted into electrical signals at the other end. The Canadian government and Canadian phone companies are presently engaged in a fibre optic's test in Manitoba. This involves a single fibre optic cable serving simultaneously phone. FM radio. T.V., and videotex services. This is an experimental system and is not commercially available. Also the province of askatchewan has commissioned more than 3,000 km. of fibre optics cables to link 51 towns, and fibre optics cable is being installed in Western Canada in many new installations for long distance phones, communication networks, utility plants, and for connecting microwave relay stations to switching centres; however, its main future use may be in the area of high speed digital data transmission or computer talk.

There has been only a decade of research on fibre optics cables, and many of its characteristics are still unknown; for example, no one knows yet how long it will last! But even assuming continuing price drops, North America is already heavily wired with copper cables and it will take a long time to replace them.

Both fibre optics cable and coaxial cable are two-way and thus can be used for both videotex and teletext; however, an additional means of transmitting teletext involves Multipoint Distribution Services (MDS), a highly directional microwave broadband service used for T.V. in North America. with a maximum radius of about 35 miles.

The Reuters News Agency, for example. broadcasts news information by satellite to Chicago, and then to subscribers via MDS instead of using the CATV connection.[8] Also firms like Equatorial Communications in unnyvale, California. in conjunction with the Commodity News Services, broadcast commodity information in the Western US over satellite plus MDS.

We turn now to a description of the actual videotex technologies developed in each country. noting that virtually all of these videotex systems contain provisions for teletext.

Telidon

Telidon is the Canadian videotex technology. Telidon is really a way of transmitting information. a software rather than a physical invention. It delivers graphics and information through alphageometrics - a method of displaying shapes and characters which are generated from transmitted geometric instructions. With Telidon, picture description instructions are sent to a small microprocessor in the Telidon terminal which tell it what to draw on the screen. Telidon graphics are superb. far better than other videotex systems. In general both information and picture quality are superior to other technologies. and transmission speed is faster. but Telidon requires a lot more memory than many systems.

The Telidon receiving terminal, presently costing about $1,200, contains microprocessor chips which allow the terminal to be independent of both the data base format and the transmission means. It is thought that very large scale integration (VLSI) will allow the Telidon terminals to fall to around $800 within a year or so and will also alleviate the large memory requirements.

Telidon can be used to display or view languages from left to right or right to left on the screen (while English reads from left to right under it) and is compatible with every means of transmitting information presently used or forecast. It can operate over the phone lines, cable lines, satellites, off-air broadcasting, microwave, or any other two-way transmission means and is independent of future developments in display technologies

The Canadian government is actively marketing Telidon, and it has already been commercially sold to groups such as the Times - Mirror Company, publishers of the New York Times, and the Venezuelan Government. In mid-1981, AT&T, America's largest phone company adopted Telidon - compatible standards for all of its future videotex projects

Telidon is being used in several videotex trials in Canada, which are being conducted almost exclusively by phone companies. In 1981, the Alberta provincial government phone company plans to begin a field trial called Vidon involving 120 homes in Calgary and such services as energy management of home utilities and security monitoring. In another trial called Vista, Bell Canada is making approximately 75,000 pages of information available for home users in the Toronto area. Telidon is also part of the Manitoba Telephone

System's Project Ida, which uses two-way cable to reach homes in South Hedingly, Manitoba,and further trials are planned by other provincial phone companies.

Captain

Captain, the videotex technology of Japan, was developed by the Ministry of Posts and Telecommunications and Nippon Telephone and Telegraph, the national phone company The Japanese language of Kanji is based on Chinese characters and has thousands of symbols; a system had to be developed to transmit them. In addition to the Chinese characters of Kanji, Captain can also display the other language forms of Katekane, Kana and Hiragana. Captain operates alphaphotographically - a method of displaying characters and graphics from individually transmitted and stored picture elements. Captain first constructs a whole character on a case-by-case basis and then sends it. Captain characters are not "downloaded" into viewer's terminals. because terminal memories would have to be extremely large. Thus unlike Telidon. there is not a character or pattern generator at the user's terminal, but a very large pattern generator at a Captain centre for many users.

At the end of 1980, there were more than 150 information providers for Captain including newspapers, publishers, advertising agencies, broadcasters, banks, public utilities, and department stores.

It is thought that future markets for Captain will be quite specialized - such as languages which have too many characters to be presented by other videotex systems. Costs of computer time and memory however are enormous, and Telidon, which has graphics which are just as good, uses much less memory and computer time.

Since December of 1979, a Captain trial has been underway in Tokyo with 100,000 pages of information and terminals in 1,000 homes and offices. The Japanese phone network has thirty six million subscribers, over 85% of Japanese homes. Over 90% of these homes have television sets, and the Japanese plan to have Captain in all homes with T.V. sets by 1991. In fact, the Japanese, as we saw, have been involved in experiments with videotex since the early 1970's in the town of Tama with the High-Ovis system (highly interactive optical video information system), which uses cable T.V. Also a High-Ovis trial was begun in 1978 in Higashi - Ikoma which utilizes fibre optics for 158 homes and 15 public places. This trial, sponsored by the Ministry of International Trade and Industry (MITI) was a joint venture of firms involved in computer, fibre optics and television equipment.

In addition to Captain, Nippon has developed another videotex system called Circle, which is economical and easy to use. This system can display photographs, Japanese characters, graphics of all types, and illustrations. Toward the end of 1979, Nippon demonstrated the system via satellite between Singapore and Tokyo, making the connection via the Intelsat communications satellite and used speech recognition equipment as an alternative to keyboards to input information.[9]

Prestel

Prestel, a project of the British Post Office, was the first operating videotex system in the world and was available from September of 1979.

By December of 1980 there were more than 7.000 users. 88% of which were in businesses with only 917 home terminals. Fifty percent of the business terminals were in the travel industry with 10% each in investment businesses and computer and electronic firms and only 5% in publishers

Prestel uses a central host computer, operated by the British Post Office, in which information is stored. It is difficult to make Prestel run on a computer other than a DEC 4080 or for its software to be written in differing computer languages, and the British are tailoring their system toward in house business usages.

In January of 1980 there were more than 400 information providers for Prestel including the Economist, Dow-Jones, Express Newspapers Ltd . the New York Times. the Reuters News Agency and Times Newspapers.

Broadcasters in Britian also operate two teletext services - Ceefax, which has had 400 pages on two channels of the BBC since 1977. and Oracle, run by the non-government ITV. As of 1980, there were approximately 35,000 T.V. sets in Britian with teletext decoders.

Prestel was initially thought of as a public network in which users could access all of the Prestel pages. However. "closed user groups" which do not want information divulged - such as financial institutions or trade unions - can use the Prestel facilities for private purposes. In fact this seems to be its main usage.

It is expected that future uses of Prestel will occur under the direction of private firms modifying software to produce tailor-made corporate applications at low prices.

Finally, seven countries have been participating in an international service called "Prestel International" - Austria, the Netherlands, Sweden, West Germany, Switzerland, England and the USA. The content is being tailored to business users such as airlines and currency and stock information. Full commercial service was begun in mid-1981 concentrating on inter-branch users of transnational corporations. and there are plans to immediately expand to the near east.

Antiope

The French government has a national integrated programme for the new information technologies called Télématique - which will incorporate a range of electronic services including facsimile transmission and electronic funds transfer, into one system, Antiope, which is designed to be a combination of both videotex and teletext; it was developed in 1973 by the CCETT Research Centre. in collaboration with the French government.

Antiope uses redefinable character sets which are downloaded into the Antiope terminals and then sorted and decoded. Like Telidon, the Antiope coding scheme is independent of the transmission means, since the order of information packets is rearranged by the microprocessor in the user's terminal.

The French are currently conducting two major videotex services. In the first, Teletel, a videotex experiment in Velizy is planned for 1981 with 3,000 users. In Teletel, all data bases will be stored on external, host computers in such a way that any information provider will also be a videotex system operator. Thus the system will allow closed-user groups to instigate and use data bases which they wish to restrict from other firms. All data bases will be transmitted by the French packet-switched network. Transpac.

In the second service - the Electronic Directory Project - the French government plans over the next decade to distribute free more than 30 million videotex terminals to replace all phone directories.

The thinking here is that once the terminals are in the home for directories, they can then be used for any other purposes, and also with this audacious strategy, France is immediately creating a mass market for home terminals. French terminals in this project retail for around $100. The 1985 goal is 4 million homes with 34 million homes by 1992.

The French are also planning a quasi two-way capacity for teletext via a hybrid system called Inteltext, which uses the broadcast channel for transmitting information and telephone lines or two-way cable for user responses.

They are actively seeking export markets for all of their videotex technology and have been exploring joint marketing with Tymshare Inc., the large California computer service firm and have sold Antiope technology to Brazil.

Bildschirmtext

The West Germans launched their first videotex tests in June of 1980 in Berlin and Dusseldolf. The test has 6,000 users and the videotex system, Bildschirmtext, was developed by the Deutsche Bundespost. As in several countries, one of the main motivators was newspapers - the Federal Association of German Newspaper Publishers. The newspapers involved in the test have called videotex

"Bildschirmzeitung" (or screen newspaper) and thus are attempting to avoid being subject to broadcasting regulations. (The federal constitution of West Germany makes the press non-regulated).

The Berlin tests are focusing on business applications while in Dusseldolf, they are centering on private consumers. In both these trials, the user purchases a license which enables him to buy a T.V. set plus the videotex decoder for the same price as the normal T.V. set. Monthly subscription rates are less than $3, exclusive of telephone charges, and there are no installation charges.

Telset and Mistel

Telset is the videotex system of Findland and was founded by the Helsinki Telephone Company in conjunction with Finnish electronics and publishing companies in 1977.

T.V. sets with videotex technology cost only $100 more than normal T.V sets. and modems (devices to hook the videotex terminals to the phone lines) are rented to users by the phone company for about

$40 per month. Eleven private firms are already using Telset as a private information system for inter-corporate communications.

The Finnish situation is very congenial for videotex since cable T.V is forbidden in Findland. and all local systems are operated by the private telephone companies. Also a recent Finnish ruling states that the electronic distribution of newspapers is not broadcasting, and thus the local newspapers can team-up with the phone companies.

In 1981 six newspapers began tests of videotex, focusing on market studies to learn what people read, how long they read, how quick access is to the system, and so forth

Findland also has a business videotex system which has been in commercial operation since April of 1980 called Mistel. It has the same features of the Telset system such as key-word search, and both systems can be run on DEC and Honeywell mini-computers.

Several other countries are experimenting with videotex technologies, but all of these are variants of those discussed.

We turn now to a description of first the North American videotex commercial services and then videotex trials which are in progress. Prestel, we saw, focused on closed-user groups of a corporate nature who use videotex mainly by creating their own private data bases. This is not true in North America. and one of the first users are farmers.

Agricultural Videotex: Green Thumb

The first functioning videotex information markets and commercial services in North America are occuring in agribusiness, with Green Thumb and Grassroots.

At the beginning of 1980, project Green Thumb (Green Thumb Agricultural Weather/Marketing Project) was began with funds from the US Department of Agriculture and the National Weather Service.

Several hundred videotex terminals in two rural Kentucky countries could access information on weather, marketing, crop commodities, pest control, and crop conditions.

The videotex terminal for Green Thumb was devised by the Tandi Corporation and is referred to as the "county machine", since it is designed to support a rural base and is very simple to use. In fact, as a result of their participation, the Tandi Corporation, via their Radio Shack outlets, now markets a very inexpensive videotex box (decoder. keyboard and modem for less than $399).

The Green Thumb system is really quite simple. Data related to agriculture is entered into a main frame computer in Lexington Kentucky and relayed to a county microprocessor via the phone lines.

Farmers select information to view on their T.V. screens. and the system merely calls the county microprocessor to request it.

Information is transferred to their own home terminal and appears on their T.V. screens. Specific agri-information includes marketing information available from the Mercatile Exchange Wire Services and the Chicago Board of Trade updated every 15 mintues, weather information from the National Weather Service which is continuously updated, price information for crops like corn, wheat, or soy beans from grain elevators within a 100 mile area of the farmer and across the nation.[10]

Grassroots

In Canada, Grassroots, an agribusiness videotex service, was begun in Southern Manitoba in April 1981. Farmers are being offered information on weather, planting, harvesting, time-dated market prices, grain and other commodity features, and fertilizer and feed costs.

Videotex terminals have been located in provincial agricultural representatives' offices, grain terminals and community centres. Specific information providers in the Grassroot service include the following:

The Winnipeg Commodity Exchange is offering complete price and volume information for all grains traded in the future markets on a 15 minute basis, coming directly from the trading floor. This packet also includes after-market summaries, and the Commodity Exchange is developing detailed graphics for farmers which provide clear easy-to-read pictures of short and long term trends for each commodity.

The World Weather Watch is a satellite generated weather forecasting service provided by Meteorogical and Environmental Planning Ltd., which offers full colour weather maps showing exactly where the weather is and how it is behaving. Twenty-four hour weather forecasts are broken down to the level of local crop districts and show weather conditions for a 50 mile radius around the farm. World Weather Watch also provides current and long term forecasts for the Canadian Prairies and daily forecasts of temperature and rain.

Future information packages will provide computer generated maps showing soil moisture content

The Manitoba Department of Agriculture provides information packages on the Manitoba Crop Insurance Programme and the Manitoba Agriculture Credit Corporation. A feature called Current Focus gives regular updates on the market outlook for dairy and poultry, grain and livestock, crop recommendations, wheat control bulletins and information about soil and wheat testing services.

The Canadian Grain Commission, which regulates all grain handling in Canada, is providing regular statistical information on the supply and movement of Canadian grain. They provide weekly summaries of supply and movement and existing stocks of Canadian grain and also make available any new rules and regulations relevant to the grain industry.

The Manitoba Cattle Producers' Association in cooperation with the Canadian Cattleman's Association is providing daily information on prices of various grades of cattle for all major markers in the US and Canada. This information is being expanded to include information on future beef prices, cattle prices, and market trends.

Farmers' Personal Computers

In January 1981 the Professional Farmers of America started a service called "Instant Update", which will incorporate Green Thumb material. For less than $100 a month farmers will be able to lease a Tandi Corporation terminal and access the data base, and firms marketing Green Thumb - like material such as weather and market information - some using satellites for information distribution, are coming into existence in the United States.

Farmers in North America are increasingly buying small home personal computers mainly for business accounting, herd performance and payroll functions. Communications software now being planned will allow anyone with the popular home computers, now diffusing through North America, to access the Green Thumb county microprocessors. It is thus planned in the second phase of Green Thumb to start software development for record keeping and problem solving for farmers to download software to the home computers. By such downloadings, farmers will be able to do stand-alone computing indefinitely. Most agricultural colleges in North America now have courses to aid farmers with computerized records and problems, and it is widely estimated that by 1990 20% of North American homes will have personal computers. The percentage of farmers will be even higher since farming in North America requires a massive amount of record keeping and problem solving. So far most of this computerized problem solving - such as recipies for mixing pesticides, irrigation scheduling, food intake analysis, etc. - has been done via large time sharing computer networks such as Nebraska's Agnet. However, distributive software for farmers via Green Thumb - like videotex systems offers real cost advantages over big time sharing networks, in which the analysis is done on the external "host" computer.

In the future we may see a convergence of videotex systems with personal computers In fact, videotex boxes and the new personal computers are almost the same things. If a farmer with a home computer also has an accoustical coupler or modem, he can access any time sharing networks such as Agnet.[11]

Information selectivity and retrieval tools like Grassroots will soon be as important to North American farmers as tractors and pesticides. With simple keypads, farmers are now directly interacting with information banks and receiving agribusiness information over their home T.V. sets.

Public Videotex: The Source

A North American commercial videotex service directed to the general public is The Source. The Source Telecomputing Corporation, owned by the Readers Digest, is a computer service company in Virginia which provides a varied range of information programming to private individuals with personal computers or intelligent terminals Its rate structure is unusual, and include an initial fee of $100 plus $15 per hour for prime time use but only $2.75 per hour for use between 6 p.m. and 7 a m. Individual subscribers, as opposed to companies, now comprise over half of their total business, and they report as of the middle of 1981, over 10,000 users with new users signing up at the rate of 700 per week.

Their services includes computer-aided messaging between terminals, downloading of accounting and financial software for individuals and small businesses, financial and travel information, journal abstracts, the New York Times and the UPI News Services, personal cookbooks, classified advertisements, computer games and computerized educational programmes.

In total, several thousand programmes and data bases can be accessed in The Source for less than $3.00 an hour. Also computer teleshopping is possible.

Speech Synthesis Capabilities in The Source

In the first part of 1981 The Source and Texas Instruments announced an agreement whereby Texas Instruments software for colour graphics and for voice synthesis commands would be available to users of The Source who had Texas Instruments 90/4 personal computer.

This capability is supplied in the form of a simple plug-in programmable ROM which goes into 99/4. The effects of adding voice capabilities to such videotex services are incalculable, but one immediate application would be to have electronic mail read aloud and in computer-aided learning.

The Source is also selling terminals and has already agreed to purchase a minimum of 250,000 cheap intelligent terminals from Télic-Alcatel - the French manufacturer who is making the terminals for the electronic directory project. The Source plans to market these terminals along with its information services to small businesses, but Telic-Alcatel is distributing terminals directly to the business community in the United States along with PABX systems.[12]

Compuserve

Compuserve, owned by H.R. Block, the big tax company, is a computer service firm with a number of main frame computers in Columbia, Ohio. It sells mainly data processing to large corporations but also sells excess time and videotex services to computer hobbyists. (Rates are about $5.00 an hour.) As of mid-1981, it has more than 10.000 users.

The Compuserve service includes computer-aided messaging, securities and commodity information, personal financial information, computer and educational games, and the personal computing services for a variety of software.

Compuserve has already been signing a number of agreements with Apple II, Atari and the Tandy Corporation. all manufacturers of personal computers, so Compuserve software may be downloaded on a variety of personal computers.

US Videotex Trials

In addition to the above commercial videotex services, there are a large number of videotex trials currently being undertaken in North America. These are important both for their content and for who is conducting them. The Americans have adapted the videotex technologies of other countries in these trials, and have not produced their own technology.

AT&T

AT&T, America's largest phone company in a joint venture with a subsidiary of Knight - Rider Newspapers is conducting a videotex trial called Viewtron in Coral Gables. Florida.

Begun in July 1980 with 30 terminals in 160 homes, Viewtron has focused on computer shopping. Information providers include newspapers such as the Miami Herald, the New York Times, publishers such as McMillan Publishing, and news and stock agencies such as Dow Jones and Co., and the Associated Press. In addition, there is retail data from Sears Roebuck, J.C. Penny Co., The South East Banking Corporation, and airlines information.

AT&T has also been conducting trials with videotex terminals replacing telephone directories in Albany, New York, and Austin, Texas, although these trials are not as extensive as the French and involve less than 800 homes. The Austin trial, however, also extends beyond the directory concept and includes classified ads which are normally the perogative of newspapers.

The newspapers are fighting AT&T, accusing them of attempting to rush in to establish a kind of "squatters rights" in videotex operations before the FCC can determine how videotex should be regulated in North America.

GTE

GTE, the second largest US telephone company after AT&T, negotiated North America license rights for Prestel software in June of 1979, and is offering local videotex franchises to newspapers. They are thus avoiding the newspaper fights.

In a plan announced in late 1980 called Infovision, newspapers would buy a complete videotex system from GTE.

CBS

In November 1980, CBS, the US T.V. network, announced market tests at two T.V. stations, both using the French Antiope technology. Antiope is providing a million dollars worth of technical assistance and equipment.

Information will include news, travel, computer games, children's education material. emergency home services. and closed captioning for the deaf.

In addition, a number of local T.V. stations such as the Morman church station, KSL T.V. in Salt Lake City, Utah, WETA, the public broadcasting T.V. station in Washington DC, are involved in teletext tests to the home.

Cable Companies

Undoubtedly one of the most innovative groups in the development of North American videotex so far has been the cable companies operators. Cable Systems Pacific in Portland, Oregan, for example, plans to offer the following videotex and teletext services: the Reuters Monitor (an information retrieval service including specific financial and commmodity information for professional investors), teleshopping (10 channels of video-retrievable shopping), Telidon information retrieval, and home education information services for public health care professionals and hospital outpatients). Cable

Systems Pacific also give users access to GTE's packet-switched data network for computer-based mail and messaging. All of these services plus 50 channels of T.V. will cost only $10.45 per month.

Many cable companies in North America are either offering or experimenting with such services Typical of these is Cox Cable, a large multi-cable operator which has developed a system called Indax which will go into all further cable markets that Cox wins. For only $6.00 a month, subscribers pay for renting an intelligent terminal with unlimited access to services such as information retrieval (for example, some of The Source data,) the New York Times, airline information, and transactional services with retailers and banks.

Other groups conducting services and trials for videotex and teletext range from libraries and news agencies to satellite programmers and publishers. Southern Satellite Systems, in conjunction with the cable companies, is planning to concentrate on teletext and videotex services over satellite for closed-user groups such as stockbrokers, lawyers and doctors, and the Satellite

Corporation, the direct broadcast subsidiary of Comsat, plans to launch pay teletext services over direct broadcast satellites in 1986.[13]

Personal Computers

Until about mid-1978, almost all the small. microprocessor-based personal computers in North America were sold to computer hobbyists. They were mainly used for home experimenting, learning games, computer networking, making graphics and music. and personal business.

There are any number of personal computers now on the market, such as The Pet, manufactured by Commodore of Santa Clara, California, retailing for just over $1,000.00, Atari Corporation's Atari 800 for about the same price, and Radio Shack's TRS-80 Model 1 retailing for just over $600.00. However, the Mercedes of personal or home computers is the Apple 2, manufactured by the Apple Computer Company of Cupertino, California and retailing for just over $1,000.00. The Apple 2 has a very fast disk drive and excellent capabilities for graphics. More importantly it has one of the best software packages available of all of the personal computers and can be expanded quite simply into a powerful machine for the small business.

New Markets

In 1975, the first year of real sales of personal computers in North America, 20,000 were sold, and by 1980 over 500,000 were sold, with predominante contenders being Radio Shack, Commodore, and Apple.

This means that now roughly between one half and one percent of the households of North America own personal computers.

Recently the market for personal home computers has shifted from the computer hobbyists toward small business professionals such as doctors and dentists who are using them for mailing lists, payroll, and accounting purposes, and toward managers and engineers in big corporations who are using them as private work stations, but the expected large consumer market for personal computers used as home educational tools and selling for $1,000 or less has not yet taken off. Some manufacturers are therefore redesigning their home computers for engineers, accountants and small business managers. Typical of the new computers is the Apple 3, introduced in May of 1980 and designed specifically for word processing and financial analysis in small businesses This computer retails for about $8,000, but has been having real problems with software availability.

Small, microprocessor-based personal computers are beginning to invade the markets of the mini-computer manufacturers such as IBM and Xerox, and increasingly managers in large firms are buying their own Radio Shack TRS-80 personal computers rather than using the firm's computer department.[14] Since some large offices of big corporations now have dozens of personal computers, personal computer manufacturers are increasingly equipping their machines with abilities to communicate with other computers in networks, as the main-frame IBM computers already do.

Until recently the personal computers have been the domain of electronics firms such as Tandy and of firms making only micro-computers, such as Apple. But since corporations are beginning to order these computers in batch for their managers and engineers,[15] large manufacturers are entering the market. In mid-1981, the Xerox Corporation became the first major producer of office equipment to enter the personal computer market. Their new personal computer, the Xerox 820, can also double as a word processor and is compatible in pricing and computing power to the more expensive computers made by Tandy and Apple. It can also utilize a large amount of software written for other computers.

The Xerox 820, retailing for $3,000, includes a half page video screen, two 5-1/4 inch diameter disc drives and 64k bytes of memory. Programmes which enable it to be used as a word processor sell for about $500.

Convergence of Videotex and Personal Computers

There is also a growing trend for videotex capabilities to be incorporated into personal computers. In September of 1979, the British Post Office allowed a personal computer manufacturer in Britian to insert modules which would allow users to access the Prestel services. In the United States and Canada, the Apple 2 personal computer users can access the Dow Jones Industrial Averages and information services such as Compuserve and The Source. Norpak, one of the Canadian manufacturers of Telidon terminals is manufacturing Telidon "interface cards" for Apple 2 and Apple 3 computers which enable them to function as Telidon terminals In fact, if videotex terminals are intelligent (that is if they have microprocessors in them), they are basically home computers, and if home computers have access to the information providers, they are also videotex terminals.

Telesoftware

"Dumb" terminals, we saw, are terminals which allow one to merely receive and display information in a fixed format but not to do any further processing at the terminal itself. All personal computers are intelligent, containing microprocessors and memory chips which enable them to store and use computer software sent to them over the phone lines. Computer software in fact, can be simply broadcasted over cable, phone lines, satellites, or any combination of these to any user's intelligent terminal. With "telesoftware" as it is called, software is downloaded into personal computers or other intelligent terminals. Although the market for telesoftware is comparatively new in North America, it already exists. Compuserve for example, distributes software to users in this manner. Software is often enormously expensive to write, cheaper to rent, and is first downloaded and stored in the user's home terminal. It is used for a certain amount of time and at the end of that time "disabled" from the other end.

Personal Computer Networks

The personal computer is basically an intelligent terminal.

It can function both as a videotex receiver and as a stand alone storage and computing device. In fact, as of the middle of 1981, videotex systems are still much more expensive than the personal computers.

With growth in the number of personal computers in North America, there has also been a growth in personal computer networks. The Source and Compuserve, both operating on time-sharing computers with information sent over the phone lines to users with personal computers and modems are examples of such networks.

The Source offers the more sophisticated key word search method, and both Compuserve and The Source are planning to initiate graphic services which will rival any existing videotex systems in the world. As of the end of 1980, both The Source and Compuserve together had approximately 20,000 users, which is larger than any videotex system. But although The Source and Compuserve offer fairly sophisticated downloading of a wide variety of software, one of their main uses so far has been computer-aided messaging beteween users.

Computer-aided messaging systems are not new, and the large multinational enterprises, international and national banks, and Japanese trading companies have long had international computer networks.

Illustrative of these is IBM's European Laboratory Computer Network. This network is used for development of software in five European countries.[16] With this network, software support work for the logical design of large scale integrated circuits does not have to be duplicated at each facility, and large costs savings are possible.

The most striking development in North America, however, has been the recent growth of the personal computer networks. Videotex information services such as The Source and Compuserve now provide computer-assisted messaging, telesoftware of all types downloaded into personal computers, time sharing computing done via the phone lines on outside main-frame computers, word processing, financial data, all types of mathematical and statistical software packages, and the ability to write software at home. With the downloaded software packages. personal computer owners can access software for home finance, small business or anything that he or she cannot write himself.

The market for personal computer services is being driven on by several factors, including the growth of computer hobbyists and the decline of computer business service organizations.

Time-sharing business computer services allow firms to use external, high-cost main-frame computers. These services are used by firms which cannot afford to buy an in-house computer or in cases where the in-house computers would be more expensive than any computer service. However with cheap microcomputers invading the small businesses, this advantage is rapidly disappearing, and so is the industry.

Some observers have noted that, unfortunately the main manufacturers of personal computers, such as Apple, Commodore Business Machines Incorporated, and the Tandy Corporation, are making the same errors that the main-frame and mini-computer industries made in their early years of development. They are building systems and software that can't communicate with products of other manufacturers and that a great deal of money is being put into software that is not portable from one system to the other.[17]

Perhaps the major reason for the difusion of personal computers is the increasing availability of software for small business. Typical of software manufacturers for the small business computers is Personal Software, Inc., who make Visicalc - a business software package which transforms personal computers into almost an executive work station. Recently this firm has introduced[18] Visiplot - a computer graphics package, Visitrend/Visicalc - a graphics, statistical and forecasting package, Visidex - a system for indexing information, and Visiterm, a communications software that allows micro-computers to use time-sharing systems. Each package retails for about $200.

With an increasing availability of business software for the personal computer, Radio Shack has entered this market, trying to sell TRS-80's to big firms to be used as personal work stations.

Speech Synthesis and Speech Recognition

Perhaps the most transformative application of microelectronics technology discussed in this work is speech recognition. Already in the West there is a wide range of microprocessor-based products which can both synthesize and recognize spoken voice - ranging from Texas Instruments' "Speak and Spell", a $60.00 hand-held educational tool for children - to $34,000.00 mini-computer based, voice recognition systems of firms like Interstate Electric, a California manufacturer, which are already used for things like factory quality control. At the end of January 1981, Interstate also announced its first microprocessor kit for voice recognition, which will be put into consumer products, and sells for $10.00 each in orders of over 100,000.[19]

Typical applications for Interstate's speech recognition technology involve matters like voice-activated games, kitchen appliances and phone dialling; however, other, more complicated applications involve voice-activated radios, air conditioning and ignitions for automobiles, electronic funds transfer-bank data entry terminals activated by voice have less errors than those activated by typewriter keyboards - and factory quality control.

Some of the Hitachi robots in Japan are activated by spoken commands, and in the US General Electric uses voice recognition systems for quality control in some of their factories; another use will increasingly be in computer-aided design, in which design engineers, using a computer-based design terminal, can simply verbally call repeatedly used designs instead of having to call them by typing on a keyboard.

The Japanese, due to the intricacies of their printed language, are particularly advanced in speech and pattern recognition. It is reported[20] that they are already planning a fifth generation computer which will be a "system that can reason and solve problems from input of natural information such as non-computer languages, spoken words, handwritten words and graphics."

For spoken announcements in office buildings, automobiles,airplanes, elevators, trains, and computer toys and games, solid state speech messages are replacing lights, bells and buzzers. Chip-generated electronic speech can now give complex directions in any language. But what precisely is solid-state speech synthesis and speech recognition?

Giving a Microprocessor Voice and Ears

Until fairly recently, electronic announcements were limited to recorded tape, which was often mechanically bothersome. Telephone announcement systems were in fact the first speech synthesis technology which used analogue-to-digital chips to convert voice into computer talk. However. until recently, memory had to be enormous even for a few words, and a single second of digital speech required up to a hundred thousand bits of memory. Present techniques of speech synthesis allow for a massive reduction in memory required for speech, as low as 400 bits per second depending on the speech quality desired.

National Semi Conductor is now producing a speech synthesis module called the DIGITALKER which consists of multiple integrated circuits containing both a speech processor chip and a speech ROM. In use with an amplifier. filter, and speaker, the system produces high quality solid-stage speech including the original emphasis and actual inflection.[21] It is possible to synthesize both male, female, and children's voices. The actual encoding or digitizing of the words and phrases the customer wishes to use is done by National Semi-Conductor.

The present applications of the DIGITALKER include talking clocks, hand-held language translators, various consumer products, automobiles, teaching aids, telecommunications equipment, and announcers of all types in transportation systems.[22]

Giving microprocessors the ability to speak is comparatively easy, and learning tools with artificial voices such as Texas Instrument's "Speak and Spell" have been on the market for a couple of years now. More difficult is teaching one's microprocessor to recognize one's own speech. This is speech recognition.

Speech recognition systems will be universally used to interact with computers in the future. Speech is the most common natural form of communication, and anyone can use a speech recognition system without any extensive training.

People presently communicate with computers by complex languages such as PASCAL, COBAL and FORTRAN, which are defined by explicit rules. "Natural languages" such as French and English however, are defined implicitly by common every-day-usage, and spoken language is automatic and rapid. Using it does not require physical or visual contact with a person or a computer. and there are no retrictions on hand and body mobility as there are when typing out a computer programme. "A machine capable of recognizing human speech can combine such advantages with quite different powers of the computer. Such a machine can provide universal access to large data bases through the telephone network. It could provide further control of complex machines by verbal command and make possible sophisticated prosthetic devices for the handicapped".[23]

Although current speech recognition technology has an extremely limited vocabulary, little ability to deal with rapidly spoken sentences, and almost no ability to contextualize - for example distinguish between spirits as wine and spirits as ghosts - its advantages are so enormous that systems capable of recognizing less than 50 words are already commercially available on the market. (Bell Laboratories claims to have at the research stage a speech recognition system which can deal with up to a thousand words, including connected speech, if the speaker talks slowly).

Until recently, speech recognition technology has been extremely expensive, but VLSI analogic-to-digital chips are rapidly changing this, and low priced modules for speech recognition, predominantly aimed at original equipment manufacturers, are coming onto the market in 1981. It is predicted that within the next couple of years products ranging from computer terminals to office switchboards and T.V. sets will be able to respond to spoken language. The market, which was 10 million dollars in 1980, is expected to top one billion dollars by 1988.[24]

Almost all of the speech recognition modules now being produced understand less than a hundred words, and those words must be first taught to the computer by repeating words and phrases several times. Such sounds are then converted into individual digital codes and stored in computer memory. When a user next utters a word, the digital code for the word is compared with the previously stored data until a very close matching is found. Most of the systems are about 85-95% accurate, but the accuracy drops if a speaker is sick (for example has a cold) or the room is noisy.

Voice recognition systems are already being commercially used in North America by the General Electric Company and Lockheed in fast-finger assembly line production, and speech recognition systems may impact on the location and economics of fast finger assembly work in developing countries.

Costs for both processing speech signals and for storing speech on memory are dropping radically, and new venture firms are quickly joining the established producers like Interstate Electric, Exxon's subsidiary Verbex, and Threshold Technology. Just within the past couple of years these firms have been joined by new ventures such as Heuristics Inc., Auricle Inc., Vortan Inc., and the Centigram Corporation of Sunnyvale, California.

Heuristics, for example, now manufactures the Heuristics 7000 Speech Recognition Unit, a low cost industry-compatible speech recognition module which will give speech input capability to almost all computer terminals now manufactured. When connected to a terminal, the unit may be used to input and retrieve data or give commands simply by talking. Since most people cannot think while they are typing, the unit allows one to concentrate on work instead of on the keyboard while keeping hands and eyes free. The Heuristics 7000 can be programmed to recognize up to 64 words and phrases, each one up to three seconds long. Such a unit is much faster and easier to use then writing, typing, or pushing buttons.

Voice linkage is also much more accurate than other forms of entering data into computers, and as yet we simply have no idea of the enormous productivity gains which will occur when people don't have to interrupt other activities to enter computer data, and more importantly when computers can be used easily by non-technical people who know little software.

The applications really are endless. "In inventory control operations, you can call up information and enter data without using the keyboard or looking at the terminal screen. In counting or tally operations, you simply speak the numbers and they are entered on the screen. If you are looking through a microscope you can enter data without taking your eye from the eyepiece . . . . Other applications include management information systems, processs control, credit verification, quality control, source data entry and verbal word processing."[25]

Heuristics also now manufactures the H2000 Speech Link, for users of Apple 2 personal computers, which is capable of recognizing 64 words or phrases of the users' choice on an Apple personal computer. The H2000 substitutes voice for the keyboard and enables one to control the computer while continuing to think. One can even write simple software on the Apple 2 by voice control. By simply talking into the terminal's microphone, one can perform almost all of the operations previously done only by typing on the terminal's keyboard.[26]

Another firm, Auricle, is manufacturing a $2,500 speech recognition module and plans to cut costs to $500.00 by early 1982, and big manufacturers such as IBM are developing speech recognition products which will be able to recognize unlimited streams of words from any speaker and not merely the speaker who trains the computer.

Uses in Manufacturing

Already original equipment manufacturers are using speech recognition units in their products. The Calma Corporation, which manufactures computer-aided design technology, is using Interstate speech recognition modules in some of their terminals. This module radically increases the productivity of a design engineer, and allows him to build an image on the screen with a light pen while simultaneously manipulating the image with 50 voice commands. such as rotate. up, and down.

The General Electric Company is already conducting pilot tests of speech recognition devices in a Colombia (MD.) plant., which will be used to collect production and quality control data. Inspectors will speak directly to the computer instead of writing down product numbers and defect codes. Speech inputs will go directly to the plant's main computer and will enable managers to track defects extremely rapidly. It is expected that the system, costing around

$300,000, will pay for itself in less than one year and a half.

Speech contains much fewer errors than written data, and in the next few years speech recognition devices will be universally used for all repetitious data entry applications and in all fast finger applications such as the actual microscopic inspection of integrated circuits

Future Industrial Competitors

The Japanese have special reasons to excel in the development of language recognition products, since their language necessitates extremely complex typewriter keyboards. It is expected that Japanese firms will soon add a speech recognition capability to products such as personal computers. Already some Japanese companies have produced T.V. sets which respond to voice command, although none of these are yet available on the market. The major US word processing companies are also entering the fray. IBM, Hewlett-Packard Company, and Wang Laboratories will be introducing products in the next couple of years, and it is thought that large multinational electronic corporations will eventually control the market for chips that can recognize spoken voice as they now do with speaking chips.

Communicating Word Processors

Word processors are simply microprocessor-based typing and editing systems. Word processors first display the text one is typing on a T.V.-like screen, allowing one to add, delete, insert, change, and vary the format of the text and get it just the way one wants before printing it out on paper.

Word processors can store a large amount of text, usually on "floppy discs", which look like 45 rpm records and which are permanently encased in cardboard dust jackets. The disc is made out of thin plastic covered with the same type of magnetic surface one finds on a cassette tape, and one can store as much as a million characters of information on one single floppy disc.

There are many excellent word processing systems on the market in North America today, manufactured by such firms as A.E.S. Data Ltd., IBM, Wang, and Xerox. However, they are all still quite expensive, and the minimum cost in 1981 for a good word procesing system runs around $4,000 - $10,000.

Although it does not have the versatility of the big word processors, the Typecorder, a comparatively inexpensive, small hand-held, portable word processor was introduced by Japan's Sony Corporation in late 1980. It uses a microprocessor for electronic typing, correcting, and editing, and has a small liquid crystal display to show the text. An executive can thus work while travelling and when back in the offfice can have the text typed out on conventional electric typewriters by using Sony's new "Actuator

Unit".[27]

Many of the new word processors can communicate with each other and with other types of office equipment over the phone, cable or satellite lines. If one has a communicating word processor into which text may be typed in New York and printed out on another word processor in San Francisco, one has a computer-aided messaging system. Such message systems store messages in the receiver's terminal if he or she is not there or simply busy, and an executive does not have to try again and again as he often does with telephones. Communication is "non-simultaneous". An executive gets a written message over his T.V.-like terminal. and is able to see and respond to the message when it is convenient to do so. There are thus fewer interruptions. By the end of the decade an organization without communicating word processors will be about as effective as one today without telephones.

Researchers claim that the content of such computer messaging is vastly improved over the less structured verbal communication, and increasingly there is attention being paid to the "people issues" of making such technology "user friendly" -- that is, making it simple and easy to use.[28] However, the real productivity implications of communicating word processors will be seen when they are linked to one another and to other digital office equipment in an "integrated office" and used by senior business people.

Integrated Office Equipment

The integrated office might include word processing, computer-aided messaging, facsimile* transmission, electronic filing for storage and retrieval of documents, and communication linkages to

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*With facsimile one can transmit graphics in addition to text. Facsimile technology, which has been around for a long time, breaks the page of information into thousands of discrete dots. transmits them and reconstructs them at the other end.

corporate files outside the company via digital satellite systems such as IBM's new packet-switched business communications satellite (the SBS-1). All of the above is accessible from a single T.V.-like terminal or work station sitting on an executive's desk. The executive is able to create both text and graphics, send them electronically to someone in another room or across the nation, and retrieve and store information in computer memory instead of a filing cabinet. Since executives spend a lot of their time trying to reach one another on the phone, word processors used as computer message systems involve major cost savings in business.

Markets for integrated office equipment are expected to range from tens to literally hundreds of billions of dollars a year in North America. The original equipment manufacturers who now produce merely one part of such office equipment are trying frantically to extend their products. The phone companies are diversifying into data processing in addition to voice, and the computer companies such as IBM are diversifying into data transmission.[29]

The main problem so far with the integrated office equipment is that each equipment manufacturer has been creating word processors, small business computer terminals, and other equipment which will communicate only with his own equipment. But as we shall see this problem is being partially alleviated with the development of local business computer networks such as Xerox's Ethernet.

Packet-Switched Networks

Although computer-aided messaging systems can efficiently operate over very old phone lines. the transmission link in North America for such messaging and for most of the communiations technology discussed in this work is a packet-switched network.

In packet-switched networks, such as Tymnet and Telenet in the United States, a computer breaks each message into tiny packets, each representing but a portion of the entire message. Packet-switching thus allows different users to send messages over the same route at the same time.

Packets of messages are first sent to a switching computer or node. If the node receives two separate messages from two different terminals, it will mix the packet from one with the packet from the other, and separate messages will travel along the same line at the same time. At the other end, another switching computer separates the packets comprising each message and sends them in proper order to the right destination where another computer reassembles them.

Since packet-switched networks can be used by many users at the same time and capacity is increased, the cost of using such a network is extremely low. The sender is normally charged simply for the amount of information sent, but not charged for using a certain bandwidth or for the connection time.

The original packet-switched network in North America was the ARPANET (Advanced Projects Research Agency of the Department of Defence), and many of the innovative computer protocols -- that is, means of getting computers to enter each other's systems and to talk with each other -- were invented by computer hobbyists messaging with each other from the artificial intelligence projects of Stanford University and MIT over the ARPANET.

One of the most important future uses of such packet-switched networks involves voice transmission to microprocessor-based equipment with speech recognition and synthesis capabilities of the type previously discussed. If one uses packet-switched networks for transmitting voice messages instead of using circuit switching, the utilization of a specific amount of bandwidth can be improved one-and-one-half to three times. More importantly, transmitting voice as digital computer data makes it possible for the message to be received by the machine, and <u>thus to facilitate direct computer interaction by voice instead of through a keyboard</u>.

Digital packet transmission of voice is still very expensive, but these costs are rapidly decreasing. ARPA is currently researching this area and is now experimentally "transmitting packetized voice messages through a multiplexer that interfaces four local area networks to a three million bit per second satellite channel. Each local area network operates at 1.5 million bits per second and services a number of voice terminals. The packetizing and depacketizing occurs at the terminals".[30]

Productivity Implications

At first the productivity effects of word processors was widely misunderstood in North America, and it was thought that their main effects would be to only replace typewriters, reduce amounts of money spent on typing, and put typists and secretaries out of work. Numerous studies, however, show that the secretary/typist in North America spends approximately 20% of the seven hours on the job actually typing, and that the secretary/typist accounts for only about 5% of total labour costs in a typical North American office (because women are still poorly paid in secretarial positions). One can easily see that typing thus accounts for less than 2% of the labour costs of US and Canadian business.

The real productivity implications of word processors, however, will be seen when executives start using them for messaging purposes. Almost three-quarters of the business labour force in North America is comprised of knowledge workers -- persons working with their heads instead of their hands-such as managers, engineers, scientists, and other technical people.

Indeed, between the 1930's and the present, the amount of support equipment for the typical manufacturing worker in North America has increased from less than $2,000 to more than $25,000, while the dollar amount of support equipment for the knowledge worker increased almost not at all.

Much more likely, in fact, to effect the secretarial work force than word processors is voice activation in both typewriters and word processors themselves, something which will be in widespread use by the end of the decade.[31] The first voice-driven typewriters, which will appear before 1985, will have a T.V.-like terminal screen which displays words when they are spoken. The person doing the dictation, or at this stage probably still the person's secretary, will still have to type in words the machine has incorrectly recognized. However, it is expected that even initial crude versions of speech-driven typewriters will get 80% to 90% of common words used in business correct.

A market research analyst quoted in a Canadian Office article notes that "IBM includes a 50,000-word vocabulary (to automatically check if spelling is correct) as a standard feature of their Displaywriter (a type of sophisticated word processor). It would be logical for IBM to use this vocabulary as the basis for guessing the correct spelling of words dictated to the machine".[32] (The Displaywriter also possesses software which recognizes homonyms (words that sound the same but have a different spelling) and which underlines them for correction). The Japanese firm Matsushita and America's Xerox are also planning to release a voice-activated typewriter by 1984.

Computer-Aided Messaging

In 1981, the Computer Communications Group, a subsidiary of the Trans-Canada Telephone System announced Envoy 100, a national computer-aided messaging service. Designed to meet the increasing Canadian business communications needs, Envoy 100 allows subscribing firms and individuals to prepare, correct, distribute, access, and file messages within and between firms.

It can be easily accessed by standard computer terminals or communicating word processors, and operates through a Canadian packet-switched network, Datapac. It has built-in compatability features and its terminals can access other types of devices of differing speeds or types. One does not have to know a computer language to use it, and it can be accessed in simple English commands. As with other computer messaging systems, Envoy 100 frees the sender and user from time zone limitations and from the availability of the receiver. Messages are simply stored in chips until the receiver signs on and tells the system to foward them.[33]

In the United States at the end of 1980 GTE Telenet Communications Corporation launched a nation-wide electronic mail/messaging service called Telemail. This service enables an executive to receive, send, and store electronic messages using communicating word processors or other types of terminals Previous research has found that executives spend most of their time at work in face-to-face or phone communication (while they are being paid their salaries), and many studies also show that it costs the firm roughly $10 each time one of its executives makes a long distance phone call or $5 for a local call. The productivity implications then of such computer-aided messaging services are staggering. They cut these communication costs roughly in half!

Local Business Networks - The Expanded PBX

One of the main problems with the new communicating processors, as with virtually all communications technology discussed herein, is that they have become an electronic Tower of Babel. Equipment of differing makes cannot communicate with each other. However, this problem is being alleviated in North American business offices with expanded PBX's (private branch exchanges) which can route and switch both phone calls and digital data from outside and within the office, and which are facilitating local business communications networks capable of handling data, text, facsimile transmission and both normal and stored voice.

The tiny microprocessor-based private branch exchange was initially thought of merely as a replacment for a large room of traditional telephone switchboard equipment, and the main idea was still to use the PBX to connect office phones to the outside. But given the large number of new PBX's which can handle both voice and data, local business networks are arising which can route digital data in the same way they can switch telephone calls. They are thus enabling office communication between text editing terminals (word processors), executive work stations, high speed facsimile machines, personal computers. and printers.

Typical of the new business PBX's is the Datapoint Corporation's Information Switching Exchange (ISX). Like the old PBX's, the ISX can perform all types of operations on phone calls from outside -- routing out going long distance phone calls to the cheapest line, automatically redialing if the number is busy, forwarding calls, automatic dialing of frequently called numbers and so forth But the ISX can also move information in the form of words and data around an office in the same way they switch phone calls.

In fact with the continued convergence of computers and communications, data processing manufacturers like the Data Point Corporation will be increasingly entering the office communications and automation market It is expected that in providing an expanded PBX any manufacturing firm will then have further outlets for an entire range of integrated office equipment -- ranging from phones to sophisticated text editing terminals to the executive work stations.[34]

A related development in local business communication networks is the Xerox Corporation's new system called Ethernet.

The basic idea of Ethernet is a local cable business communication system that will enable computer talk between intelligent terminals, word processors, printers, and electronic file cabinets. Each of the office machines in Ethernet is intelligent enough to decide whether or not to transmit a message. so no central or host computer is needed to control traffic on the cable. Xerox has been actively pushing the Ethernet concept as an industry standard and has already managed to get the Digital Equipment Corporation, a mini-computer manufacturer, and Intel, the most innovative chip manufacturer, to design computers and chips for it.

In addition to local networks such as Xerox's Ethernet, software innovations are facilitating intelligent network concepts such as the INET Gateway to be introduced by the Computer Communications Group of the TransCanada Telephone System. The software basically will provide users universal, direct accessibility to information providers and related computer-based services. With a single point of access such as an executive work station, INET users will be able to satisfy a wide range of business information needs. Using Datapac, the Canadian packet-swtich network, users of INET will be able to link to other international packet-switched networks in the US and the rest of the world. A field trial of INET will occur in 1982.

Executive Work Stations

Increasingly the new office equipment is "user friendly". The Xerox Corporation, realizing that executives won't take time to learn programming languages for microprocessors, has just introduced their executive work station, the Star.

Looking like a T.V. on the executive's desk, it uses Xerox's local cable business network, Ethernet, to digitally communicate with electronic files, information retrieval systems, other work stations for computer-aided messaging, and printers. The Star is trivially easy to use, and will probably alter the way North American managers feel about computers, which is still basically very negative.

The Star operates almost entirely by pushing a pointer on the screen, called "the mouse", to the correct spot and hitting one of four commands. These spots are pictoral representations or symbols of office functions. An executive might use "the mouse" to put a memo into the microprocessor file cabinet, into the out basket, or simply send a copy of it to 100 people, all merely by moving "the mouse" to the right spot, and hitting a key.

Thus just as with word processors, an executive can write and edit his own reports, but he or she also can easily insert some graphics and distribute messages and reports to people at other work stations. He or she can also instantly print a final copy of a report with corrections. (As part of this system, Xerox is planning to introduce a laser scanner for facsimile reproductions of photographs, documents, and signatures).[35]

Although the Star costs almost $17,000, other new venture firms have already entered this market. Apollo Computer Incorporated and Convergent Technologies sell microprocessor-based terminals to manufacturers of executive work stations. Bell Northern Research of Canada is also planning to introduce an electronic work station this year built around their private branch exchange. But since most North American executives still basically seek information by word of mouth and spend most of their time in face-to-face verbal communication or on the phone, the market for executive work stations like the Star is still basically unknown.

Videodiscs

The videodisc, heralded for a decade is now finally here. They will be used as file cabinets in the future office equipment. There are two types of videodiscs, magnetic videodiscs. and optical videodiscs.

Magnetic videodiscs look just like records and store information on a plastic disc. Optical (or laser) videodiscs are made of plastic coated with aluminium. Information is stored on the discs simply by punching holes in the aluminium with a laser beam and is read back by bouncing another very low intensity laser beam off the disc. Information is coded in digital form or computer talk, where a hole means yes and the absence of a hole means no. Unlike magnetic discs, they can't be erased, but since the information is digitally coded, microprocessor driven optical videodiscs systems can talk to other digital equipment such as computers.

Illustrative of the magnetic systems is RCA's magnetic videodisc player which appeared on the market in early 1981; the player costs just under $500.00 and the discs $15.00 to $28.00 each. The RCA videodisc player, aimed toward the mass market, ressembles a record player but uses a diamond needle which moves up and down instead of sideways to change the intensity of a current and also to prevent the needle from constantly hitting the disc. Such a system, relying just like phonograph players upon the property of capacitance, uses an electrode next to the needle to read the current changes and to produce a video signal on a television.

This RCA technology is competing with the optical videodiscs systems of Japan's Pioneer, the Japan Victor Corporation, and Phillips of Holland.

Optical videodiscs may be used to randomly access any single visual frame instantly and for slow and fast motion. Thus if the mass market does not pan out, the optical videodisc manufacturers will modify their products and further diversify into the areas of computer memory and educational retraining technology for industry. Unlike magnetic discs, optical discs are immune to damage, and since they are read by lasers sweeping over their surface instead of needles riding in grooves on the surface, it is very easy to randomly access single bits of information on the disc. Such random access is facilitating their use as memory devices for computers and an electronic file cabinet.

The optical videodisc players now on the market sell for around $750.00, an individual disc for $23 00 to $30 00 each, but so far none of the videodiscs systems will play discs designed by other manufacturers.

The optical disc of Philips contains approximately 54,000 concentric grooves per side. Since with both sides together the disc contains 60 billion bits of information and has a rotation speed of 1,800 rotations per minute, this gives it the ability to hold about an hour of video material.

In summary, the main features of optical videodiscs are that their material is far cheaper to manufacture than magnetic tapes or films, and since they are light and compact they can be carried or mailed easily and lend themselves to precise and rapid retrieval of single frames of information.

Prerecorded videodiscs are much cheaper than prerecorded video cassettes and are already competing with television. Big film companies in North America are now releasing films on videodiscs a mere six weeks after their theater premiers, and it is thought that the entry costs of these big film producers into direct videodisc marketing will significantly lower the prices of home videodisc recorders in the near future.

In the fields of information and education they will be used to replace and supplement paper publications such as dictionaries, special interest magazines, and mail order catalogues. Sears, one of the largest North American retail businesses, has already placed its mail order catalogue onto videodisc, and if videotex actually goes as a mass media. it seems likely that videodiscs will be used for teleshopping by videotex - people will directly order items through videotex which they have seen in videodisc mail order catalogues. (AT&T is presently investigating such teleshopping by videodiscs and telephone).

Videodiscs also make excellent storage devices for computers. Given the fact that one can mix graphic and textural material or anything else onto a videodisc and have a high speed access to a single frame by a microprocessor, videodiscs are being thought of as electronic filing cabinets in the office of the future. However, the most interesting uses of videodiscs are in educational and industrial retraining areas. As early as September of 1979, IBM in conjunction with MCA - a large American entertainment company - set up Disco-Vision Associates to explore this educational/retraining market. If the labour displacement effects arising from the rapid diffusion of microprocessor-based information technologies are as great as predicted, new means will have to be found in the advanced industrial societies to re-educate people. There are not enough qualified teachers, and many present teachers are quite intimidated by the computer technologies. It is the role of videodiscs in this re-education that is so important. Any home computer hooked up to a disc system creates a stand-alone educational tool. Almost anything can be placed onto a disc and replayed over the T.V. set, and media also may be blended.[36]

Future Growth of Integrated Office Equipment

Real, wide spread implementation of the integrated office equipment will require the development of more communication networks which enable computer terminals of different manufacturers to communicate with each other. However, North American firms are acknowledged leaders in office equipment, and the incorporation of chip technology into both telecommunications and office equipment is much more rapid in North America than in Europe. US telephone companies for example, annually purchase about a billion dollars worth of semi-conductors compared to less than $200 million in Europe, and European producers of office equipment are at least ten years behind those in the United States and Japan. This is because in Europe the national telecommunications authorities own the networks for phone, data and telex and control, through severe approval procedures, exactly which equipment is attached to these networks. The Europeans also frequently get bogged down for year in questions of international standards -- that is the means of hooking computer networks of different characteristics together across national boundaries -- during which US equipment has gone through several generations of development.

The best communication system of all would be an all digital, computer talk system in which personal computers, communicating word processors, and executive work stations could communicate very rapidly. However, the European nationally owned phone networks are being modernized bit by bit, and many European countries are planning to go to national satellite-based telephone networks instead of overland digital networks. The French and the West Germans are planning to launch their direct broadcast satellites by 1983.

The biggest problem world-wide with the development of digital packet-switched messaging systems has been the computer software. AT&T, America's largest telephone company, has been planning an intelligent network which would permit terminals of different types and characteristics to communicate with each other. called the Advanced Communication Service, this network has been postponed several times because the software could not be completed in time and because it is increasingly difficult for the FCC to regulate this type of thing.

The FCC in the United States has recently encouraged considerable competition in telecommunications/office services and equipment. However AT&T was allowed to become America's biggest phone company only if it agreed to keep out of other industries. But since increasingly one can no longer tell where the computers end and the communications systems begin, this regulation is becoming vastly more complicated.

Broadcast Satellites

Nowhere is the convergence of computers and telecommunications more apparent than in the field of broadcast satellites. International Business Machines, the largest computer manufacturer in the world, launched its first satellite in late 1980. This satellite, called SBS-1, in a geostationary orbit 22,300 miles above the earth, is focusing on business communications and will transmit voice, video conferencing, and high-speed digital computer talk between terminals, communicating word processors, executive work stations, and other office equipment.

The market for business communications is booming, and it is expected that these business demands for new services such as video conferencing and high-speed data comunications will increase 40% annually over the next decade, reaching a 150 billion dollars by 1990.[37]

The SBS-1 is the first, all-digital, high bandwidth business satellite system. Since it is all-digital, intelligent computer terminals and business equipment anywhere can use it to talk to each other. There is also long-distance phone transmission over the same satellite channels, and it is estimated that the prices for telephone services over SBS-1 will be eventually 30% lower than the direct-dialing charges of American Telephone and Telegraph.[38]

The satellite will also be used for electronic printing, in conjunction with high-speed communication copiers, with very fast facsimile transmission of 4,200 pages per hour, (which is about one hundred times faster than the existing facsimile methods).

AT&T itself has recently filed with the Federal Commmunications Commission to begin distribution of T.V. signals by satellite. Their first customer will be NBC, the big T.V. network. Their first satellite, which will be launched in 1983, will be used as part of AT&T's US telephone network and will also carry facsimile, T.V.. and computer talk for business purposes.

The satellite market in North America is being spurred on by three main factors. First, the incorporation of chip technology into earth terminals to receive satellite signals. These terminals (or ground stations) are rapidly becoming cheaper and more portable. Small innovative firms such as Equatorial Communications Company of Sunnyvale, California, already sells small, all-digital earth stations to receive satellite signals for less than $2,500. Operating on one of the Westar satellites, the microprocessor-based earth terminal contains built-in diagnostics and is extremely easy to operate. Since it is based on solid-state integrated circuitry, there are no moving parts. The indoor unit is 18" x 14" x 6", and the small outside antenna is .6 metres in diameter.[39]

Secondly, many nations are poised to put up virtually hundreds of new satellites over the coming decade via America's Space Shuttle Programme. For one-fifth of the cost of conventional rockets, the Shuttle will enable nations to place into orbit very heavy satellites of high power. Since transmission power is higher, earth stations may be even smaller and cheaper.

Finally, the regulatory climate is changing quickly. The FCC has already ended mandatory licensing of receive-only earth stations -- satellite earth stations which can only receive signals but cannot send them -- and in mid-1981 the FCC agreed to hear the issue of the direct-broadcast satellite. For all of these reasons, the broadcast satellite business is exploding. In late 1979, R.C.A., for example, gave away, free of charge, $50,000 satellite receive-only earth stations to any T.V. broadcasting station or cable broadcaster who would accept and use them for receiving R.C.A.'s T.V. signals.

For the most part, the old domestic communications satellites of North America have been used mainly to transmit the existing T.V. and telephone services. The direct broadcast satellites are so different they are almost a new communications medium. These satellites will have much fewer transponders (or channels) than found on existing satellites, and the transponders themselves will have a very high output power, which will enable signals to be received in homes on the ground by extremely small and cheap antennas. The direct-broadcast satellites will transmit mainly on the so-called Ku band (12 to 14 GHz), but it is also thought they will be able to incorporate transponders capable of receiving and transmitting on both the 12 to 14 GHz band and also on the 4 to 6 GHz C band, now used by domestic communications satellites.

In spite of the specific regulatory decisions made in North America concerning the broadcast satellites, it seems certain that within a few decades many more developing countries will have adopted direct-broadcast satellites for their telecommunications services and that millions of people in the world will directly receive satellite signals. A number of developing countries are already using broadcast satellites for telephone purposes. SPAR Aerospace (a Canadian supplier) has recently sold terminals for 13 earth stations involving 670 trunk circuits in the Amazon Valley for Brazil's domestic satellite system, and countries such as Rodesia, Algeria, Peru, Saudi Arabia, Sudan, and Brazil have leased INTELSAT 4-6 GHz transponders.

In parts of the world where heavy rainfall excludes the use of the 12-14 GHz band, such as Indonesia and Brazil, countries will, in fact, continue to lease 4-6 GHz bands from INTELSAT.

Since the older communication satellites shared the same broadcast frequencies used by the phone companies to relay long-distance phone messages and T.V. programmes between cities, their radiated power had to be kept low to avoid interference. Ground stations had to be extremely big and had to be located away from city centres to avoid telephone and T.V. interference. Since the new satellites broadcast in higher frequencies which have been exclusively reserved for them, their broadcasts do not interfere with T.V. or telephone systems, and earth termainls may be much smaller, cheap, and portable.

Recent History

All broadcast satellites are geostationary, which means that they rotate at the same rate that the earth does and thus stay over the same place. With a direct broadcast satellite, signals are picked up directly from the satellite by anyone with a ground receiving terminal, provided of course they are in the satellite's "footprint" (the area covered by the satellite's broadcast signal).

The first direct broadcast satellite was the US National Aeornautics and Space Administration's ATS-6 -- which was the last in their series of satellites for exploring new applications of technology. It was used for a variety of experiments, one set occurring in the US and the other in India. ATS-6 had a 15-watt transponder and broadcast in the 4-6 GHz band. It could be received with dishes of the minimum size of 9 feet.

Between 1974 and 1975, ATS-6 was used in Appalachia, through the Rocky Moutain Area and in Alaska to broadcast T.V. programmes for teacher education and community development to earth stations located in community centres and classrooms. Some of these experiments had a 3-meter antenna, as contrasted with the 10-meter antennas which were required at that time for the "fixed" satellite service. ("Fixed" merely means that the broadcast of the satellite signals is only to selected fixed points, such as the cable companies, but not to everyone).

The earth stations themselves were designed for use by technologically unsophisticated users, and ground station controls often consisted of simple on/off switches and a meter to indicate that the antenna was properly pointed towards the satellite. At that time these receiving stations cost a little less than $5.000.

At the conclusion of the North American experiments, ATS-6 was shifted to a new orbit over the Indian sub-continent so that it could be used for the Indian Satellite Instructional Experiment

(SITE). Between 1975 and 1976 T.V. programmes on family planning, agriculture and education were received by 2,500 Indian-built earth terminals placed in villages. These programmes were further relayed by India's terrestrial T.V. broadcasting station to 2,600 additional villages.

Canada

Further broadcast satellite experiments have been conducted by Canada between 1976 and 1979, using the Communications Technology Satellite (CTS). This satellite was designed specifically to make use of a then-newly-available bandwidth for satellite broadcasting. The World Administrative Radio Conference on Space Telecommunications, established in 1971, ruled that the frequency allocation for broadcasting satellites would be in the 12-14 GHz band range.

This satellite, called Hermes by the Canadians, was mainly used to test T.V. broadcasting applications. The Hermes satellite with 2 transponders of 21 watts and 200 watts power, used a .6 meter ground antenna which had been developed by the Communications

Research Centre of the Canadian Government.

By early 1979, the Ontario Education Commmunications Authority was testing community broadcasting to remote parts of Northern Canada on Hermes.[40] Three hours of daily programming were provided on alternate days in Northern Canada with receiving stations located at remote school houses with 1.2 meter antennas. Emissions of 3-1/2 hours of normal CBC national T.V. programming were transmitted in the afternoon.

In 1981 Hermes was repositioned in the Pacific so that its footprint included both Sydney, Australia and Ottawa. Signals were broadcasted from Ottawa to receiving stations in Australia to be relayed to remote outback communities which the Australia's terrestrial T.V. network could not reach. This experiment was successful, and as a result the Australians decided to buy their own domestic communications satellite system.

The Canadians have also been conducting experiments for broadcasting services with their ANIK-B domestic communications satellite. This satellite, possessing 4 transponders of 20 watts each, has been used for T.V. broadcast to community and home receivers in 45 remote Canadian locations.

Canada's experiments with the new higher frequency (12 to 14 GHz) broadcast satellites have proved that direct broadcasting may be a cost-effective means to transmit T.V. signals to remotely populated areas of the country. The 37 experiments conducted towards the end of the '70's have shown that even in severe weather, low-cost, small antenna earth stations can be accurately aimed and will give a good signal reception.

Japan

As early as 1978 the National Aeronautics and Space Administration launched an American-built Japanese broadcast satellite. Japan is composed of many smaller island chains which are too little to make cable T.V. economically viable and also simply cannot be reached by the existing terrestrial microwave network.

Although this was not really a true direct broadcast experiment, but rather signals were broadcast to community centers, it was found on most islands that antennas of 1 meter could be used to receive excellent signals.

India

India plans to continue its SITE experiments to broadcast T.V. to earth stations located in villages. Ground stations will have 12 foot antennas made of chicken wire. Such cheap stations will be satisfactory for all of India except for some northeastern states in which more sophisticated equipment will be needed to receive the signals. The satellite was built by Ford Aerospace and Communications Incorporated, but the Indians plan to build the rest of their own satellites.

Although communications media like radio and T.V. have played dubious roles in educational development in the Third World, SITE was virtually the first application of the broadcast satellite to include education of a mass rural population. None of the preceding ATS-6 experiments in Alaska or Appalachia, had more than 70 satellite receivers.[41] The general menu of development topics in the SITE experiments included agricultural productivity, health. nutrition, and family planning; however, there was a virtual absence of strategies and objectives with respect to the content and format of the actual T.V. programmes. Not infrequently programmes were broadcast to villages in the wrong languages.

Satellite Transponders

Any satellite distribution system is composed of a transmitter (or up-link), the satellite, and the receiver (or down-link). With commerical satellite broadcasting in North America, T.V. signals are sent to the satellite on one of twelve channels in the 6 GHz frequency, amplified, and sent to a big earth station, typically owned by a cable company, to be further distributed to home subscribers.

Up until now the main market for satellite ground receiving stations in Northern America has been these cable company operators rather than individuals. Cable operators receive the T.V. signals from the satellites and then distribute them via the cable lines to homes.

The main technology in the satellite is a microprocessor-based transponder, which receives the up-link signal, alters its frequency, and transmits it back to earth. Thus signals approaching and leaving the satellite are of a different frequency and therefore will not interfere with each other.

Satellites vary in the precise number of transponders on them, but in many of the recent American satellites there have been typically 12 transponders, each transponder handling a single 36 MHz T.V. channel. However, by a new technique called cross-polarization, the capacity of such a satellite can be increased to 24 channels (or transponders). The technique allows one to transmit two signals on the same frequency by using horizontally and vertically polarized antennas that isolate the two channels from each other.[42]

Satellite Antenna Size

In recent years the size of the antennas on the satellites has been growing, extending their life-time and reducing the amount of power consumed. (Satellites are expendable and have a typical lifetime of approximately 8 years). Unfortunately, as both satellites and the size of their antennas grow larger, the footprint or ground area receiving the satellite's signal lessens, with a minimum projected area ranging around 200 square miles. These footprints of broadcast satellites are presently enlarged by bouncing signals from earth to one satellite, down to earth again and then up to another satellite. This is quite wasteful, and a scientist at Hughes Aircraft has proposed putting into orbit clusters of satellites which would operate separate from one another but which would also communicate with each other by radio via a centrally placed chip-based switching satellite. It is thought that with the proper switching satellite, such clusters of satellites could accomplish a variety of different tasks, and individual satellites comprising the system could be replaced as they wore out. Also there would not be interference from neighbouring satellites transmitting on the same frequency.

Earth Terminals (Ground Receiving Stations)

The earth terminal is really the essential part of any commmerical direct broadcast satellite system. The terminal picks the satellite signal up, amplifies it and remodulates it to be received by T.V. sets. For general use such earth terminals must be produced at extremely low costs such as $200 to $300 and must be small enough so that they are portable. They should also require a minimal effort to install and maintain.

There are two types of earth terminals for direct broadcasting satellites. The first, commonly used by cable broadcasters in North America, uses low noise amplifiers at the centre of their antennas or "dishes". The second contains a "down-converter" in the dish which immediately converts a 12 GHz signal from the satellite to a lower frequency. This makes it much less susceptible to noise degradation as it passes to the T.V. set.

Hobbyist Earth Terminals

All over North America, satellite hobbyists have taken to building their own backyard terminals which can pick up T.V. programmes from the broadcast satellites. Thus, just as with personal computers, development in this field is being spurred on by the home hobbyists.

In the United States the big T.V. distribution companies are trying to get the hobbyists prosecuted in the courts, and in Canada, the Federal Government is trying to prevent home viewers from directy receiving the American T.V. programmes, since they are trying to get more people to watch Canadian T.V. Both efforts are about as likely to be successful as stopping running water with one's hands.

The home satellite T.V. terminals are remarkably easy to make, and cottage industries are springing up all over the United States to manufacture variants of the "phase-locked loop" radio circuit to receive satellite signals. These sell for around $1,500.[43]

One main factor inhibiting a further price drop for terminals is that the major satellite designers in the United States, such as Scientific-Atlanta, now sell most of their satellite terminals to the cable companies, the same group that is fighting the home terminals of the hobbyists.

Earth Terminal Antennas

Although France, West Germany and other countries are planning direct broadcast satellites by 1984 to beam T.V. programmes directly to rooftop antennas on people's homes, the main economic problem is with the cost of the antenna in the earth station. To receive T.V. signals directly from satellites to the home, a receiver needs an antenna to pick the signals up, an amplifier to make them louder, and a modulator to change the down-link signals to a lower frequency which can be taken by a normal T.V. set. A large antenna can receive a very weak signal and therefore does not need an expensive amplifier to reproduce the signal, but a large antenna is much more expensive than a smaller one. (In general, if one doubles the size of the antenna, the total costs of the station increase four-fold). Also a large antenna has to be very carefully lined up so it can pick up a very narrow beam from the satellite.

The main firms now working on antenna design are Scientific Atlanta, Hughes Aircraft, Nippon Electric, Tops and Dash CFG, and Phillips. Phillips plans to introduce a 90 cm. antenna in the mid-1980's for $700 to $800 plus installation costs which are about $400; however, Scientific Atlanta has projected that there will be antennas available within a decade for $400 to $500.

Contemporary Developments

Today, at the beginning of the '80's, American firms alone are poised to launch more than 25 new communications satellites over the next half decade. This will triple the existing satellite capacity and in most cases will by-pass the terrestrial telephone networks of AT&T. The new satellite systems are focusing almost exclusively on business communication for very large firms. Initial customers for IBM's communiations satellite will include Westinghouse Electric, national banks, and computer service companies of large aerospace firms. American Telephone and Telegraph, we saw, has asked the Federal Communications Commission to allow it to offer a nation-wide video conferencing service for big firms, and it has also asked permission to put in a private satellite network for both text and data between three printing facilities of R.R. Donnelley and Sons, Company. In addition independent phone companies in the US such as United Telecommunications Incorporated and Continental Telephones Incorporated are leasing channels on exisiting satellites for telecommunications. It has been estimated that American business spends between 600 and 800 billion dollars a year merely for people communicating - most of which is accounted for by salaries of managers when they are travelling, returning phone calls or writing. Substituting teleconferencing (in which executives in different parts of the country can see one another on T.V. screens and converse) for travel seems an obvious development.

Specifically designed for high speed business communications, satellites like SBS-1 will digitally transmit data, documents, voice and video signals to earth terminals, executive work stations and other digital office equipment.

Diffusion in the Developed Economies

The British were the original Cassandras in predicting dire labour consequences due to the diffusion of chips through the economies of the developed countries. They have subsequently recanted and now believe that the effects of the microprocessor technologies will be "gradual and evolutionary".[44]

However, if we look not merely at the extent to which microprocessor technology has diffused in the developed countries (for which there is only sporadic data anyway) but at the rate at which it is diffusing, we realize that it is incredibly rapid. In fact all previous diffusion research[45] has shown that there is a considerable time lag -- usually between fifty and one hundred years -- between a basic discovery in science and technology and the first reaping of commercial benefits. Clark Maxwell, for example, formulated his basic discoveries in electromagnetism in the early nineteenth century, and these did not bear commercial fruits until a hundred years later. In the early twentieth century Cammerlingh Onnes was working with substances of extremely low temperatures and found that near to absolute zero, there were metals which loose all of their electrical resistence and become so-called "super-conductors". It is only eighty years later that this discovery is being commercialized in items like fusion reactors.

With microprocessors however this time lag is remarkably short. The integrated circuit, in fact, was invented in 1969 and the microprocessor in 1971. Now, ten years later, there are already thousands of commercial applications.

Throughout the industrial societies, microprocessor technology is now diffusing at a breathtaking rate, with initial applications predominately in information and communications technology described in the first parts of this work now extending through all informational, monitoring, and control phases of design, manufacturing and distribution. In a 1980 survey of innovation and technological change in five Canadian manufacturing industries conducted by the author for the Economic Council of Canada,[46] over 90% of the products and production processes reported in telecommunications -- such as PABX's, and satellite earth stations, were microprocessor-based, with significant cost and size reductions and increased reliability over previous technology. At the same time, microprocessor technology and the melding of computers and telecommunications has facilitated entirely new communications products and services such as the diversity of videotex systems now emerging such as Prestel, Telidon, and Captain. Chip technology has also invaded colour T.V.'s, video cassette recorders, cars, ovens, cameras, washers, watches - virtually all consumer products with controls in North America. Many of these products are rapidly becoming cheaper than the equivalent exports of developing countries. But perhaps the most significant effect on the Third World arising from the developed world's adoption of microprocessors will come from their direct application in manufacturing itself -- in such areas as computer-aided design and manufacturing (CAD/CAM), the microprocessor control of machine tools, and robotics.

Microprocessors in Design and Manufacturing

Using a T.V.-like terminal, an engineer can place designs onto a screen, rotate, invert, and break them up in varying ways. Parts of any manufactured item may be classified according to common families of parts and indexed so they will not have to be designed again. Since computer-aided design systems allow one to draw directly onto the terminal instead of onto a drawing board, errors may be instantly corrected. Engineering is an area of universal skill shortage in the industrial countries and the major effect of CAD's introduction so far has been the extending of scarce resources. CAD can, in fact, extend engineering abilities three to four times, but since such systems are still very expensive -- typical equipment serving four engineers might cost a half a million to a million dollars -- the firms using it have been mainly big aerospace, electronics and petrochemical firms. However, firms like Perkin-Elmer are already producing extensive software for mechanical engineering design and drafting by microprocessors, and the Japanese are making CAD technology for small manufacturers.

The technology has it's genesis in the early 60's at the Massachusetts Institute of Technology. where scientists got computers to draw pictures of solid objects onto a T.V. screen. These first computers, which could draw only straight two-dimensional layouts, were purchased by computer manufacturers themselves for the internal wiring of microchips and for the manufacture of printed circuit boards. The leading North American suppliers of CAD systems are Computer Vision, based in Boston, and which has a 40% share of the North American market, Calma and Applicon, each with an approximately 15% market share. It has been estimated that world-wide[47] the market for such systems is worth more than 13 billion dollars.

Microprocessor Brains for Machine Tools

One of the most significant technological trends in the industrial economies has been towards the incorporation of microprocessors as brains for machine tools. By simply altering programme instructions, a machine tool can be changed to another set of instructions and thus increase production speed. Although rapid diffusion is expected in this area in the next five years, to date the growth of computer controlled machine tools in the developed countries is slight. The existing stock of such machine tools is around 5% of the total number of all machine tools; however, this number is growing at the rate of about 25% per year in Japan. One recent study done in Canada estimates that by 1985, there will be approximately 3,200 new machine tools installed, most being computerized.[48] The majority of vendors, the author notes, have discontinued manufacturing hard-wired numerical control systems for machine tools and now manufacture only computerized drafting systems which are microprocessor-based. The author also finds that several big Canadian aerospace manufacturers are considering "distributed numerical control" in which a single large computer is first given design instructions by engineers working at terminals and then feeds these instructions to a series of microprocessor-based machining tools. (Countries such as Britain, whose textile industry has in recent years been re-equipped with numerical control machinery instead of microprocessor machinery may be at a distinct disadvantage in this area, because the microprocessor technology is so much more versatile.) It is thought that by 1986 the number of computer controlled machine tools will reach about 50% of all metal cutting machine tools produced in the United States. A similar trend is apparent in the main suppliers of machine tools for developing countries in western Europe and Japan.

Robotics

The main difference between a microprocessor driven machine tool and an industrial robot is that the robot can be programmed to do a variety of tasks beyond mere cutting. In fact many devices called robots are merely numerically contolled machine arms operated by punch tape controls. True industrial robots consist of a microprocessor brain, a power unit, and a moving mechanical part to carry out the instructions given to it by the microprocessor. There are about

20,000 industrial robots now in use in Japan, the world expert in this field, and several thousand in use in the UK, the US and Canada. Unimation -- the largest North American manufacturer of industrial robots -- estimated that by 1977 they had installed about 1.600 real, programmable robots world-wide and that of these about half were being used for welding. In fact the biggest industrial users of robots world wide still are metal working and forming industries, but the Japanese Industrial Robot Association has estimated wide spread use of robots by 1985 in small and batch production firms. Japan, currently possessing half of all the worlds computer-controlled robots, is planning to aggressively export them to North America as they did with automobiles. With 139 robot builders, one of their main commercial targets now is the small job shop. Fujitsu Fanue and other Japanese companies are planning the same marketing strategy for robotics as they used with computerized machine tools -- producing cheap, reliable products which will appeal to the small job market, which is often ignored by the big suppliers. Realizing that this market doesn't have the cash to invest in their own robots, some Japanese firms are joining with the Japan Industrial Robot Association to establish an organization which will lease robots to small firms throughout the world.

Just as we could see the productivity implications of computers and communications only when they blended, the same is true of the blending of robotics, CAD/CAM, and microprocessor control of machine tools. It is thought that the next stage of production will involve distributed sensing control, in which a single computer will be able to control several machine tools or production processes simultaneously using sophisticated feedback from sensors. This will involve basically the automating of batch processing, and these issues are being examined in several countries such as in Britian's Automated Small Batch Production Project and in the Methodology for Unmanned Metal Working Project in Japan. Aerospace manufacturers in Canada plan to go to distributed numerical control within five years.

Given the types of developments we have seen in speech recognition, speech synthesis, and microprocessor control, the robot of the future, in the eloquent words of Adam Osborn[49] "will be able to pick up and move objects, operate machines, insert, weld, and manipulate, provided its mechanical limbs are dexterous and strong enough for the task . . . the robot of the future will be able to hear spoken words and non-verbal sounds and will be able to respond to what it hears. The robot of the future will be able to speak with an extensive vocabulary and generate sounds of almost any type. The robot of the future will be able to combine what it sees and hears with the movements of its limbs to perform any task which can be explicitly defined". The robot of the future will eliminate the blue collar work force as we know it in North America.

Diffusion in the Developing World

Here we are interested in both how the new technologies are entering developing countries and how they will spread within. Unfortunately in many developing countries, one of the first agencies adopting the computer information technologies has been national security and police, and if a society represses human rights, the communication technologies will horribly facilitate this end. National and international airlines in developing countries were also very early adopters of computers for scheduling, and Third World students in North America are even buying TRS-80 personal computers and taking them home to use as private work stations in government, business. and research. TRS-80 personal computers are also being used in the developing world as computer-aided instructional tools to teach software writing. However, the main channel for the technology will be the multinational corporations discussed in the next section.

With respect to certain critical economic indicators such as the balance of payments for high technology, the degree of foreign control in industry, and the amount of research and development performed by industry, Canada more ressembles an extremely wealthy developing country than it does, say, the US or Japan. Thus in the Canadian survey of technological change we investigated how rapidly both multinationals and Canadian-controlled firms were getting new technology for production processes. The "lag rate" -- the number of years between the first world use or commercialization of a new technology and the first Canadian use -- was about six years, on average, for production technology of multinational subsidiaries, while this figure was almost 16 years for Canadian-controlled companies -- roughly a decade longer! This multinational-subsidiary pathway then is one of the main sources of developing countries' production technology. And in spite of the inappropriate nature of much North American research on the Third World and the extreme differences in industrial conditions, it seems reasonable to speculate that one way the microelectronics technologies will spread within some developing countries will be by new venture, spin-offs from the multinationals' subsidiaries.

In any case with both the production and communications technology based on microprocessors, there is absolutely every reason to assume that developing countries which actually need and can afford them, such as the newly industrialized countries, will be rapid adoptors, especially in the production areas of their export trades such as in electronics, textiles, and machinery.

An important factor in both the diffusion and production of these technologies in developing countries is government policy. Many countries have, as parts of their technological development and industrial policies, centralized agencies and systems to make purchases, grant import and joint-venture licenses and for technological monitoring. However one author has noted[50] that most of the diffusion escapes these agencies, because microprocesors are being incorporated into a wide range of products and processes beyond main-frame computers, and besides with microprocessors it is no longer a game of counting the number of computers. There are millions! Another central factor constraining the diffusion of microprocessor-based production technology to developing countries is that low labour costs in these countries makes high technology equipment less competitive, and amortization of the equipment takes much longer.[51] Even so one must expect rapid diffusion of these production and communication technologies to developing countries which can afford to use them. Beyond the present uses of broadcast satellites, word processors, and personal computers in developing countries, the most recent communication technologies discussed in the first part of this work are already being planned.

Videotex in South America

Videotex is being planned in both Brazil and Venezuela.

Telesp, the provincial telephone company of Sao Paulo is planning a videotex trial with 1,500 terminals in the Brazilian city of Sao Paulo in the beginning of 1982. The test will use the French Antiope technology, and a Paris manufacturer, Mantra, is the primary contractor for terminals. The city newspaper, Estavo De Sao Paulo, and a national newspaper, the Journal du Brazil, will be information providers. The Brazilians are also actively soliciting international information providers, and initial plans include 500 business terminals and 1000 terminals in the home.[52]

In Venezuela the Presidential Office of Statistics and Information has signed a 750 thousand dollar contract with Infomart, the Canadian videotex information provider, to put in a Telidon-based videotex system in Caracas, to transmit public information on health, social and economic aid programmes.[53] It is thought that this Venezuelan trial is a part of Venezuelan effort to diversify out of oil and develop their own telecommunications industries.

Although there are instances when the real developmental needs of the Third World can be aided with technology manufactured in the developed countries, the history of high technology in development has had a consistently pecuniary flavour to it, with the West usually turning a profit at the expense of the developing world. Even so, the new communications technologies discussed in this work have real developmental and educational significance. We shall concentrate on two of their uses, computer-aided messaging and using the hand-held talking computers for literacy purposes.

But just as significant as the appearance of the technologies in the developed world, is the appearance of packet-switched communications networks. Such packet-switched networks, we have seen, are widely used in North America with personal computers, communicating word processors, executive work stations, and other intelligent terminals to message and communicate with one another. One of theses packet networks, Tymnet Incorporated of Cupertino, California, provides reliable, economical, and almost error-free data communication for firms ranging from multinationals with branches in several countries to videotex information providers such as The

Source. Packet-switched networks like Tymnet can interconnect with almost all types of computer terminals and other networking equipment no matter what type or make or interface codes they use.

Tymnet now extends into more than 28 countries, including Argentina, Hong Kong, the Philippines, Singapore and Taiwan.[54] By arrangements with local domestic carriers in these countries, Tymnet offers all of its network services, such as computer time-sharing, numerical control applications, and access to various data bases such as the System Development Corporation's Orbit and Lockheed's Dialogue, which are technical, and scientific information banks.

In North American business, we have seen, all digital, computer-aided messaging over equipment ranging from videotex terminals, personal computers, word processors, to executive work stations -- and using satellites, cable, and packet-switched networks for transmission, is rapidly growing. The North American executives spend over half of their work time in communication of some form, and computer-aided messaging - in which a message is shot to a memory in the receiver's terminal and stored for later retrieval - is being rapidly installed and utilized. But computer messaging does not require a sophisticated packet-switched network to operate but can satisfactorily operate at a 60 words per second rate, (sufficient for electronic mail), over the most primitive phone lines. The question then arises to what extent can we consider computer-aided messaging as a substitute and supplement for telephony?

Computer-Aided Messaging

Much futurist nonsense has been written about village terminals in poor countries accessing data bases in the developed world via satellite channels. The specific idea here however involves the possibility of using low cost, all-digital computer message systems for telephone and mail, thus decreasing the demands for rapid voice communication in many parts of the developing world, and using a technology which can ultimately serve business and government needs by communicating word processors.

Computer messaging systems can operate at extremely low bit rates and very poor signal-to-noise ratios and can therefore often be used with existing transmission facilities in developing countries. Although there obviously always will be certain circumstances in which voice-to-voice phone contact is required, such written computer messaging should be considered as a real alternative to voice. Communications support equipment needed for a single phone may cost from 10 to 20 times the gross domestic product per capita in a developing country. Phone costs per installed phone line are so expensive in rural areas of many developing countries, when compared to major cities, that any cheap communications alternative, especially one that can be modified for more sophisticated business and governmental uses, is extremely pertinent.

At first it seems rather that all digital text transmission via computer is a step backward from voice communication. But the text transmission needs of governments, businesses and rural mail, can all be adequately handled by digital text transmission. More significantly, as two authors have noted[55] all digital text transmission systems also involve the "provision of a new range of services which are byproducts of computer-based text handling," including most of the information services discussed in this work. The main advantage of computer based text transmission over conventional telephone lines is that the capacity required is several orders of magnitude below voice requirements. Compared to the phone lines they can operate with extremely low signal to noise ratios, and this means that combined with their low channel capacity, "Simple equipment, (e.g. VHF transceivers) can be used satisfactorily to deal with rural communities too expensive to reach by standard microwave, UHF, or cable systems."[56] Cheap, intelligent terminals might be placed in rural and urban areas and used for messaging to supplement letters, telex, telegraphy, and phone.

Basically the introduction of computers into messaging enables one to use an old, existing transmission linkage (the phone lines) for new applications (computer messaging). Such systems, perhaps with public terminals operated by a small staff, could also operate over a packet-switched satellite channel with text transmission being the main mode of communication and voice only being a secondary minor use. Such a system, mapping out quality electronic mail in the local script, could also easily interface to any existing telex and telegraphy facilities. A small number of jobs might even be created in illiterate areas for village readers, if such a system were used for rural mail and messaging. But although such technology will ultimately be used in the urban areas of the developing world by business and government, we now know almost nothing about whether rural people would actually use it, if available.

Until recently one technological-cultural problem to such computer messaging systems in the developing world is that the West has created its technology in Roman script. Recent chip-based innovations such as the Farsi word processor are eliminating such language barriers.

The Farsi Word Processor

The Farsi/Arabic/Urdu group of languages is spoken by more than 600 million people in the world. All of these languages are cursive, meaning that the exact sign used to represent a sound depends on where in the word it is placed. Arabic script, for example, has more than 28 characters, the specific shape of each character depending on where in the word it is positioned. For each character there are usually four shapes -- initial, free standing, medial and terminal.

Because this language is cursive it was impossible to represent the full, printed, proper form of Arabic on typewriters, word processors, or printers. In all typing and telex transmission, an abbreviated, culturally offensive form of Arabic had been used. However, with the invention of the Farsi word processor, it is now possible to print the full representation of proper Arabic cursive script. With the Farsi word processor, invented by Syd Hyder, a Canadian at the University of Montreal, when a symbol is typed, a small microprocessor in the terminal receives and stores it in memory. Only when the other characters appear is the correct form of the first character determined and printed. This technology, initially being used for Arabic, is applicable to virtually any of the Farsi/Arabic/Urdu group of languages and other cursive scripts also.

(Several Saudi Arabian countries, in fact, have already purchased more than 5 million dollars worth of equipment. But as is the case in North America, the present barrier for further Arabrian development is the lack of suitable software and software packets in Arabic in virtually all areas -- banking, industry, education, etc.[57]

Since this invention allows printing, word processing, and messaging in virtually all of the Farsi/Arabic/Urdu world, in a form which is culturally and religiously acceptable and which people will actually use, the productivity gains are incalculable. Also since people all over the world generally like to have hard copies of their correspondence, the Hyder technology could allow computer text correspondences in the correct local script.

The Brazilians have already successfully tried computer messaging between universities. In October of 1979 computer messaging was carried out by personnel in the National Computer Networks Laboratory and university researchers. The National Computer Networks Laboratory is attempting to overcome distance factors in scientific interchange between researchers.[58]

Hand-Held Speaking Tools

Another immediate use is in education. Computer-aided learning (CAL) involves supplementing a teacher with a computer to teach a foreign language, mathematics, engineering . . . or basically anything else that can be learned by repetition and drill.

Equipment can vary from hand-held, computer-based educational tools like Texas Instruments' "Speak and Spell", to personal computers with courses on videodiscs, to satellite-based videotex systems in which educational software is downloaded into user terminals.

Most of us have extremely bad images associated with replacing people by computers and there are obviously many situations in which the human touch is necessary, but many basic subjects can be easily and rapidly learned with CAL. Learning software is becoming increasingly sophisticated, and the technology is becoming much easier and interesting to use. CAL, however, has existed in the developed economies for about 20 years now with almost no results whatsoever. Early systems were not user friendly. There was not much good software for different courses, and the computers had limited ranges of responses and prompts - mainly limited to filling in blanks, multiple choice and matters of this nature. But most of all the technology was very expensive.

Plato is the CAL technology of the Control Data Corporation of Minniapolis. Plato can teach about virtually thousands of topics. But until now its educational impact in North America has been non-existent, and since the system is so expensive -- a single Plato terminal and access to the software costs about $10,000 per year -- Plato customers have been limited to extremely weathly institutions or firms.

But given the fact that there are now "higher-level" computer languages, such as Canada's Natal, to write courseware in, and given the large number of videotex and teletext systems in the world, the next stage would seem to involve shooting Plato-like material over videotex or teletext to home T.V.'s, personal computers, or cheap terminals. This has already happened. The BBC is selling $400 personal computers in connection with a computer literacy course they offer on the BBC-1 T.V. network. Using CEEFAX, their teletext system, they are downloading telesoftware into the home computers. Manufactured by Acorn of Cambridge, there will be intitially 12,000 personal computers in this project.[59]

If anything, chips should have even more potential educational and health applications in the developing world than in the developed world. But whether they will be actually used for these purposes is another matter. Carl Argila[60] tells of one of the first stand-along educational computer tools used in the Phillipines. Comprised of a small Altair 8800 computer, a surplus teletypewriter and a tape cassette recorder, it was used to teach arithmetic and spelling to deal children, for which there are almost no teachers in the Phillipines. The system cost about $500.[61]

Of even more immediate educational interest are the new personal computer which are being used in education in the developing world and the hand-held educational tools based on speech synthesis. In 1979 Texas Instruments stunned the microelectronics industry by producing "Speak-and-Spell". This small, hand-held tool with a little screen and keyboard first pronounces one of thousand of English words, asks the child to spell it on the "Speak-and-Spell" keyboard and tells the child in a pleasing manner when correct, (or if incorrect asks him to try again). After three tries, the module both spells and pronounces the word and goes on to another word. "Speak-and-Spell" can operate at different levels of difficulty and also contains mind-teasing word games for the children. Best of all it sells for about $60. Western children do not have the prejudices against computers which their parents do, and use of "Speak-and-Spell" in teaching literacy in North America has been extensive.

Just as with computer-aided messaging, we have almost no knowledge concerning the cultural acceptance of "Speak-and-Spell" - like tools among differing people. However in many of the poorest countries of the world, those with average annual incomes of less than $200, over the next decade or so there will either be computer education like "Speak-and-Spell" or nothing at all. Speaking in local languages and with its liquid crystal display powered by solar batteries like many of the new pocket calculators, a single literacy tool could serve several children and run indefinitely.

Industrial Effects in the Developing World

What will be the initial industrial effects in the Third World resulting from the developed countries adoption of the microprocessor technology? It is too early to determine if microelectronics will increase or decrease the world's scale of industrial production. (If it is increased, microelectronics assembly operations in developing countries may themselves be increased). However the following trends, suggesting the opposite, are apparent.

Of the largest 100 economic units in the world, 40 are multi-national enterprises (MNE's) and 60 are countries. It is estimated that by the end of the century this portion will be reversed and that 10% of these MNE's will be from developing countries. The microelectronics industry similarly is dominated by large MNE's operating on a global basis. World wide, MNE's such as IBM and Digital Equipment Corporation dominate the market for main-frame and mini-computers respectively, while the market for microprocessors, while still quite diversified, is also dominated by MNE's. In the field of consumer electronics and robotics, Japanese MNE's predominate, and in telecommunications equipment, IT&T accounts for approximately a third of world-wide sales. Other world class multi-national corporations in totally unrelated fields have also heavily diversified into microelectronics. The Exxon Corporation, the largest oil company in the world, now owns Optical Information Systems which produces semiconductor laser products for data processors, Vydec which makes word processors, Quipe which makes facsimile transmitting and receiving devices, Delphi which designs voice recognition technology, Periphonics which provides voice data communications for computers, Ramtek which manufactures colour graphics computer displays, Qyx which produces electronic typewriters, and finally Intermagnetic General which produces super-conducting devices.

To utilize cheap labour, many microelectronics MNE's have located labour-intensive portions of their production in the Third World. Although in some cases computer-aided design and computer-aided manufacturing (CAD/CAM) is facilitating high technology production by unskilled labour, its main effect is to totally eliminate the unskilled labour components from production. Phone maintenance and simple replacing of electronic CAM modules may relax requirements to have highly skilled operators in some industries in developing countries, but the main industrial effects of CAM adoption in the developed countries will be to eliminate much assembly, fast-finger operations in the developing world since they are comparatively more expensive. Researchers at the University of Sussex[62] have speculated that since the use of microprocessor equipment in manufacturing facilitates automatic detection and control, it may reduce the need for highly skilled labour to maintain equipment which could operate in rural areas without consulting engineers from the developed countries keeping the equipment going; however, the main effect of CAM now apparent is to lessen the input of unskilled labour.

In fact this effect of reducing the importance of unskilled labour in production can already be seen in the exact area of many of the NIC's exports -- textiles, leather and garments, and electronic consumer products.

The second and perhaps most significant industrial effect on the Third World of the west adopting microprocessor technology arises from increased marketing and managerial advantages in coordination of information by using communicating word-processors, executive work stations like Xerox's Star, international videotex systems for corporate closed-user-groups such as Prestel International, and all digital high speed satellite business systems such as IBM's SBS-1. In the developed countries economic activities are increasingly concerned with the production, reproduction, and distribution of information in addition to material commodities. Information, as is now well-known, has properties different from physical commodities - it can, for example, be simultanteously possessed by more than one person at different places. Its value in a business context often derives not merely from its possession but from its rapid, efficacious use. The value of certain types of information also often depends on how constantly it is used, and both of these factors in turn depend on how rapidly information can be retrieved and moved about. As we saw this is now being done with communicating word processors hooked together to one another and to large external computerized data banks via the phone lines or satellites - and is facilitating both information retrieval with a massive reduction of information search time and computer-aided messaging.

Thirdly, microelectronics is effecting exports from developing countries. The average growth rate of the developing countries exports between 1967 and 1974 was approximately 26%.[63], and 80% of exports were accounted for by the NIC's. Many have observed that the NIC's mainly trade with countries close to them, and although they vastly vary in industrial structure and degree of foreign control, the highest exports of the NIC's are in those sectors which have the highest degree of foreign control. This means that decisions about terms of trade, type and intensity of local production, etc., are being made by the MNE's in their global interest rather than by the host countries.

About half of the NIC's export trade goes to the US and Canada, and despite recent GATT agreements, these North American countries are continuing to protect domestic industries by non-tariff barriers such as special-case clauses, import quotas and countervailing duties.

Although many of the NIC's such as Taiwan, Hong Kong and Singapore will be rapid adopters of the new microprocessor-based production technologies for traditional products such as garments and textiles (and thus will decrease the price advantage of the developed countries), markets for many traditional products of poor developing countries will be entirely eliminated.

Finally microelectronics is also facilitating the automation of batch production. With microprocessor-based manufacturing machinery fed instructions by computer, the same production line may be utilized to produce more diversified goods in a short amount of time. In engineering in North America over half of all goods are produced in batches of less than 50, and in many developing countries batch is the predominate mode of production. Much of this batch production in developing countries will be automated and returned to the developed countries.

Future Research

Just as in the industrial revolution the trains were not important because of who made the locomotives but rather what they carried (and who controlled the tracks), it is not as important who actually manufactures the chips but what applications they are put to. But both assertions are true only as long as there are locomotives and as long as there are chips. Regardless of how short term economic cycles effect the yearly production of chips, world-wide there is a trend toward the production of customized chips and an increased scarcity of chips on the open market.

The equivalent of the train tracks are now the large packet-switched networks and satellite channels and the latter are almost entirely the domain of the MNE's and national governments. But the equivalent of what locomotives carried are chip's applications, and each application requires a considerable amount of programming software. In fact in the Canadian survey of technological change, 80 to 90% of the costs of the new products and production processes incorporating microprocessors were often for software.

World wide, the capacity to develop new chip applications -- entirely a software task is growing, we saw, by only about 18% a year, while the yearly demand is almost double this rate.

Critical world software needs now include the following: (1) Sensing designers - in the survey a critical manpower need found across several industries such as electrical industrial equipment and crude petroleum production was people who could write software and also knew about sensing devices. In a plant extracting oil from tar sands, there is considerable variation of the grade of ore; other equipment in the plant must be able to electronically respond to varying grades, and with microprocessor-guided machineing tools, tools must sometimes cut around imperfections. Both of these sensing problems occur at the interface between the microelectronic and mechanical parts of the equipment. (2) Software design engineers for CAD/CAM in industry -- requiring people who are experienced in both software and hardware. CAD/CAM is as yet mostly design but not manufacturing. This is because there is not yet much software which enables a computer to interconnect with design modules and physically drive a plants' machinery. (3) Educational software designers -- needed to create the software for the CAL - videodisc - videotex systems, and actual courseware in local languages. (4) Applications engineers -- who will incorporate microelectronics in both products and processes in different industries. (5) Business software designers -- who will produce software packets for small business and governmental use in local languages, and (6) Process software engineers needed for actual chip production. There will also undoubtedly be many new software jobs we cannot anticipate.

Writing software is a cumulative, extremely specialized skill. Furthermore to incorporate chips into actual products or production processes, one must have a high degree of technical knowledge in both the machinery, the microelectronics hardware and software. But even with all these qualifications it must be noted that software writing is a basically simple mathematical-logical ability that can be quickly and easily learned by anyone with a certain level of technicial education in a related field. Also some developing countries such as India have a real "software advantage", since programming may cost as little as one tenth the costs in developd countries. For any LDC then, with the technological capability to do it, the development of computer software is an important component of any industrial policy. Given the changes in the patterns of international trade already discussed, should countries further concentrate on software and software packets which are integrated into the local production systems and which can be eventually exported to other developing countries.[7] In Brazil, which is a model for other developing countries computer communications policies, software expenditures comprise only about .5% of total national computer costs.

Japanese Software in Asia

Singapore, in fact, with the aid of the Japanese, is presently converting itself into a regional centre for computer software development and services. As the Committee on National Computerization sees it [64] their first task in developing the software industry is to create more trained manpower especially at the higher levels. It's thought that any subsequent task in attracting international software houses to Singapore will be easier once this is accomplished. In the area of training the committee has set up computer training centres to produce software programmers -- the Japan-Singapore Insititute of Software Technology and The Institute of Systems Science (with IBM).

The Committee is providing computer training not merely to professionals like engineers, accountants, administrators but also to senior managers and policy makers. Also, to increase computer software expertise, they are planning to import expatriates with high technology skills, mainly to organize courses to transfer skills to local professionals.

Local promotion of the software industry will occur after the training centres are fully operational, and they have a regular large input of software personnel. In the mean time they are trying to attract computer software firms which will bring in expertise and which are willing to train Singaporians in software, either locally or in the parent firm.

The following tax incentives have been made immediately applicable to Singapore software industries. With the international consultancy service incentive, they are making available the benefit of a 20% tax rate qualifing export profits for 5 years. A minimum requirement is 1 million dollars revenue per annum for overseas projects. With the capital pioneer status incentive, they will allow complete exemption of any companies tax for 5 to 10 years. But exemption will be granted only to those companies which carry out very sophisticated software development.[65]

In the schools the Ministry of Education is introducing computer studies at all junior colleges and secondary schools. By 1980 computer science courses orignating at the University of Cambridge were introduced into the Singapore Junior College. At the secondary school level, computer appreciation courses have been instigated, and they are also planning to equip secondary schools with personal computers. To introduce courses into education, the Ministry has also instigated courses to train trainers. The Department of Computer Science of the National University of Singapore now has a diploma in computer science, and courses in the National Junior College on the operation and use of microcomputers have begun with the students themselves being secondary school teachers.

The Singaporians are being aided by the increasing expertise of the Japanese in computer software. The Japan-Singapore Institute of Software Technology is a 6 million dollar training centre which will produce several hundred senior programmers and systems analysts yearly and will also provide computer training to business managers. Japan is presently building a global market, especially in South East Asia, for both computers and computer software. Although their world market for computers is presently only about 250 million dollars, Japanese computers are sold in many developing countries, and they have plans for global manufacturing capabilities. Aided by their expertise in alphaphotographic videotex and facsimile transmission, they will probably be the first to penetrate the Chinese market.

Japan is a net exporter of semi-conductors, but until now their semi-conductor manufacturers have constructed very few off-shore assembly plants, unlike North American producers. NEC for example has plants only in Malaysia, Brazil and the US; Hitachi only in Malaysia and Taiwan; and Toshiba in Korea, Malaysia, and Mexico. Texas Instruments by contrast has plants in 14 countries.

Although world software expertise presently lie in North America and Britian, Japan, not known for her software expertise, is developing a significant export of software to South East Asia. As early as 1970 MITI created the Information Technology Promotion Agency explicitly for the purpose of developing computer software. By 1976 MITI had created the Joint Systems Development Corporation (JSD), an export pool of 17 software firms, and five large Japanese corporations formed a 5 year joint project to develop and export computer software, with the government providing half of the estimated 400 million required.

There are, of course, other means of obtaining software besides creating it oneself. Alternatives involve licensing software for royalty or managerial fees, imitating and adopting foreign software, and, for subsidiaries, utilizing software of the corporate parent or its affiliates. Much of the software actually licensed by the developing world could be easily written in those countries. For example, whenever one sees a survey of computer languages used in developing countries, the authors inevitably list "report generator" with languages such as Pascal, Fortran, and Cobol. But "report generator" is not a computer programming language at all but a software packet for generating reports (usually in English). Many more packets can be written in developing countries. Realistically however many countries will continue to get much of their software packets from the foreign software suppliers, and the problems of developing countries obtaining software via these channels -- transfer pricing, packaging and unpackaging of technology, may be even greater than those in obtaining other technology on the international market or via MNE subsidiary transfer.

What we can be absolutely certain of is that the software cost components of new products and processes, even with the current advances in automation of programming, will remain extremely high over the next 15 to 20 years. In fact as early as the 1970's a UN study[66] estimated that in 1971, of 2,500 computers then in developing countries the main costs involved consultancy fees for systems analysts, salaries for programmers, and licensing fees to MNE's for software packets. All of these were software costs! In the words of Hoffman and Rush,

"The central importance of software will probably create new lines of technological dependence that do not apply in the current pattern of direct purchase. It is not yet clear what form software supplies will take - maybe the purchase of a package, or some form of contractual arrangement including ongoing maintenance. Opportunities to "unpackage" transfers of technology incoporating computers are likely to be few (since software is often hard-wired into chips and thus cannot be easily taken apart, understood, and duplicated as machinery may) and the unpackaging route to local capability, which has sometimes been open in other sectors, will be blocked, and entirely new options will have to be sought and explored for the developing countries."[67]

By economic analysis of the international trade in computer software and studies of microelectronics assembly plants, computer software institutes, chip production facilities, and technical colleges in selected developing countries, the following issues should now be examined: 1) What types of software and chips are being produced (or planned) in developing countries and what is the nature of intercountry software "trade" in terms of costs and industrial sector? By what means is software being generated and transfered - LDC production, parent-subsidiary transfer, joint venture, licensing, etc.? In other words what types of software expertise can be developed? 2) What types of policy measures can and are providing effective in forcing the MNE's to contribute more to software development? 3) To what extent can LDC technical colleges, national banks and other institutions contribute to immediate software development?

REFERENCES

1. Innis, Harold A., The Bias of Communications, Toronto, University of Toronto Press, 1951.

2. See for example, Lall, S., "Developing Countries as Exporters of Technology", Development Research Digest, No. 3, Spring 1980.

3. Cited in Rogers, E., "Technological Innovation in High Technology Industries," Paper presented at the International Conference on Technology Transfer, International Institute of Management, Wissenschaftszentrum, Berlin, December 8-10, 1980.

4. Microelectronics Survey, The Economist, 1-7 March, 1980, p. 5.

5. The Economist, 8-14 November, 1980, p. 3.

6. "Grassroots; Up To The Minute Agriculture Information. Meeting the Needs of Modern Farmers", Infomart Brochure, undated.

7. "The Computer as a Retailer", The New York Times, Monday, January 12, 1981, page D1.

8. "CATV Versus Telephone Lines; Comparing ViewData - Videotex Delivery Systems, Research Memorandum No. 14," Link, May 1980.

9. "New Viewdata System from Japan", Viewdata/Videotex Report, Vol I, Number 14, December 1980, p. 143.

10. "Farmers with Green Thumb have the Edge", the Progressive Farmer, August 1980, p. 4.

11. Hughes, Harlen, "Computers and On-Farm Microprocessors for Farm Business Management", Paper presented February 16-17, 1981 at Computer Technology in Agriculture, a course at the University of Manitoba, Winnipeg, Manitoba.

12. Electronic News, September 22, 1980, p. 74.

13. International Videotex/Teletext News, No. 7, January 1981, p. 4

14. The Economist, 7-13 June 1980, p. 94.

15. Pollack, Andrew, "New Xerox Personal Computers Also Serve As Word Processors", New York Times, June 9, 1981, p. d4.

16. Branscomp, Lewis M., "The Computer and World Communciation", Telephony, December 17, 1979 .

17. Scannell, Tim, "Vendors Warned of Micro Incompatibility," Computer World, May 11, 1981.

18. Blumenthal, Marcia, "Personal Computing Finds New Meaning at NCC '81", Computer World, May 18, 1981.

19. The Economist, February 21-30, 1981, p. 67.

20. Electronic News, September 15, 1980.

21. Smith, Jim, Weinrich, Dave, "National Semi-Conductor Application Note 252", December 1980. See also Morris, Dennis E., et. al. "A New Speech Synthesis Chip Set", IEEE International Conference on Acoustics, Speech and Signal Processing, December 1980.

22. "Product manual for the MM 54104 DIGITALKER Speech Synthesis System", National Semi-Conductor Corporation, December 1980.

23. Levinson, Stephen B. and Liberman, Mark Y., "Speech Recognition by Computer", The Scientific American, April 1981, Vol. 244, No. 4, p. 64).

24. Business Week, April 6, 1981, p. 40.

25. "How to Use Your Terminal When You Can't Use Your Hands or Eyes", Heuristics 7000 Product Specification Brochure, Heuristics Incorporated, Sunnyvale, California, January 1981.

26. DePeyster, Deborah, "Microphone Replaces Keyboard On New Terminal", Computer Business News, March 3, 1980).

27. Product Manual for the Typecorder, Sony Corporation of America, undated.

28. Tapscott, Don and Mcfarlane, David, "Perspectives for the Office of the Future", Bell Northern Software Research Incorporated, 1979).

29. Pollack, Andrew, "Xerox Stalks the Automated Office", The New York Times, May 3, 1981, p. 4f.

30. "Packetized Voice Seen Impacting Work Stations", Computer World, May 11, 1981. p. 28.

31. "Voice-Activated Typewriters Available by 1983", Canadian Office, December, 1980, p. 41.

32. Ibid., p. 41.

33. Product Description Manual for the Envoy 100, the Computer Communications Group, undated.

34. Business Week, April 13, 1981, p. 122.

35. Business Week, May 11, 1981, p. 108).

36. Segal, Efran, et.al., Videodiscs, College Industry Publications Incorporated, White Plains, New York, 1980, p. 71.

37. Business Week, April 6, 1981, p. 89.

38. Technology Watch for the Graphic Arts and Information Industries, Vol, 1, No. 2, December 1980.

39. "The Equatorial Multipoint Data Distribution Network," The Equatorial Communications Company Product Brochure, undated.

40. Hauck, R.W., and J.W.B. Day, "The Experience of Satellite Broadcasting Applications with CTS/Hermes ", paper presented at the 9th International T.V. Symposium, Montreal, 1979.

41. Block, C., Foote, Denis R., Mayo, John K., "SITE Unseen ; Implications for Programming & Policy", Journal of Communication, Autumn 1979, Vol. 29, 4).

42. "Preliminary Report on Prospects for Additional Networks, Appendices", The Federal Commmunications Commission Network Inquiries Special Staff, March, 1980, p. 20 .

43. The Economist, 22-28 November 1980, p.112.

44. See for example, Sleigh, John, Boatwright, Brian, Irwin, Peter, and Stanyon, Roger, "The Manpower Implications of Microelectonic Technology ", Crown Publications, 1979.

45. See for example, Mansfield, Edwin, "Technological Change and the Rate of Imitation ", in Industrial Research and Technical Innovation, W.W. Norton and Company Incorporated, New York, 1968, and Edwin Mansfield, John Rapaport, Jerome Schmee, Samuel Wagner, and Michael Hamburger, Research and Innovation in the Modern Corporation, W.W. Norton and Company, New York 1971.

46. Demelto, D.P., McMullin, K. and Wills, R., "Innovation and Technological Change in Five Canadian Industries", Discussion Paper No. 175, The Economic Council of Canada, Ottawa, 1980.

47. The Economist, December 6-13, 1980, p. 95.

48. Crozier, J.E., "A Study to Indentify the Attitudes and Awareness of Numerical Control Users to CAD/CAM Technology ", Technologial Innovation Study Program, Department of Industry Trade and Commerce, November 1980.

49. Osborn, Adam, Running Wild, The Next Industrial Revolution, McGraw Hill Incorporated, Berkeley California, 1979, p. 61.

50. Rada, Juan, The Impact of Microelectronics (Geneva: International Labour office, 1980)

51. Rada, op. cit.

52. The Home Video Report, Vol. 11, No. 14, April 6, 1981, p. 4.

53. Telidon Report, Department of Communications, Ottawa, Ontario, No. 3, December 1980.

54. "International Services Provided by Tymnet", Tymnet Incorporated, Cupertino, California, March 25, 1981.

55. Gupta P.P. and Ramani S., "Computer Message Systems for Developing Nations, a Design Exercise", Provisional Proceedings of the International Symposium on Computer Message Systems, Ottawa, Canada, April 6, 1981.

56. Gupta and Ramani, op cit., p. 4.

57. Canadian Patent Application No. 155-204, December 12, 1978, "Electronic Digital Systems and Method for Reproducing Languages Using the Arabic/Farsi Script.

58. Tarouco, Liane M.R., "An Experimental Message Computer System Between Universites in Brazil", in Provisional Proceedings of the International Symposium on Computer Message Systems, Ottawa, Canada, April 1981.

59. International Videotex/Telextext News, April 1981.

60. Argila, Carl, "The Microprocessor Revolution: Its Impact on Developing Countries ", in Proceedings of the International Conference on COMPUTER APPLICATIONS IN DEVELOPING COUNTRIES, Vol II, Bangkok, Thailand, 1977.

61. Ibid.

62. Hoffman, Kurt and Rush, Howard, "Microelectronics and Industrialization in the Third World", Development Research Digest, No. 3, Spring 1980.

63. Lall, S., "Developing countries as exporters of technology and capital goods: the Indian experience", Oxford University Institute of Economics and Statistics, 1979.

64. "Report of the Committee on National Computerization", Singapore, October 1980.

65. Ibid., p. 21.

66. "The Application of Computer Technology for Development", 2nd Report of the Secretary General in Response to General Assembly Resolution 2804, New York, 1973, Document ST/ECA/176.

67. Hoffman and Rush, op. cit., p. 52.