講　演

The Status Quo and Perspective of Electronics Technology

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電子技術의 現況과 展望

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本文은 지난 7月 5日(月)에 있었던 本學會招請學術講演會(光云工大大學院講堂)의 講演內容 全文입니다.

Good morning, Mr. Chairman and all the members of Korean Institute for Communication Science;
First of all, I would like to thank you for giving me an opportunity to visit this country and talk about Electronis in front of all of you.

Today's theme of my lecture is "The Status quo and Perspective of Electronics Technology". I am going to talk about two major subject;
1. Trends and movement within electronics industry encompassing office automation field, information system field, etc. toward one integrated, specialized industrial segment.
2. Present and future state of art of closely related technologies amidst the integration and convergence trends of various electronics-based industries.

Addition to these subjects, I would like to talk about some interesting problems, which I have been considering these years.

If you have any question, I would be happy to answer it during later question-answer period.

As I view it, the world industrial revolution has taken place since the later part of the 18th century with development and introduction of the steam engine. It has brought about tremendous changes in our economic, social and industrial systems as the result of increased productivity which grew en crescendo over time. These changes represented the process of industrialization, supported by stepped-up R & D in newer material and energy resources. More recently, the systematized body of information has emerged as the third resource in our day-to-day life. This is an attempt of the mankind to systematically and intentionally utilize the value of information for upgrading the management standard and the quality of our life, with a notion that it contributes greatly to efficient utilization of materials and energy. Information is indeed indispensable in our endeavor of smooth shift to a newer and more improved civilization in industry, in society and at home.

Information systems development backed up by neverending pursuit of computor technology tends to exert widespread impacts upon not only advancement of industry as the whole but also modernization of the medical system, solution of environmental polution abatement, office automation, increased quality of individual life, etc. In particular, the microprocessor developed as the result of recent microelectronic processing innovation has seen a broad range of applications in various industrial equipments and home appliances as the indispensable functional unit which is capable of performing intelligent operations unlike the conventio-

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nal computer. On the other hand, today the information system industry which is known to be knowledge-intensive, uses less material and energy resources and has negligible effects on environmental polution is receiving a tremendous degree of growth expectation and is considered to be the prime mover of technological development.

Next, let me discuss on the electronic industry formation in which electronics technology is both intensively and extensively utilized. It can be divided into the following 5 types:

As you may be well aware, there are home electronics, office electronics, social electronics and national electronics built upon personal electronics which is down at the base, as is portrayed here.

In our consideration of electronics advancement it is important to first assess changing requirements of the social system, which represents a decisive factor. Here, we are required to make a lot of assumptions from the futurological point of view. Basically, I believe that the world in which we live is marching toward the post industrial society, judging from current changes in our social

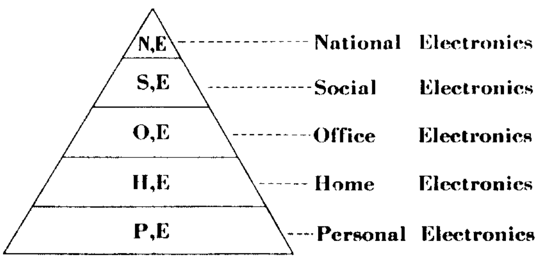


Fig. 1

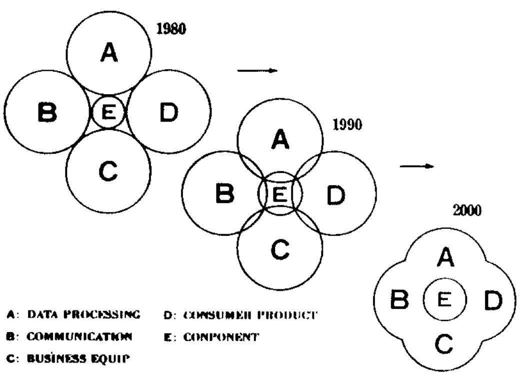


Fig. 2

system. I also feel confident that this brings about an increased level of electric/electronic industry convergence and integration commensurate with changes in the social system. Consequently, the domain in which technological innovation tends to become more intensive are as shown in Figure 2:

Please look at Figure 2 carefully. Characteristically, in the 1960's each electronic industry such as electronic in the 1960's each electronic industry such as electronic component, computer, telecommunication, data processing, office machine, home appliance, etc. operated independent of others. Stated in other way, each was separate and different. Each strove to build up its our empire. The 1970's saw agitation and fermentation among these industrial segments to endeavor to merge each other's business and technology. The 1980's represents a decade during which each of the 5 electronic sectors mentioned earlier will intensify further interchange and consolidation of business/technology so as to supplement and complement each other's market position. This undoubtedly tends to bring about the synergical effect which sparks further technological/business development. Today, we see a wide variety of computor-aided communication equipments produced by telecommunication industry. Word, date and image processors are growingly utilized in office machines, electric home appliances, data processing equipments and many other electric/electronic products with increasing sophistication of software technology. In the rapidly innovating electronics field where today's useful product/technology may become obsolete tomorrow it is constantly replaced by newer and more complex one. Research and development is always underway to implement, wherever feasible, building of "intelligence" into various hardwares so as to achieve more flexible and efficient performances.

As such, what is likely to happen in the 1990's is as follows: I want to invite your attention to Figure 2 again. Please note that integration and interchange of the 5 electronics sectors will be carried to the extreme during the decade and become firmly established toward the turn of the century.

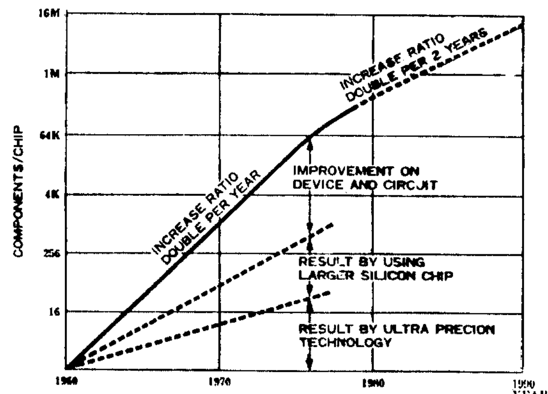
Mechanization of office work popularly referred to as office automation is a process of integrating machines and devices developed by 4 electronic sectors; computor aided communication equipment, office machine, data processing equipment and electronic component. I can predict with a reasonable degree of precision that such office system tends to grow in sophistication and complexity further and will become the mainstay of the futuristic office automation one can think of.

In Figure 2 the home electric/electronic appliance sector has been left out unexplained. Indisputably, it is and remains to be a big industrial field. Products produced by this industry will be growingly used in and tied into the office automation system, too. All these electronic sectors combined and integrated will form the social system industry and contribute grealy to development of the futuristic society as well as the wellbeing of people at large. To illustrate my point, development of home automation (HA) permits one to work at home just as well without being present at his office or remotely control and operate equipments located in the office or vice-versa. Moreover, when he is far away from the office on business or otherwise, he can still get in touch with the office through cable telephone, radio communication, satellite communication and other media. With advent of the TDF (Transboarder Data Flow) age one can do shopping at home here in Japan without being present at a department store in West Germany in the future. Consequently, so-called personal automation (PA) is developing at present, reflecting further diversification of personal needs and wants. Products under the PA category are many. One that stands out among others is pocket computer which is highly integrated in system and miniaturized in configuration. PA holds a promise of tremendous product development in the foreseeable future, as more and more people tend to become intelligently lazy. In development of the PA product category it is increasingly important to take into account the man-machine system concept. It also gives rise to further problem-solving (debugging) and perfection of display engineering, human voice synthesis, optical recognition methodology and many other related technologies.

Next, I wish to spend a little time elaborating the present and future states of art of office automation industry, information system industry and others which are built upon and continuously building on electronics technology.

Electronic component industry has fared remarkably well in integration and product miniaturization technology. Looking back on the past, the scale of integration grew twice as much every year largely due to stepped-up R & D endeavor. Factors responsible for this commendable accomplishment are many. First, devices and circuits have been progressively improved and upgraded. Regret to say, component integration seems to be carried to the extreme at present and chance of further upgrading is quite remote. Secondly, improvement possibility of the component can be accomplished by enlarging its chip surface and by increasing the number of sensors to be integrated therein. But this is indeed a time consuming developmental process. Component industry still fails to get the successful result out.

We are now placing a considerable degree of confidence in the further success of super miniaturization in electronic component industry. At the current time, the 64k bit MOS IC memory incorporates 160,000sensors on its 6mm×6mm chip with the line width as fine as about 2 microns. Furthermore, in development of the 256k bit MOS memory or the 32M bit microprocessor which becomesone digit smaller in number of sensors to be integrated it is no longer feasible to do micro assembly under the light visible by the human being. It calls



ANNUAL CHANGE OF COMPONENTS/CHIP AND FUTURE TREND

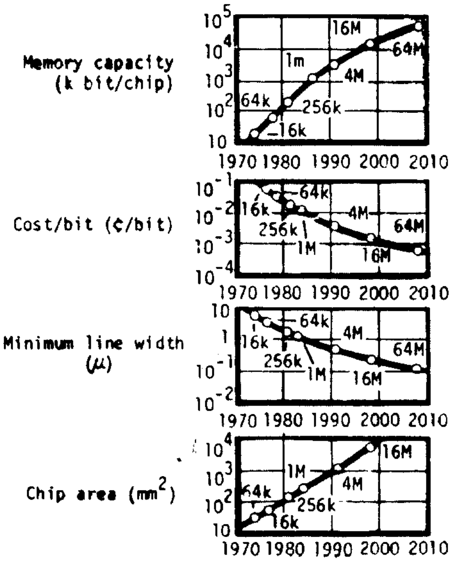
Fig. 3

for super microprocessing in the order of onc micron or under. The most promiseful method which emerges today as a solution to this problem is application of the electronic beam and X ray transfer printing technology which are being continually improved in terms of integration. Other achievements in this respect which are worthy of mentioning, which will be brought withinthe realm of commercial feasibility before long are molecular processing, three dimensional integration, super grid sensors, etc.

Circumstances being such as they are, I venture to say that scaling upward of integration hereafter tends to slow down slightly compared with the past years and will probably grow twice as much in every two years. The continuing trend toward higher scale integration will result in the following improvement effects; (1) further product miniaturization and lower power consumption, (2) higher product performance, (3) faster speed, (4) higher reliability, (5) lower cost per function. Therefore, it can be reasonably assumed that depending upon level of scale integration at any point of time in the future, new and unique products (for example, electronic translator) will be developed and placed in markets one after another. As we look back on the past, rapid development of microelectronics symbolized by IC has triggered a series of computer technology innovation and given birth to microcomputer, data processing equipment and other sophisticated electronic products out of mere desk top calculator technology.

Initially, the microcomputer was of multi-chip construction, comprising CPU chip, memory chip, I/O port chip, etc. Later on, all these chips were integrated into single chip which permitted more compact configuration of the equipment. As the result, the microcomputer has succeeded in making explosive market penetration. At present, almost all 4 bit microcomputers are single chip in make-up with special-purpose application. The microcomputer of 8 bit general-purpose application is also selling well in markets. As I see it, the trend toward progressively shifting one class upward in processing capacity is noticeable, meaning that a portion of 4 bit microcomputers are graded up to 8 bit and that a portion of 8 bit microcomputers are graded up to 16 bit. Moreover, it should be noted that development of high performance microprocessor such as 16 bit, 32 bit, etc. can not be achieved without design verification by means of CAD and well-organized developmental procedures starting from determination of required specifications. I should say that MOS LSI technology will be growingly utilized in development of these higher class microprocessors. Figure 4 shows a technological forecast toward 2010 when MOS LSI technology will be established and widely diffused in industry. It indicates changes in memory capacity, cost, line width, etc. over the time series.

As is clear in this Figure, memory capacity per chip will be increased 100 times by 2000, using the present capacity level as constant. Cost per bit will substantially decline due to higher scale integration. The most advanced semi-conductor memory as of today incorporates 64k bits. It is likely that semi-conductor memories of 256k bits and 1M bits will be developed and brought within the realm of commercial feasibility in not too distant future. To achieve this, however, it is mandatory that industry strives to pursue super micropqocessing technology still further. Indeed, it takes a tremendous degree of precision control and conceptual shift in the order of submicrons from the conven-



Long Term Forecast of Integration.

Fig. 4

tional 3 microns, which virtually revolutionalizes the present state of art.

Next, turning to discussion of the data processing industry, it is vital for the industry to develop unique technoloqy and know-hows on its own, whereby meeting widely diverse informational requirements of product users who are non-professionals in general, which is not the case with computers. This product segment also requires supportive processors and software which are commonly applicable to all product lines. There are various types of processing which can be thought of. Data processing (DP) is concerned with order processing, form control, information retrieval from the master file, etc. Word processing (WP) is applied for preparation of reports, DM's, letters, etc. Image processing (IP) is utilized for portrayal of images, drawings, graphic arts, etc. Development of data processing technology brings with it advancement of telecommunication system which includes facsimile and others.

The data processing equipment tends to be bigger in capacity so as to meet requirements of increased data volume which must be gotten out. particularly, in Japan we use a wide variety of Chinese characters of highly complex patterns in our written messages, which definitely compound the communicative confusion, unlike people in Western countries. Consequently, the machine must be capable of storing a vast number of data in the memory. Today, there are various high performance memories available in markets, which include magnetic disk, magnetic bubble memory capable of large volume, high speed data transmission, etc. With reference to the magnetic bubble memory, the first 64k bit memory was developed and marketed in 1976. In the year immediately following, 1977 its capacity increased to 256k bits. In 1979 its capacity further increased to lm bits. At the current time an intensive R & D is underway in industry to develop 4m bits magnetic bubble memory sometime in this year or the next year.

As concerns the image processing, an ability to store and retrieve non-numerical data such as objects, hand written word symbols, etc. has been growingly demanded by users in the recent years. An answer to this problem is emergence of CCD as the device for analogue signal processing. In addition, development and marketing of photo-magnetic disk (small size) is now underway.

The topic I wish to deal with next is telecommunication technology.

The important factors responsible for success of OA are communication channal technology, network technology, communication sub-systems development, etc. When we consider media of communication, there are two types; wireless and wired communications. In the case of wireless communication utilizing the electric wave signal the communication system by means of satellite will be extensively introduced in the office automation field.

Wired communication can be accomplished both electrically and optically. It is being dominantly carried out by means of copper wire channels. It is predicted that almost all new communication sub-systems to be introduced in the future following rapid technological development of photofiber cable technology are bound to capitalize on the new optical medium. At present, the optical wave length of 0.85 μm band is predominantly in use. Compared with the conventional coaxial cable transmission, distance required to relay signals between two stations can be extended 3 to 5 times. While considering the current price transition of the photofiber cable, it appears that the new system definitely costs less in installation. The photofiber cable communication systemis now considered to be more than adequate in local networking of a small or medium scale office automation scheme. With further development of data and image transmission system, the digital display feature is demanding both at home and abroad. Due to furtherance of digital communication networking which will necessitate multiple routings sales of the code transmission equipment tends to grow substantially.

One of the major OA features is that a higher utilization of the digital networking becomes possible. Japan Telephone Telegram Corporation is now in the process of developing and perfecting a program called the INS (Higher Information Communication Service) for the duration of more than 20 years starting from now. It is exactly this kind of service I am referring to. The digital network which we can make use of at present consists of conventional telephone cable line system with a vast number of modems and the DDX network which is under the JTTC jurisdiction. It is predicted that starting from the mid-80's, diverse civil network services and satellite communication service will commence as the result of projected Japan's communication network liberalization.

When all these services will come true and will be available for use by the general public, the telecommunication networking, both global and national, which office workers can make use of will be strengthened still further.

Another important movement worthy of note relative to the networking is an attempt to develop and achieve best workable local networks countrywide, which enables efficient intraoffice communication. When I said the local network, I was referring to a networking workable within the confine of a few kilometer radius locality. At the current time, intensive efforts are being exerted jointly by the concerned governed government offices, agencies and private industry to develop and introduce the local network standardization and specification. As such, further technological development in this area can be anticipated before long.

Next, with regard to the office machine sector a continued attempt of systematically centralizing a variety of stand-alone office equipments throgh introduction of microcomputers is being made, which is continually upgrading the office automation system. System centralization of multiple office machines has two purposes to be achieved.

They are, (1) functional diversification, (2) functional compounding. Research and development along these two technological requirement themes are currently in progress in industry. For example, an office machine made to simply copy or calculate begins to be equipped with a judgemental or discriminatory capacity. It is then tied in to a big host computer by means of telecommunication. If this comes true, each individual office machine which appears to stand alone is no longer so. It turns out to be a terminal and become an integral part of the intricate office management system.

In any office automation or information system the display sensor plays a vital role in performance. Conventionally, various display sensors have been used, which include CRT for character, graphic display, neon discharger tube for big, outdoor advertisement, flourescent lamp and liquid crystal for desk-top calculator display and LED and mini light bulb for other displays. More recently, sensors such as liquid crystal, EL (electro luminescence), EC(electrochromic), POP(plasma display), FL (flourescent lamp display) are growing in importance.

Today, as much as over 80% of liquid crystal display sensors are being applied in calculators and watches. It holds a promise of extensive application growth in the future. It contributes greatly to product miniaturization, super thin and light weight configuration, low power consumption, etc. It is CMOS-compatible because of its low drive voltage. Its matrix-driven display device results in distortion-free image.

The colored liquid crystal is still in the developmental stage and is not complete yet. We are watching technological developments in this area with a great deal of attention.

As concerns the electroluminescence, ever since our company had announced development and marketing of ZnS thin film EL of more than 10,000 hour life in 1974, research and development of thin film EL has become growingly intensified in industry. At present, the luminescent type solid surface display is considered to be the most promiseful EL display panel because of easy processability and is attracting widespread attention. However, we still recognize the needs of upgrading the brightness still further and implementing the new material developmental research so as to attain suitable colored EL's.

As I stated earlier, there has been a notable tendency of business/technology convergence and integration among telecommunication sector, data processing sector, office equipment sector and home appliance sector collectively known as the el-electronic industry due to growing duplication of technology and know-hows which are in common with one another. For the most part this kind of integration has taken place in the area of hardware development. As the integration tends to grow and is carried to the extreme, the role which the software plays becomes vital and expanded.

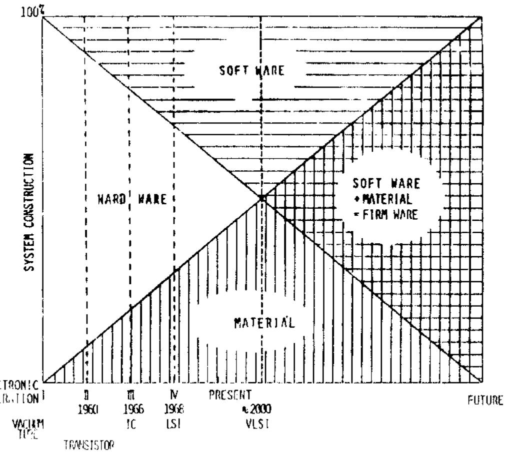


Fig. 5

Figure 5 shows system structurization vis-a-vis each electronics generation.

It is clear that over the first two electronics generations—vacuum tube and transistor—the software cost gradually hiked upward relative to the declining hardware assembly cost, meaning that purchased component and material costs have risen sharply over time. As industry transits through the third IC and the fourth LSI generations, the ratios of software cost and, consequently, component/material cost in the total manufacturing cost formation become enormous. In 2000 when MOS LSI will be universalized in our life, almost all manufacturing costs will account for software and material purchase. As we extend this thinking process further, we come across an area where both software and purchased component/material partially overlap and become integrated. This is what we term "firmware". This is an area which is considerably humanized and personal. As such, every thinkable means of our life including machine, appliance tool, etc. which are supported by rapid technological innovation will be growingly sophisticated, permit man-machine two way interaction and become equipped with an increased level of "intelligence".

The microcomputer which partially performs the function of our brains is manufactured upon a Si substrate at present. However, development of the element which is capable of higher speed processing is demanded due to an increased level of data which must be processed today. It is considered to be physically impossible to pursue high speed data processing with use of the Si substrate. We have to search out for other suitable elements which serve the purpose. Right now the so-called "post silicon" IC research is in progress. Top candidate runners-up are Josephson element, GaAs element, etc.

Unlike conventional semi-conductor elements Josephson element is one which makes use of super electroconductivity phenomenon. It must always be immersed in the liquid helium, but its use permits extremely compact construction of computer body—about 15 cm spuare. Compared with Si element performance, it is over 10 times faster in processing speed, and 1/10,000 in power consumption. However, it poses a number of serious technological problems in product development. We still have to go a long way before we will be able to develop it and commence its commercial production.

Under circumstances such as these we are now concentrating our efforts in development of GaAs element which is considered to be a prelude to Josephson element. GaAs element can operate under the normal temperature and process 5 times faster in comparison to Si element. Nevertheless, there are many shortcomings and problems we have to overcome before the successful product development.

On the other hand, we are striving to bring about further improvement of existing Si product. We realize that there are many constraints with Si element, which prohibit higher speed processing. The improvement areas we are trying to approach are cost reduction, certain degree of processing speed increase and introduction of more improved processing methodology. Generally, the present computer operates on the principle of one processing at a time. What we try to do now is to introduce the parallel processing method, using a number of processors. This permits simultaneous multi-data processing operations in parallel as shown in Fig. 6 and results in an increased data processing speed.

Under the simultaneous, parallel multi-processing operation method we can eliminate a need of

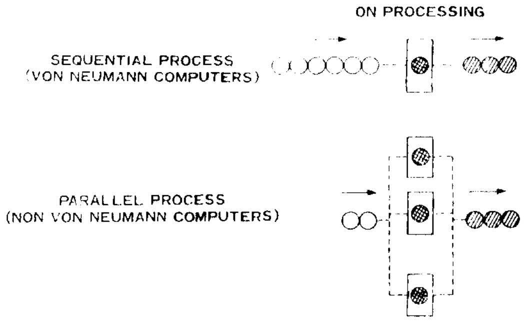


Fig. 6

programing each operation and consequently can achieve increased software productivity. Thus, development of software which simulates the human thinking process capable of recognizing patterns and performing parallel data processing in now demanding. Currently, research and development of the microprocessor capable of performing parallel data processing operation is underway. When such processor comes true and can be integrated into either office or information hardware, we will be able to achieve the system undreamed of heretofore. Moreover, the microcomputer will witness expanded applications in virtually all walks of our life.

In conclusion, I am strongly convinced that electric/electronic equipments and appliances will be continually upgraded in terms of function and reliability with corresponding sophistication of supportive electronic devices and components such as microprocessor, display sensor, etc. Electronics development is always expanding as it pervades all aspects of our modern social system. The forward momentum and growth pattern from the past years should continue into the 1990's toward the turn of the century.

Thank you very much for your close listening.