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"THE JAPANESE COMPUTER INDUSTRY: ITS ROOTS AND DEVELOPMENT"

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FOREWORD

Dr. Koji Kobayashi, Chairman of the Board and Chief Executive Officer of the Nippon Electric Co. Ltd., visited IIASA on September 27th, 1979 at the invitation of Dr. Jermen Gvishiani, Chairman of IIASA's Council. In the course of his visit he presented the following paper at a seminar attended by members of IIASA's staff as well as some interested visitors from Vienna. Dr. Kobayashi has kindly agreed that his paper should be published as an IIASA Collaborative Paper.

The relevance of this paper to IIASA's research interests hardly needs emphasis. The tracing of the development of computers in Japan within the context of the communications industry is of relevance to the work we are undertaking improved scientific communication through computerized networks, teleconferencing, etc. As an intimidating example of a successful innovation process it is of direct value to the Management and Technology task concerned with Innovation. The emphasis that is given to the software problem for the future is an indication of the need for further research into the management/computer interface in the coming decade, on the lines of the task under that heading also being tackled in the Management and Technology Area. But the paper is clearly of interest and significance to a wider public--and we are proud to issue it as a Collaborative Paper.

Rolfe Tomlinson
Area Chairman
Management and Technology Area

Contents

"The Japanese Computer Industry: Its Roots and Development"

Koji Kobayashi

1. FIVE MILESTONES

I am greatly honored to have been invited to speak to you, researchers at the International Institute for Applied Systems Analysis (IIASA). I have heard that this meeting was arranged by the considerate suggestion of Prof. Dr. J. M. Gvishiani after my visit with him in December of last year.

I would like to take this opportunity to say a few words on the Japanese computer industry, its roots and future trends. The advent and development of computers in Japan have been founded on communications, and I hold high expectations for the future when the merging of the computer and communications will lead to the emergence of totally new abilities and functions inconceivable while the two existed as separate entities. This in turn will lead to the creation of many new technologies of value from the user's point of view. This is the direction which I intend to explore in my remarks today.

This subject represents the theme on which as keynote speaker of Japan, I spoke at the 3rd U.S.A.-Japan Computer Conference held in San Francisco, California, U.S.A. in October 1978. At that time, I announced that the year 1978 marked the beginning of our new era of "C & C"--unification of computer and communications. I will speak to you with 1978 as the starting point.

I would like each of you to visualize for yourself the time span of which I am speaking. From my purely personal, experience-based viewpoint, a number of major milestones can be placed along a time axis divided at intervals of about 10 years (Figure 1).

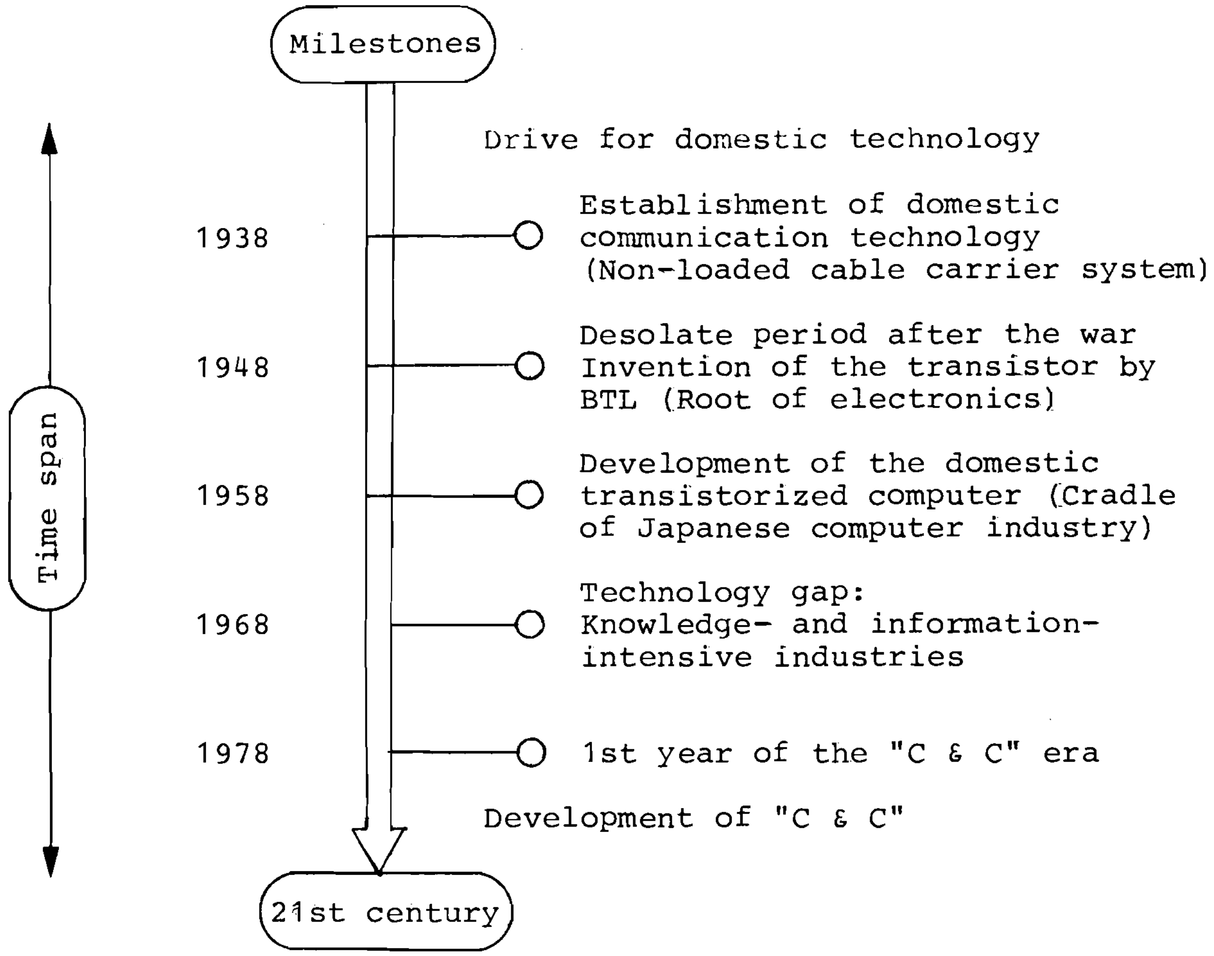

Figure 1. Milestones of the Japanese Electronics Industry

How about 10 years ago? Japan's technology gap was being discussed in an international context. The existence of a gap at the same time means that there is scope for development, that there is potential. It was also at this time that emphasis began to be placed on the power of knowledge and information, or on the power of the intellect.

And what about 10 years before that? It was at that very time that Japan's electronics industry came into being. The subsequent attainment of independence and the rapid progress made by the industry in Japan, alone among the world's industrial nations, must be attributed to the concerted efforts of the industry itself and the government's supportive policies.

How about 10 years before? It was the desolate period after the war. Who, at that time, could have predicted the present vitality of the Japanese economy and electronics industry? In that year, however, on the other side of the Pacific, the invention of the transistor took place at the Bell Telephone Laboratories.

And a decade before that? Those were the days of my youth, some 10 years after I entered the industry. In that year, a

Japanese volunteer technical team was engaged in the construction of a long-distance cable circuit using a nonloaded cable carrier system with a total length of 3,000 kilometers, which traversed the main island of Japan and crossed the Tsushima Strait and the Korean Peninsula to reach distant Shenyang in China. This was a great undertaking, on a level of accomplishment represented by Drs. Matsumae and Shinohara of the Ministry of Communications, predecessor of the present Ministry of Posts and Telecommunications.

Let us now turn our gaze in the other direction, to a point 20 years hence. History will have drawn to close the 20th century, and the era of the 21st century will be within reach. The long-dreamed-of 21st century will be on the point of becoming a reality. We should take note that we now stand at the important turning point which is both the boundary and the link between the past and the future.

2. THE ORIGIN OF JAPAN'S DOMESTIC TECHNOLOGY

I would like to begin on the subject from the time when I entered the industry, that is, from the late 1920's to the early 1930's. What was the situation of technology and industry in the telecommunications field in Japan at that time? As many as 90 percent of the patents were foreign, and the related materials and parts industries were in so poor a state as to be almost nonexistent. Almost all of the important materials and equipment were imported from overseas.

We young engineers inevitably felt a sense of calling to overcome this situation somehow. We must acquire our own technology and our own engineering, for the sake of both the country and the people--this was the spirit which welled up in us, and this was the background of the domestic production movement which arose of necessity in prewar Japan.

At that time, the leading enterprises overseas were the "giant" firms. Before such giants, we were nothing but a tiny puppy. In general, no country should be dependent on others for the important sectors of its infrastructure such as communications. It must gain the ability to supply its own needs with its own technology. This trend gained strength around 1932-1933, with the slogan adopted by the engineers being "domestic technology".

In order to concentrate one's energies, one needs a goal, a specific problem. The goal which appeared at that time can be said to have been the "non-loaded cable carrier system." The puppy, with its new technology, confronted the giants with their loaded-system patents who were then ruling the communications world. This can only be ascribed to the boldness of youth. We were determined to succeed, whether it took us 10 years or 20, and since in fact the project did not reach technical perfection until after the war, it did indeed require 20 years.

However, I did not raise the subject of the technology of 40 years ago for the sake of reminiscing about the history of communications technology but because I see here a lesson, an example, for the further development of Japanese computer industry.

As in the case of communications, provided that we establish ourselves firmly, without being overly impatient or depending on expedient borrowings but meeting the challenge with our own strength, I believe that the Japanese computer industry can also walk tall, ranking with the giants of the world in the future.

3. THE ROOTS OF THE JAPANESE COMPUTER INDUSTRY

Next, we come to the second milestone. How did Japan and its electronics industry stand in the year 1948? Research on radio wave technology in specified fields had been prohibited by the Occupation Forces. The situation was such that even the news of the invention of the transistor reached us only as the barest outline filtering through the GHQ of Allied Forces.

How much further, then, were we from gaining any news of the development of the computer. There was no way in which we could have known of the birth of ENIAC at Pennsylvania University in 1946, nor the fact that the first computer, EDSAC, was being completed at Cambridge University in Britain in 1949 based on the idea of stored programming control proposed in 1945 by Prof. J. von Neumann, let alone the development of the automatic computers MARK-I and MARK-II centered on Harvard University (Figure 2).

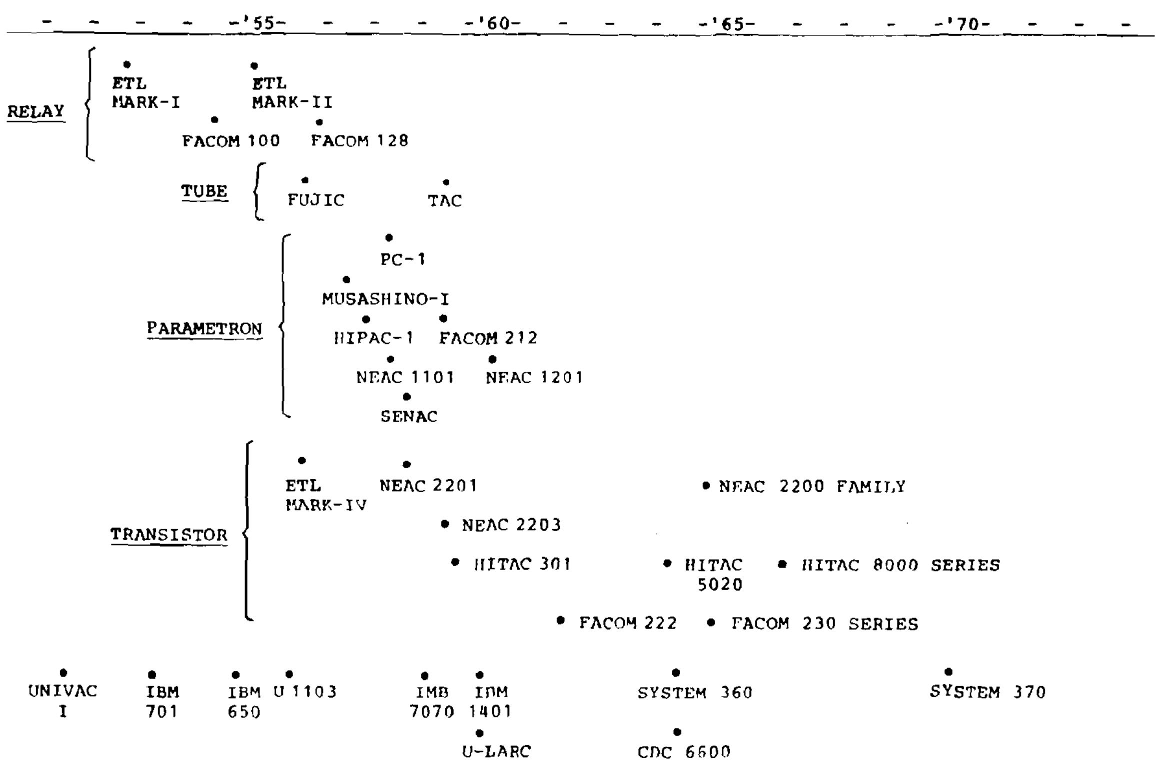

Figure 2. Roots of Japanese Computers (1)

As research and development became active, the computer and the semiconductor, which were to form the basis of the new industry, began to be considered as the favorites for future industry. Loo ing back to the best of my recollection, what comes to mind first is the Todai Automatic Computer (TAC) project, begun by the University of Tokyo in 1951, which drew attention as a full-scale computer development project and was participated in by Tokyo Shibaura Co., Ltd. (Toshiba) as a joint research partner. Although TAC underwent many difficulties due to the use of a very large number of vacuum tubes, it finally reached completion in 1959. Though TAC never had the opportunity to see development for practical use, the experience gained in its development contributed in many ways to Japan's computer technology.

One other result of the work with vacuum-tube computers should not be forgotten. This is the research and development of the FUJIC by Fuji Photo Film Co., Ltd.'s engineer Dr. Bunji Okazaki. Begun as early as 1949 and constructed almost single-handed, this was finally completed and put into operation in 1956. It is the FUJIC, I believe, which deserves the honor of being regarded as Japan's first computer.

In the field of relay-type mechanical computers, these developments were preceded by pioneering attempts by the Electrotechnical Laboratory of the Ministry of International Trade and Industry and by Fujitsu Limited, namely, the ETL MARK-I completed in 1951 and the ETL MARK-II completed in 1955. I have heard that the FACOM 128 is the outcome of this lineage. In the ETL MARK-I, logical expressions based on Boolean algebra were adopted in the circuit design. This approach, in the form of the Nakajima-Hanzawa theory of Nippon Electric Co., Ltd. (NEC), which emerged from prewar research on switching systems, attracted attention widely both within Japan and overseas. I would also like to mention here, among work done on binary logic elements other than the relay, the valuable results obtained by Dr. Iwao Nukada, also of NEC, on the thyratron.

After the war, the invention of the transistor by Bell Telephone Laboratories certainly came as a major shock to us. However, shortly thereafter the development of various types of semiconductor products began to make rapid progress in Japan also; for example, at NEC a prototype point contact transistor was successfully developed in 1953.

It was at this time that the parametron was invented, in 1954, by Dr. Eiichi Goto of Tokyo University. The parametron element, which could be described as a kind of solid circuit, was not only far more stable than the conventional vacuum tube but was also far more economical than the transistor. In addition to these advantages, the fact that this was above all a Japanese invention gave rise to enthusiastic discussion of the practical potential of this new element.

The greatest potential was seen to lie in the computer. Realization of this potential began with the MUSASHINO-I, (developed by the Communications Research Laboratory of NTT), which entered operation in 1957. At the University of Tokyo, work on development of the parametron computers PC-1 and PC-2 was commenced under the direction of Prof. Hidetoshi Takahashi.

In the field of communications, as I expect many of you are aware, one of the key areas is the network theory in relation to filters. This theory was being developed with dramatic speed in a contest between the United States and Germany. I should note the development of an original new theory by Dr. Hitoshi Watanabe of NEC.

Since the development of actual filters based on these new theories required enormous computation time, the demand arose for a computer to be used therein. At the time there was no computer in Japan suited to this type of scientific calculation. For this reason, engineers began to express the desire to work on computer development within the company. The outcome of this movement was the appearance in 1958 of a practical-use parametron computer, named the NEAC-1101. This was highly significant in that it greatly facilitated not only the filter development work already mentioned, but all scientific calculation required in the company's subsequent development of new technology and new products.

It was at this time that NEC first participated in the computer industry. A second model was developed in cooperation with Tohoku University for its own use, and has become well-known as the SENAC. On the basis of these results, NEC thereafter endeavored to commercialize parametron computers, taking advantage of the parametron's high reliability and long life cycle, and marketed a series of commercial products, small business computers known as the NEAC-1200 series.

Meanwhile, the development and industrialization of the transistor were making steady progress. We were at work on development of a high-speed alloy junction transistor for use in communications equipment and computers. Until that time, there had been no computers in actual use in Japan, but merely punch card systems (PCS) and relay calculators. The IBM-650, developed in 1953, and the UNIVAC-60 and 120, were, as I remember, brought to Japan in about 1956-57; these were still vacuum-tube computers, however.

The first development of a transistor computer in Japan was by the Electrotechnical Laboratory (ETL) of the Ministry of International Trade and Industry. The ETL MARK-III completed in 1956 used point contact transistors, and the ETL MARK-IV which followed in 1957 employed junction transistors.

At the same time at NEC as we worked on development of the parametron computer, we decided to develop a model to rival the IBM-650, based on the ETL MARK-IV technology. This model, the NEAC-2201, was completed in 1958 and demonstrated in 1959 at the exhibition of the 1st International Information Processing Conference (AUTOMAS), held in Paris under the auspices of

UNESCO. As we understand, the NEAC-2201, although small in scale, was the first commercial transistor computer to be announced and operated anywhere in the world. It was not long before the IBM-1401 came into the market, heralding the age of the transistor computer, the second generation of computer development.

In the process of these developments, one area I would like to touch on is that of software. In the period of which I am speaking, programming used either machine language or assembly language. However, in the NEAC-2203, the successor to the NEAC-2201 and a large computer for its time, an attempt was made to sharply cut down the labor and time required for user programming by the installation of the new NARC compiler, an early development among Japanese commercial computers.

A further result of these development efforts was the introduction of Japan's first on-line real-time seat reservation system by the Kinki Nippon Railway Co., Ltd., in 1960. It was from this point that the full-scale development and progress of the computer were finally launched on an ongoing widening course.

Here I would like to summarize the events so far, to the best of my ability (Figure 3). First, in Japan full-scale computers were introduced into the business world from the second generation, employing transistors as elements, having skipped the so-called first generation, i.e., the vacuum-tube type. This represented a turing point, from the stage in which governmental or university research agencies headed the research work with the cooperation of private enterprise, to a new era in which private enterprise played the main role in the computer field as a business activity.

ROOTS OF JAPANESE COMPUTERS (2)

1. FROM SECOND GENERATION (TRANSISTORIZED COMPUTERS)
2. ON THE BASIS OF COMMUNICATION TECHNOLOGY
3. BY JAPANESE INDUSTRIES' CREATIVE EFFORTS

Figure 3. Roots of Japanese Computers (2)

Second, as I have outlined earlier, the Japanese computer industry was launched on the basis of communications technology. We tackled computer development in the expectation of further growth of the communications field, and the establishment of the Japanese computer industry can be credited to the full realization in the computer of technologies, parts and elements developed for communications.

A close relationship or parallel course of development can be traced between the computer and communications in all areas of technology, such as circuit design, digitalization, solid state conversion, etc. That is to say, in direct contrast to the Japanese situation, the predecessors of computer manufacturers in the United States and Europe in almost all cases had been business machine companies, which were transformed into computer companies by the incorporation of electronics in the course of their development.

The roots of the Japanese computer industry are, in a word, communications. I would like to point out that, rather than being a simple accident of history, this is significant in that it endows the future of the information processing equipment field with conditions conducive to rare characteristics. I intend to return later to this point.

4. KNOWLEDGE- AND INFORMATION-INTENSIVE INDUSTRIES AS A MEANS OF CLOSING THE TECHNOLOGY GAP

The fourth subdivision is found at the point 10 years later, when the use of computers had already begun to spread among government agencies and private enterprise. Though this is taking events somewhat out of sequence, it seems that at the time that the computer was first developed in Japan, there was the reaction in business management circles, based on the expenses of the hardware equipment only, that this was an attractive undertaking. What they had overlooked was the software. With the software omitted from cost calculations, the resulting figures amounted at the time to dumping of about 20 percent.

Needless to say, the early computers also required programs. However, these were still at a limited level, and the expenses involved were treated as research costs with no strong intention of recompense. However, in computers of the second and later generations, the mainstream was occupied by general-purpose machines. Accordingly, only when used together with complete software could the machines fulfill their function as complete computers. In consequence, one could even say that, granted the importance of the transistorization of elements, what really characterized the second generation of computers was the expansion of the role of software. This point marks a major departure from the situation regarding conventional communications equipment and mechanical engineering in general, which were on a hardware basis.

As I mentioned earlier, we tackled the development of this new technical field of software. In doing so, we became keenly aware of the immense labor and expense required for its development and maintenance. On the basis of this experience, in an attempt to reduce the time and labor involved in software preparation, research began in Japan in about 1961 on system description languages for the generation of automatic compilers.

In the drive toward rationalization of software use, this increase in the relative importance of software naturally gave rise to the concept of the "family series," in which a single software system is used to gain increasing sophistication as the processing capacity is successively enlarged from small computers to medium-scale and finally large-scale computers. If the existing computers could be described as "point-oriented computer," then the results of this process could be termed "line-oriented computers."

In response to the development of large-scale computers as part of this family series, in the field of software development such achievements as, for example, the new operating system MOD-IV, developed for use with the NEAC-2200/500, or the time-sharing system installed at Osaka University deserve special mention. On the other hand, however, it may be recalled that the growing sophistication, complexity and enlarged scale of software functions served to bring home the realization of the extreme seriousness of the problems of software development and maintenance.

Invisible knowledge was in the process of becoming a new concept of the industry. The same was true of technology. The question was asked, "Are not research and development also the production of knowledge and technology?" Then broadcasting and education, too, are nothing less than the transmission and increase of knowledge and information. The growing sophistication of industrialized society reflects the increasing weight of what could be termed "knowledge industries." Surely computer software affords the most typical example of this. That is, we have seen the arrival of the software age.

Stimulated in this line of thinking by the views of Prof. Fritz Machlup of Princeton University, I spoke of the importance of these considerations in the special speeches I gave at the Joint Convention of the Three Institutes of Electrical Engineers of Japan in Nagoya (1964) and Tokyo (1965). I saw this as a new industrial outlook bringing hope to the resource-poor country of Japan, and considered it not impossible that Japan should attain the top international level by using her brains, that is, the highly educated manpower in which she is rich.

The "knowledge industries theory" later gave rise to the "management information system (MIS) theory" in industry and then to the systems theory, and eventually came to form one of the pillars of the government's basic policies in the spheres of industry, science and technology. However, on reflection

I also realize that at the theory of the information revolution rapidly gained popularity, the knowledge industries theory did not necessarily come to as full a fruition as I had expected in such areas as promoting steady research and development and achieving completion of software.

The following two points suggest themselves as background reasons for this approach of mine.

1) From 1965 onward, as Japan was caught up increasingly in the whirlpool of internationalization, I could not help but consider the proper position of Japan in the world, whether in terms of technology, industry, or economics.

2) As a direct cause, I had increasing opportunity to attend various international conferences and symposia. For example, in 1965 I was asked to give the keynote speech at the 11th National Symposium on Reliability and Quality Control in Miami. These were invitations to me to tell the secret of the transformation of the image of Japanese products from "cheap but inferior" to "good and low-priced." At such conferences and other international forums, I encountered the subject of the technological gap. In this debate, Japan was not so much a direct party as in a position between the United States and Europe. Although we used to speak of the United States and Europe in the same breath as advanced nations, they themselves saw the situation as being "the United States vs. Europe."

In 1965 I was a panel member at a debate held at the National Academy of Engineering in Washington. However, since Japan was not of particular concern at the time, it was in something of a neutral position. The discussion went like this. Concerning the origin of the technology gap between the United States and Europe, the European delegates accused the Americans of unfair competition, in that the United States was doing business with technology produced through Government development funds, i.e., technology produced at no cost.

What was the answer of the American delegate who responded to this? "Not just the rocket and atomic power, but the seeds of virtually all modern technology originally came from Europe. As for the computer, take Babbage. It is American enterprises which have taken these seeds and raised them into the finest products in the world. So if there is some kind of gap between Europe and the United States, rather than a technology gap one would call it a 'management ability gap.'" In this way, the American delegate countered the European attack.

In the past year, I have often had cause to reflect on this exchange of 10 years before. Why?--for no other reason than that the recent censure of Japan by the United States shows a similar logic to this debate on the U.S.-European gap of 10 years ago, though the standpoints have now changed. Moreover, these attacks are concentrated in the field of electronics, and especially semiconductors.

For the past 25 years we have labored without a day's peace of mind, constantly aware of the threat from the giants, and today we continue still to worry as to how to ensure the success of our enterprise and survive in the tempest of international competition. Surely, according to this argument, the fact that we have steadily consolidated and achieved results-although we cannot rest secure--is something we have learned from overseas.

5. A PERSPECTIVE ON THE NEW SITUATION: "C & C"

Computers and communications, or communications and computers--the era of their coupling or merging is about to dawn. This is the key to future development. The loci of development of the computer and communications have intersected, and with the addition of the semiconductor, these three are being united into a single entity and are poised on the threshold of the next stage of development (Figure 4).

First, in the computer field, development commenced with the single-function type which was divided into categories for scientific use and for business use, and later, with diffusion of the computer, development shifted to the multipurpose or general-purpose type. This general trend occurred mainly in the decade from 1955, which can be seen as the age of the point-oriented computer.

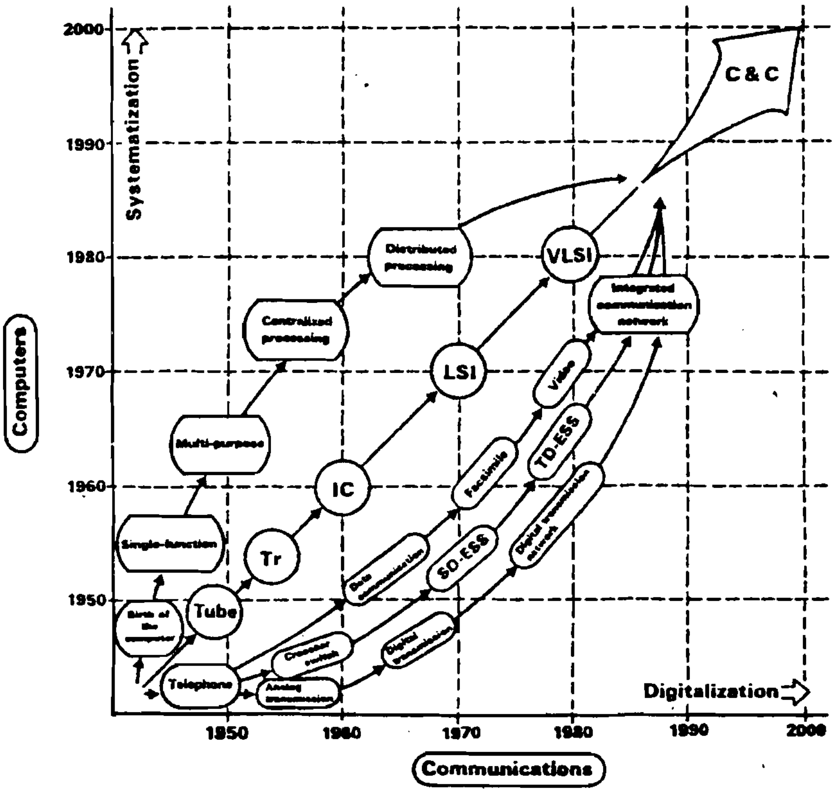

Figure 4. Future of "C & C"

Toward the mid-sixties, however, with the increase of processing data and the diversification of methods of use, the family series (which provides computers of all scales--small, medium and large) became predominant. This could be considered the age of the line-oriented computer due to, among other factors, the inheritance of software products made possible by the continuity of the system design concept. However, the series' characteristic vertical integration pointed the way to the centralized processing system using a large-scale computer, and led, in the early seventies, to the development of very large and mammoth systems.

This excessive centralization encouraged an uncritical escalation toward large scale, which effectively consisted of increase in the size and complexity of the hardware itself, thus rendering unavoidable increase in the size and complexity of the software. As a result, there was an increasing tendency toward loss of flexibility and reliability and toward extreme man-hour requirements for maintenance. At this point, it became clear that not only was it difficult for the computer enterprise to take follow-up measures to meet these requirements, but also that the user was not obtaining full satisfaction.

As a means of overcoming this obstacle, the distributed processing system was indicated. This is designed to carry out that processing which is possible at the site where the information originates and is to be used, and therefore does not rely on a single large-scale machine but adopts a structure combining several relatively small computers. In other words, it compensates for the deficiencies of vertical integration and aims for the realization of a more economical system, while also taking horizontal integration into account. One could say that with this system we are entering the age of the area-oriented computer.

In this case, it obviously becomes essential to connect a number of computers and various terminals for the exchange of information. This is exactly what is meant by "network architecture." Thus, I believe that the necessity of uniting this system with the communications network has now become apparent from the viewpoint of computer technology also.

If we should try to illustrate the similarities within the course of computer development I have described, we obtain the following diagram (Figure 5).

Next, in the field of communications technology, conversion of the automatic exchange system to electronics is under way, having begun with digitalization of the circuits. An instantaneous voice network, through the telephone, has already been completed, and data communications have entered a stage of rapid development. Video communications have also made their debut. This implies a transition from man-to-man communication to man-to-machine, and beyond this to machine-to-machine. In response, we can expect to see the development of a diversity of terminal equipment. Clearly, this is leading to the formation of an integrated communications network.

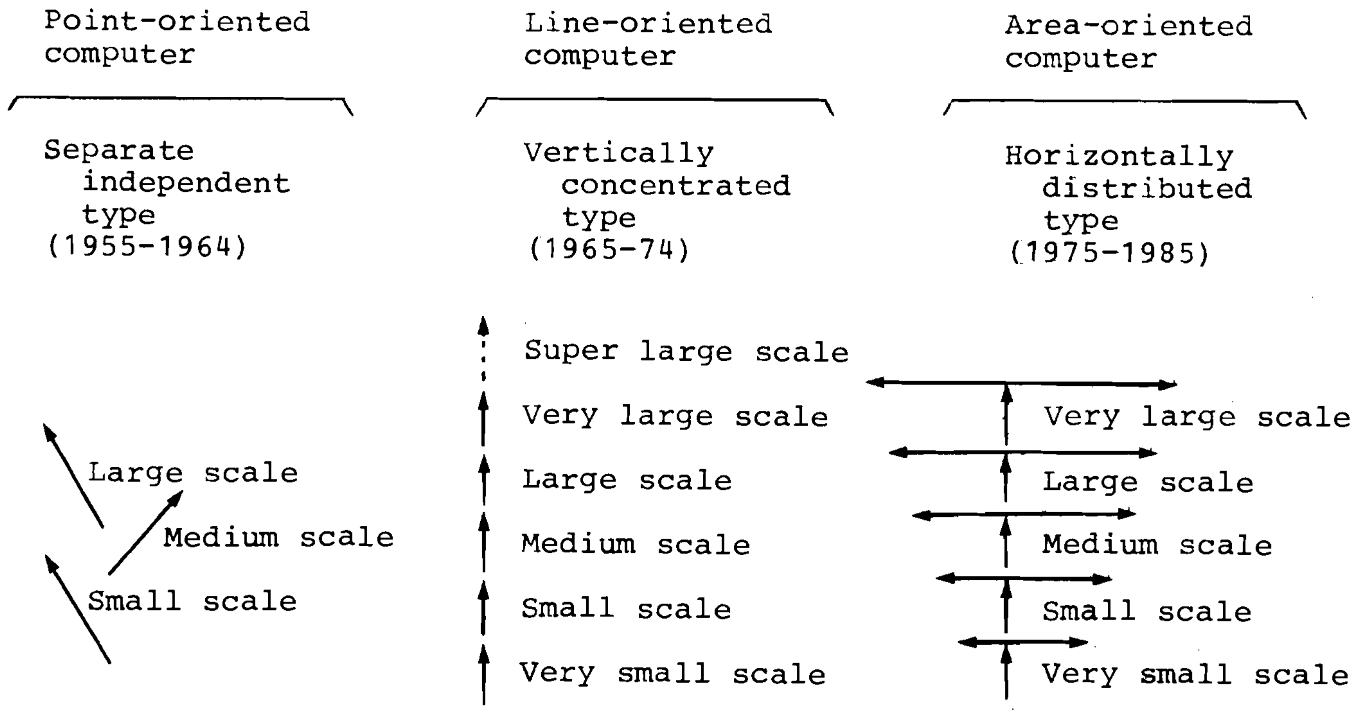

Figure 5. The Course of Computer Development

Practical application of optical communications may also be not so far distant. In particular, such digitalization of communications equipment in itself represents the computerization of the equipment. We have now reached the stage where extension of the diversity and heightening of the standards of services can no longer be contemplated within the conventional framework of communications, i.e., the telegraph and telephone. That is, we have arrived at the stage of computer linkage.

The third item which is worthy of note from the technological viewpoint is the progress in the semiconductor field. ICs are on the point of advancing from the age of the LSI and the microcomputer to that of the very large-scale integration circuit (VLSI). This will provide the key to further development in the hardware field of both communications and computers. The potential for progress in the integration of elements is so unlimited as to defy prediction. Consequently, it could even be said that future development of computer and communications hardware will only be possible for those with the capacity to develop their own semiconductor products. Fortunately, in this field Japanese industry has already reached a level, in both technology and patents, at which we can hold our ground with the forerunners among overseas industries.

In the foregoing remarks I have attempted to sketch the trends in each of the three fields. Of paramount importance, however, is the fact that at the point of intersection of these three trends, we find the development of a higher system stage in which the computer and communications are merged and fused. This is the formation of the "C & C" that I discussed earlier. Furthermore, I regard this as containing the potential of the fourth generation of computers and communications.

Figure 6 illustrates the composition of C & C. The central broken line distinguishes between the images of C & C for users and C & C for system suppliers.

The communications industry, and therefore the Japanese computer industry which arose from the communications industry, due to the weakness and lack of guidance and experience inherent in their origins, have had to clamber painfully up a steep path to where they stand today. Nevertheless, it can also be said that, due to this very background, now that the computer industry processes a high level of communications technology and accompanying industrial capacity, the industry will have ready adaptability to the C & C age in which computers and communications will be merged and fused. It is for this reason that I have taken the opportunity here to ask myself, "What are the roots of the Japanese computer industry?" and to set forth my answer: "Communications."

In looking back at the course we traced to the point at which we began the development of each new technology or product, it is clear that each had as its starting point some form of need. This was also true of the effort to create domestic communications technology 50 years ago, and of the computer research and development, and the setting of this on a business basis that took place 30 years ago. Surveys and analyses of the contemporary application fields--the areas in which the new technology or product would be used--were needs. In short, research and development based on needs are indispensable, and this has become even more important today.

The social use of future systems, technology and products combining computers and communications can be broadly divided into four fields: the individual base, social base, commercial base, and administrative base. On an individual base, due to the growth of human abilities and the diversification of needs, systems which can instantly provide information as the need arises in daily life, e.g., in such areas as education, shopping, leisure, etc., will offer the individual higher quality information. Among systems on a social base, development of systems to improve services to the community, such as medical treatment, environmental conservation, traffic systems, etc., will be required as a step toward a welfare society. The information systems used for these purposes must be capable of accurate acquisition, transmission and scientific processing of data. Hence, this is expected to become a leading field of C & C application.

In systems on a commercial base, the needs are for effective use of resources, business decision-making, and systematization of industry. A major direction in the future will be

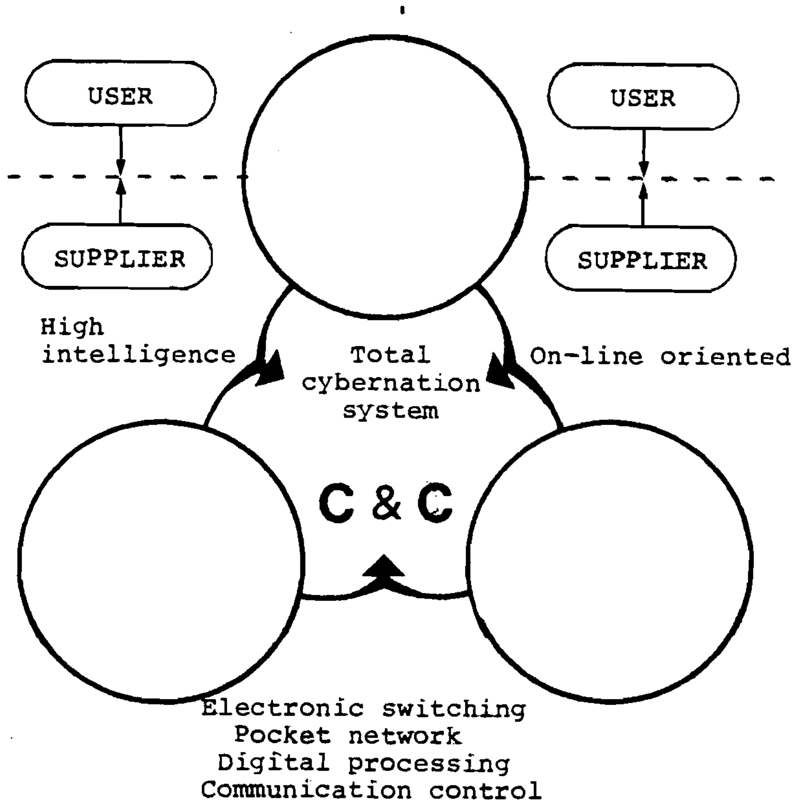

Figure 6. The Image of C & C

the development of total systems which encompass all business activities, going beyond the existing separate systems for production, sales, and inventories. Further, the construction of information system networks using C & C among affiliated companies or between different industries is expected to bring about the realization of a total system which transcends the boundaries of the individual business entity.

Finally, in systems on an administrative base, the needs are for effective service to the people by the administration and also for information processing relating to policy-making by state and local public organizations and decision-making by the administration. The basic common technologies necessary for realization of these various systems include office automation technology, information system network (network architecture technology), distributed system technology, man-machine interface technology, and related basic subsystems, application program groups, etc.

As one specific example, modern business processing systems using office automation must be developed for use in our daily lives in such a way that we are not especially aware of the fact that we are using computers and communications, i.e., in a form which blends in with our lives. In Japan, office work is heavily dependent on the processing of handwritten documents including ideographs. We must therefore establish the fundamental technologies and useful devices for information processing in the Japanese language, using ideographs, in the very near future.

In order to realize the total utility of "computer and communications," the development and use of high software and system engineering, etc. will be called for (Figure 7). Although the investment of funds in software development already exceeds that in hardware development, this trend will inevitably become more pronounced as time goes on. Accordingly, greater importance is being assumed by the problems of raising the software itself to the level of modern industrial products and improving its productivity and quality.

Also, it is naturally important to gain recognition of the economic value of the software itself as an independent product. By this I mean the unbundling of software, which was one of my aims in the past in advocating the knowledge industries theory.

Various types of benefit are obtained from computer and communication systems: that of the individual user, that of the organization which manages and operates the system (a company or other organization), and that of the system supplier (developer, manufacturer, etc.). It is important to minimize the total cost in the broad sense, while maximizing the total benefit. In the C & C age, we can expect greater movement in the direction of increased benefit for the individual user. Therefore, the new functions of C & C must be able to respond to these needs and demands.

Based on these experiences and predictions, in my judgment now is the time when C & C is indeed becoming necessary. And I am confident that if we have a true vision, we are sure to achieve this goal. The most important factor here is the time required to develop this vision. I tell myself that we must not be too impatient, but must work out the development thoroughly.

In the communications field, too, it has taken me all of 50 years to become a full-fledged member. Our work with computers has not yet reached even half that number of years. We must allow the great tree of C & C to grow from its roots in communications over an ample time span.

In conclusion, I would like to again express my warmest thanks for the honor of being invited to give the speech at this meeting, which has given me the opportunity to put forward my personal views on the roots of the Japanese computer industry, based on the awareness that we are standing at the threshold of a new era, and to join with all of you in considering our hopes and expectations for development toward that bright future.

Thank you.

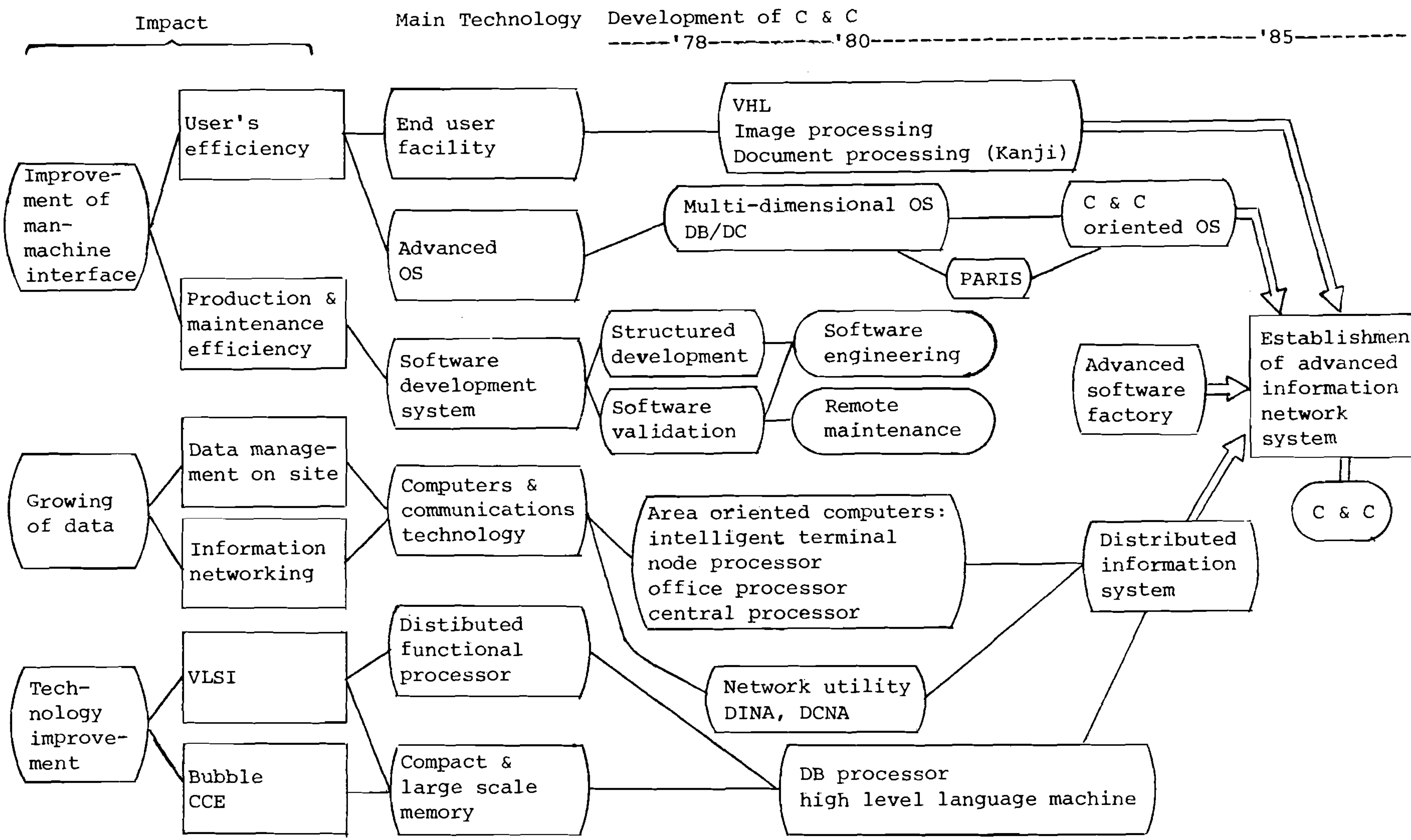

Figure 7. Users Needs and Technology Impact on Computers & Communications