Information Technology: Some Benefits and Problems

Lee, Choong Woong*

A. Introduction

During the past hundred years there has been a revolutionary increase in our ability to transmit, process, and store, and retrieve information. This revolution has brought us both benefits and problems.

Information technology has integrated activities that in the past were often functionally or geographically separate. This has permitted sophisticated functions to be performed more efficiently and has allowed geographical separation of individual activities that are part of a single unified project. However, societal activities that are closely connected by information technology may be vulnerable to misuse of, or accidental or intentional leaking of personal information, which infringes on privacy. Such activities are also vulnerable to destruction of data, to errors introduced in data, and to breakdowns or malfunctions of information systems. Further, effective integration may not be possible if technological standards do not permit adequate interfacing.

Information technology can help to change the present industrial structure of mass production and consumption to a structure that consumes less material and energy and produces fewer things—but things—that have greater values added. Further, the productivity and working conditions of traditional industrial areas can be improved by the use of information technology. However, changes in the industrial structure can lead to a loss of jobs in traditional sectors and a shortage of workers in emerging industrial areas.

Information technology promises to improve such services as medical care and transportation, making it possible to provide them effciently and at less cost. However, in such areas, the same information-based technology may endanger human life if it does not work reliably. It may also infringe on privacy if security measures are inadequate.

New information technology permits the integration of various information

* Professor, Department of Electronic Engineering, Seoul National University

services that are now provided separately. Such integration, known as the convergence of service modes, can provide users with diversified information more effectively and at less cost. But if we are to take full advantage of the convergence of service modes, present regulatory policies must be changed. Moreover, appropriate measures are required to avoid concentration of control over a number of media and to alleviate uneven distribution of information resources among countries and districts.

Information technology can provide a powerful tool for understanding and preserving the human cultural heritage and for enhancing the cultural creativity of mankind. Information technology can help a community to learn about the cultures of other communities; this, too, has advantages and disadvantages. Communities can enrich their cultures by selectively introducing elements from foreign cultures. However, communities can lose their cultural identity and be overwhelmed by outside influences.

We will give a brief overview of some of the societal benefits and problems that are associated with new capabilities of information technology. Later we will discuss selected areas in greater depth.

B. Integration of Societal Activities

Human society and civilization developed through an intuitive and inherent desire to integrate the activities of individuals and thus acquire knowledge and skill for the betterment of life. Tribal villages, city-states, kingdoms, empires, and republics were formed to promote the integration of societal activities.

The integration of our modern society is supported by the transportation network, the power network (carrying electricity and liquid, gas, and solid fuels), and the information network. The flow of passengers and freight, the flow of energy, and the flow of information through these networks amalgamate the activities of individuals in diverse locations into an integrated whole. The information network is the most vital. It is indispensable in our society and it plays a controlling role concerning all other networks.

The information network is making it possible for an industry to have a real-time control of its inventory and production at widely dispersed locations continuously by computer, in accordance with sales over an ever-greater geographical area. In banking, similar networks provide on-line services to

customers while allowing for control of lending and other financial operations in accordance with the bank's assets and liabilities as tracked by a central data base. In electric power networks, generators are controlled in real time to meet changes in demand and to generate and distribute electric energy most economically. Thanks to such networks, engineers or scientists may work at home by using their terminals, which give access to the large computers and data bases of the company; much waste of time and energy in commuting to and from an office can thereby be avoided. A man or woman can use a computer terminal at home to produce computer software. This opens up important possibilities for part-time work and sharing of household duties.

The integration of activities that infomation technology allows is beneficial, not simply to large corporations, but also to individuals and small enterprises. This technology permits such activities carried out over a wide geographic area to be integrated into a single functional enterprise. It allows the resources of computers located elsewhere to support local activities. Data bases linked by a network can be distributed for easier maintenance and updating by local specialists. Still more broadly, the individual user at a terminal can connect with these computers and data bases as if they were on his or her own premises—surely a great benefit to individuals and small operations.

Governments also benefit from the integration of activities provided by information technology. Statistics covering agriculture, industry, finance, education, environment, health, and other areas can be collected easily and comprehensively from all over the country. Data bases that store these statistics provide the government with a large variety of economic and social indicators, which, in turn, allow the government to adjust its policies more sensibly and adaptively by using computers. The government can also use these data to aid law enforcement by detecting dubious financial dealings, repeated patterns of crime, false income tax statements, fraudulent driver's licenses, and so on.

Here we clearly see the dangers as well as the benefits of the integration of activities. People in modern society, especially those living in large metropolitan areas, prefer to live unnoticed by others and to enjoy freedom of speech while being protected by privacy and anonymity. If a citizen knew that all details of his behavior were recorded in government data banks, he or she might well worry about the use, abuse, or leakage of that information.

Will mass media, armed with the right to know, obtain private data from the government and publicize it? Will a competing company, by claiming freedom of information, gain access to financial and technological secrets of an enterprise and endanger its existence and the livelihood of its employees? Not only private persons, but corporations or other enterprises, may feel that they are under excessive control and are vulnerable to the leakage of information. It is proper to be concerned about corporations, because the potential financial losses of a corporation may be far larger than those for individuals, and damage to a single corporation can damage many individuals, not just one.

If a government wished to gain full advantage of the benefit of information technology in this respect, it would have to enact and effectively enforce a series of legal measures that would protect the privacy of individuals and enterprises while maintaining reasonable freedom of access to the information collected by the government itself. And its information technology should make use of all practical measures to protect information from leakage, corruption, and destruction. Even with the best of intentions and the greatest of efforts, this will not be easy to achieve.

The reliability of information systems is also vital. Information technology is drawing us toward a tightly linked, highly complex, and vital organization. No matter how complex the technology becomes, it must continue to work smoothly in order to fulfill its functions—functions vital to our social and economic well-being. As we indicated previously, these systems overall and their hardware in particular are remarkably reliable, but still greater reliability should be sought, particularly in software systems.

Standardization of technological specifications in terms of hardware as well as software also deserves careful attention. Without this, integration to form networks cannot be accomplished, because interconnection of equipment of different makes and models will be either impossible or uneconomic.

Systems are being integrated not only within nations but also among nations and across and between continents, combining societal activities together on a global scale. The benefits and problems of this integration are of worldwide importance and concern.

C. Change in Industrial Structure

The industrial structure of our society has undergone many changes in the

past. Most changes were evolutionary, but some have been large and sudden—depending on the technological innovations that caused them. These changes in industrial structure have permitted society to support an ever-increasing population and to meet an apparently limitless desire for a better and more convenient way of life.

The present industrial structure, which was based on mass consumption of energy and raw materials and mass production and consumption of products, needs to be adjusted to alleviate the difficulties mentioned above. Consumption of energy and raw materials should be reduced, and productivity of labor and capital should be increased in traditional industrial areas, including the iron, steel, and chemical industries so vital to society. Similar improvements are necessary in productivity in agriculture and the distribution of agricultural products, which are also vital for human survival. Beyond this, more emphasis should be placed on high-technology products, because these consume less energy and raw materials and have higher values added.

Information technology will play a major role in reaching these ends. Information technology, including process control computers and industrial robotics, reduces the consumption of energy and raw materials, enhances the productivity and performance of conventional industrial products, and relieves workers from unnecessary monotonous labor. Information technology, including meteorological satellites and computers for weather forecasting as well as computerized distribution systems, helps to improve the productivity of agriculture and the distribution of agricultural products. Knowledge-intensive products and systems, including computers, telecommunications equipment, numerically controlled machine tools and microprocessor-oriented equipment, which are based on information technology, save energy and raw materials, and they have higher values added than conventional industrial products.

However, a change of the industrial structure presents problems. Whenever structural changes in industry have taken place, workers in traditional industrial areas have become obsolete and have lost their jobs, while newly emerging industrial sectors have suffered from a shortage of workers. A change to an information-oriented industrial structure can be no exception. Skilled workers, such as those doing routine machining jobs in industrial plants, may lose their jobs because of the increasing use of process control computers and industrial robots. General office workers without special talents may also lose their jobs because of the rapid penetration of word processors

and other office automation equipment. Changes in distribution channels may lose jobs in various sectors, for example, food production and distribution. On the other hand, enormous job opportunities will be created in the area of software production, since much new software is needed to improve productivity in traditional industrial sectors and to support knowledge-dependent products and services. No matter the extent of machine support in this effort, this software is ultimately written by human beings, and the need is immense. Education and training, which allow a smooth shift of the labor force from decaying to emerging sectors, are crucial for such a change in industrial structure.

It seems clear that developing countries need information technology for efficient development of their natural resources and for enhancing the productivity of their agriculture as well as of their industries. It also seems clear that, in view of the enormous amount of software needed for the informatization of industries, software production has to be shared on an international basis. In particular, programs for specific applications have to be produced locally to meet end user's needs which differ in many respects among differing societies. Some countries, where wages are relatively low and job opportunities for educated people are insufficient, may have an advantage over some developed countries, where wages are high and people are not motivated to promote structural changes in industry.

D. Strengthening the Societal Infrastructure

The present industrial pattern of mass production and mass consumption stimulated rapid urbanization. A large portion of the population drained from rural areas and concentrated in metropolitan districts as people pursued better job opportunities. The results were the environmental disruption of urban sprawl near large cities and the increasing abandonment of remote rural villages. The pace of urbanization was so fast that the deployment of societal infrastructure was unable to catch up, and the quality of life in metropolitan districts was degraded. In rural areas, where the population steadily decreased, societal infrastructures, such as medical care, were lost. Such tendencies have been observed throughout the world. Rapid industrial expansion in developed parts of the world and the population explosion in developing countries have been major causes.

A strengthening of societal infrastructure is urgently needed.

Information technology can play a significant role. Let us take emergency medical care as an example. Success depends almost solely on how quickly proper medical treatment, including surgery if necessary, can be provided to a patient. Sometimes, however, an ambulance takes a long time to arrive at the site of need and then has to go from one emergency hospital to another in order to find specialized doctors on duty. In addition, the facilities and paramedics of the emergency hospital are not always in readiness for the doctors to provide proper medical treatment.

An emergency medical information system can be of great help in such situations. It quickly locates the nearest ambulance and directs it to the site via radio telephone. Paramedics on board the ambulance report the patient's injury or symptoms to the center, which immediately determines which hospital to direct the ambulance to by consulting a computerized table that stores, in real time, information on emergency hospitals in the area, including availability of doctors, paramedics, and facilities. The center relays information about the patient's condition to the doctors so that they will be ready to provide proper medical treatment immediately upon the arrival of the ambulance.

Without a system like this, a much larger number of ambulances, doctors, paramedics, and medical facilities must be available around the clock in order to provide a similar level of service. This is a direct increase in productivity. It may also be noted that an emergency medical information system provides better service because, without this, delay in treatment or even improper treatment is more likely. The system also improves the lives and productivity of doctors and paramedics, who, intead of idly standing by in their clinics and hospitals, could relax in their homes and dormitories or be engaged in productive work of lower priority until summoned by an emergecy call.

A computerized road traffic control system is another example of efficient improvement of an infrastructure. By means of a very large number of detectors, the amount of vehicular traffic in a complex road network is measured and sent over communication lines to a central computer. The central computer analyzes the data and, in accordance with the changes of traffic pattern, directs the local controllers at each of the intersections of the road network to switch traffic lights in such a way that the total travel time of vehicles within the road network is minimized. Basically, this is accomplished by

controlling traffic lights in favor of more heavily traveled routes. As a result of such control, significant reductions in travel time, fuel consumption, air pollution, and driver fatigue have been reported, as vehicles in heavier traffic flows are permitted to pass several intersections without stopping or with less acceleration and deceleration. The system also increases the traffic capacity of the road network under control, thereby saving the cost of expanding roads and avoiding community conflict that might arise through such expansion.

Air traffic control systems are still another example. A radar system detects a number of aircraft en route or around an airport and, with the help of transponders on board and computers on the ground, displays on its cathode-ray tube the image of each aircraft along with a tag that indicates the aircraft's speed, altitude, and flight number. Using this display, a traffic officer can direct each aircraft in his flight area to maintain a proper speed, altitude, and distance from other aircraft. The system not only improves safety but also allows more efficient use of the flight area. By adjusting flight schedules and speeds, the system can also reduce stackups above the airport and thereby help to save energy.

Although these examples are only a few out of many, they clearly tell us that information technology results in significant savings in money and human effort while providing better services.

Information-oriented infrastructure also must meet demanding requirements. First, it must be extremely reliable, as in the example of air traffic control systems. It also must be extremely secure. For instance, the benefit of an emergency medical information system would be greater if the system could have access to data bases that stored patients' medical records, as such access improves the speed and accuracy of diagnosis. But here, people must become concerned about abuse or leakage of information. Would competitors steal one another's medical records and use them to jeopardize their rivals' political or corporate futures? A doctor may worry that information on certain cases might be stolen and used in malpractice suits.

Likewise. a computerized road traffic control system would be upgraded if the central computer could trace and guide each vehicle from its origin to destination to provide the shortest travel time. The drivers might then fear that the traffic police will make use of the computer trace and automatically give them tickets for speeding or other violations. A sales company may

suspect that the activities of its sales vehicles are known by its competitors through leakage of information.

E. The Convergence of Service Modes

As a result of rapid innovation in information technology, a variety of information services that traditonally have been considered separate are becoming increasingly similar. This trend is often referred to as the convergence of service modes. If we look back in history, we see that this is not a new phenomenon. The postal service is a convergence of services that were previously provided by heralds, couriers, and messengers. The use of such technological innovations as horsedrawn wagons, trains, and trucks stimulated the convergence and enhanced the economy of scale of the postal service, as did the ingenuity of the policy makers who provided a single service with a distance-independent rate.

Telecommunication and information-processing services have already merged to provide data communication or on-line processing. The benefits of such systems on-line banking, airline or train seat reservation, emergency medical information, and traffic control were brought to our society by this natural and inevitable convergence of service modes.

The telecommunication common carrier now provides facsimile communication service, in which customers can either use their own terminals or lease them from the common carrier. The postal service also provides electronic mail service, in which one post office, upon receipt of a sender's letter, transmits it by facsimile to the post office closest to the receiver. In the latter service, documents must still be transported physically between customers and post offices, but both types of service will soon merge in some form so as to transmit copies of documents more rapidly between customers.

Videotex of telecommunication service and teletext of broadcasting service both display still pictures on customers' television screens. The difference is that in videotex, pictures are provided selectively upon the customer's request via telephone lines, while in teletext, pictures are carried one way over radio waves or coaxial cables for the customer's choice. The difference may become less significant as cable television systems acquire two-way capability.

Newspaper, book, and journal publishers increasingly use word processors, computerized typesetting, text transmission, and facsimile transmission. In

fact, by using a text-editing program and computer composition, anyone can now prepare reports in good form without going through a publisher. Newspapers are now exploring the possibility of facsimile delivery to their customers by means of a subchannel piggybacked on a television channel. Information vendors who provide data base retrieval service to their customers are expanding their repertoires by adding news reports. Libraries are also providing bibliographical-information retrieval. Eventually, they will provide copies of book and journal pages by facsimile. By that time, newspaper, book, and journal publishers will be able to provide similar services.

It is clear that by the extensive use of information technology, capabilities of all sorts of information services are enhanced. In particular, traditionally nonelectronic services, such as postal service, newspaper, book, and journal publication, and libraries, are acquiring capabilities they never had before and thereby tend to merge together with the traditionally electronic services, such as telecommunication, information processing, and broadcasting.

The benefits of the convergence of service modes are that it brings economy of scale and that a variety of information can be provided in various forms through a variety of media. The high cost of information collection, processing, and creation in the forms of data bases and audio and video programs can be shared by users of a number of media. More communities of interests of smaller scale can be served by providing the specific information they need. However, the convergence of service modes presents some problems.

One such problem is regulation, as the convergence is dismantling barriers between traditionally regulated and unregulated services. For instance, data communication or on-line processing is result of convergence between telecommunication, which is regulated, and information processing, which is unregulated. If a user of a data communication system instructs the computer to process information and forward the results to another user, this may seem to be an extension of information processing. If, on the other hand, a user instructs the computer merely to store information and forward it without any processing to another user, this may seem to be an extension of telecommunication known as message switching.

Here, questions arise as to whether an information processing firm that provides message switching should be regulated or whether a common carrier that is a regulated monopoly can enter the information-processing business in which firms are unregulated and competing. This is one of many examples

that make it difficult for policy makers to keep abreast of the rapid progress of information technology. Unless the policy makers have foresight and wisdom, the merit of the convergence of service modes will be totally lost.

Another problem is the danger of centralized control of various media. A conglomerate that owns newspaper companies, book and journal publication companies, radio and television stations, and computerized information vendors would be able to utilize its information resources very efficiently, take advantage of the complementary characteristics of various media, and provide information to match its customers' needs at low cost. However, the conglomerate might use its influence to control opinion by providing biased information through a variety of media. Such multiple control of media might have a significant influence if the conglomerate had a nationwide network of operation and few major competitors who held different views. Clearly, the worst case is that in which the conglomerate is part of a totalitarian government and is given a complete monopoly.

Still another problem arises from the fact that information resources are unevenly distributed on the earth. The success of information services that take advantage of the convergence of service modes depends almost soley on the quantity and quality of the information they can provide. However, it is not easy to collect, accumulate, update, and distribute information. Hence, the supply of news reports in the world is, to a large extent, in the hands of five major news agencies, AFP, AP, Reuters, Tass, and UPI. The majority of data bases for bibliographical retrieval and other purposes are in the United States. In general, we find more information resources in developed countries than in developing countries and more in large metropolitan districts. This brings about differences in the ease of access to information resources in countries and districts. If the convergence of service modes is left solely in the hands of market forces, more information will be collected and distributed in developed countries and in large metropolitan districts, rendering them even more information rich, and the rest of the countries and districts even more information poor.

F. Enrichment of Human Culture

Since ancient times, information technology has provided humans with a great many tools useful in developing their cultures. Such ancient technologies

as recording characters on paper, printing copies of these records, and distributing the records and copies by mail have stimulated creative authors to write letters, diaries, and books of great literary value. Likewise, technological progress in musical instruments and painting materials have helped composers and painters to create their masterpieces.

Emerging information technology is providing artists with new means of expression. Serious composers and listeners are increasingly paying attention to electronic musical instruments and computer-synthesized musical sounds. Producers of television programs, motion pictures, and stage performances are rapidly introducing computer-graphics, lasers, holograms, and other special effects, not only in science fiction dramas, but also in more serious productions. Computers are helping architects and industrial designers, by providing structural analyses an animated graphics, to implement their ingenuity without sacrificing practicality. Computers are also assisting fashion designers in laying out forms and patterns through interactive graphics.

Information technology has been very useful and will be even more useful to humans in learning about the cultures of different communities. However, exposure to different cultures brings both advantages and disadvantages. It helps one community to understand the cultures of others, and by selectively borrowing from these, a community will be able to enhance its own culture. If, on the other hand, one community is exposed to a powerful culture and absorbs it without discrimination, the cultural identity of that community will be lost. This is particularly true when a remote rural community is suddenly exposed to an advanced civilization. Because of the conveniences it provides, an advanced civilization may quickly overwhelm the community, and the traditional culture of the community may be lost. In the past, we have seen many instances in which an advanced civilization was successfully adapted by a number of communities and flourished through the endogenous efforts of such communities. However. we have also seen other instances in which the introduction of advanced civilization merely caused chaos or complete loss of identity. Thus, an effort should be made to strengthen the endogenous culture of individuals and communities and to maximize the profit and minimize the loss due to such interaction.

G. Conclusions

We have reviewed benefits and problems that have been brought to our society by unprecedented capabilities of information technology concerning the integration of societal activities, the change in industrial structure, the strengthening of societal infrastructure, the convergence of service modes, and the enrichment of human culture.

Among a large variety of societal impacts of information technology, the most vital are those that affect human identity. Typical examples are the impacts on the languages and means of learning on which human identity and culture depend. Another emerging impact that is becoming increasingly significant is that on arts and letters.

Market forces have played and will continue to play a major role in promoting and bringing into use the capabilities of information technology for the betterment of human life. However, there are some areas in which market forces are weak or do not function properly. Protection of privacy and security, establishment of optimum regulation of information services, standardization of hardware and software, and implementation of societal infrastructure are typical examples of such areas in which the intervention and assistance of the government are required.

Whether or not market forces and governments function properly, the people of the world today face enormous opportunities and problems. The formation of a great variety of communities of interests, the creation of vast employment opportunities in the area of software production, and the conveniences for home life and work are examples that can benefit people. The difficulty of obtaining needed information, the displacement of the labor force through automation, and a lack of proper evaluation of service quality are examples of impacts that confuse people.

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