# The Impact of Information Processing on Mankind*



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During the past 10 years of your lifetime, the number of computers in the world has grown mfro a few to over 12,000 systems. In this short time, you have seen information processing become one of the fastest growing scientific activities in our contemporary civilization. The digital computer is already a commonplace tool in business and government. It is being used in all branches of the physical, social, behavioral, and medical sciences. In many parts of the scientific community, it has become as ordinary a tool as a slide rule. In fact, you will soon see the day when more people are taught how to program and operate a computer than will be taught to use a slide rule. It is clear that the computer, and its application to information processing, will have a far greater constructive impact on mankind during the remainder of the 20th century than any major technological development of the past two decades.

Yesterday people questioned our ability to build a digital computer. Today the computer has already shown that it is one of man's great tools, and that its potential benefits for mankind are tremendous. But these benefits are not inevitable. Nor are they unmitigated. You will have to work hard to fully realize the benefits. The entire world will have to plan carefully to avoid the dangers that accompany progress.

It is important for you to remember......and for the rest of the world to realize......that the computer has begun an information revolution that will profoundly affect the lives of everyone. I realize that these are strong words. Not everyone will agree that the changes in progress are actually revolutionary. But the computer and modern information-processing techniques do far more than amplify man's physical force, which was the basis of the industrial revolution. These tools amplify man's ability to manipulate information. This amplification will cause revisions in our economic, govermment, and social structures equally drastic as the ones caused by the industrial revoultion.

Let us consider what information processing has already achieved and what it can accomplish.

The computer has opened up areas of science long held closed to us by the sheer magnitude of the mathematics involved......meterology, oceanography, and combinatorial mathematics. By increasing our capability to assimilate large quantities of data, it has made us better medical diagnosticians. By giving us insight into matters too complex for the unaided human mind, it is helping us penetrate the mysteries of genetics. By enabling us to simulate extremely complex situations, the computer has given us new, statistically valid guidelines in the critical area of economic planning.

In the social sciences, the computer is being used to help man better understand and evaluate the interaction of the myriad of variables affecting him. In this role, it may foster changes in psychology and sociology as sweeping as the scientific and social changes of the past 200 years.

In the developing countries, the computer is a prime tool for achieving the great leap in technological and economic progress in one or two decades. For the industrialized countries, it is a tool for utilizing their resources more completely and efficiently.

Though the impact of the computer has been great, the challenge of the computer is even greater. Never before have there been so many people producing so much information. Never before have we had the ability to communicate with one another as quickly or as effectively. Never before have we had a tool for processing information on a scale grand enough to enable man to use the intellectual power buried and

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* Address at IFIP Congress 62, Munich, Germany, August 27, 1962

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dormant in the huge amount of information he creates and accumulates.

Exactly what are the potential dangers and benefits of the computer. The dangers are hidden, and I will point them out shortly. The benefits can be seen by examining some of the key areas of human activity.

One such area is the field of biomedicine. Probably the most dramatic use of the computer in biomedicine has been for diagnostic purposes. The computer makes its diagnosis by analyzing the patient's symptom-disease complex. If the logical analysis shows that the data is inadequate for a definite diagnosis, the computer provides an optimal sequence of tests to gather additional data. If a definite diagnosis still cannot be made, the computer can then calculate the probability of alternative diagnostic possibilities.

The computer is also being used to analyze electrocardiograph readings to detect heart and vascular disorders and to analyze peripheral-circulation measurements to detect circulation blockages.

To us, the significance of the computer's work is clear. By improving the doctor's ability to diagnose disease and disorders in the early stages, it is improving the patient's chances for survival. But we can go much further. Biomedicine is rapidly reaching the point where mathematical computations and mass data-reduction and analysis are absolute prerequisites to further progress. The computer can enable theories to be explored, experiments to be performed, and problems to be solved that would otherwise be impossible.

To accomplish these things, we must help the entire medical profession develop a fuller understanding of the computer and its capabilities. Doctors and medical researchers must learn how to communicate with computers and with information-processing scientists and technologists. Information-processing science and technology must become a part of medical science and technology. A program of education must be developed not only for the students but also for the practicing physicians and researchers. The computer should be as much a part of medical practice as the latest information in neurophysiology or electrocardiography.

When the medical profession develops a competent grasp of the computer, we can be assured of getting a full measure of the benefits this machine can provide in this field.

Compared to biomedicine, the science of meteorology is making relatively slow progress in its use of the computer. This, despite the fact that the first electronic computer, the ENIAC, was originally conceived by Dr. John Mauchly to assist in the problem of weather forecasting.

The computer has greatly extended the meteorologist's computational ability and, in turn, his ability to deal with the complex interactions of a large number of dynamic variables. As a result, the meteorlogist has developed two methods for weather forecating, both based on the use of simplified mathematical models of the atmosphere. One method, the hydrodynamical approach, is directed toward the solution of partial differential equations of hydrodynamics and the associated equations of state continuity and thermodynamics. The approach has been successfully used to predict the planetary wave systems. The planetary wind flow determines the distribution of the high-and low-pressure air masses that produce our weather at ground level.

The second method, the statistical approach, attempts to establish a functional relationship between a set of parameters characterizing the initial state of the atmosphere. This method is directed at determining valid relationships for future weather situations and minimizing the uncetainty in the probability distributions.

Although both these methods are improvements over past techniques, they are still tentative in that we still cannot forecast weather with consistent accuracy. This is a difficult field, and we still have much to learn about how to formulate its problems on a computer.

I mentioned earlier that the computer is the first technological tool to have a significant effect on such social sciences as psychology and sociology. What information-processing techniques mean to the social scientist is demonstrated by work being done in a very specialized area of psychology, the study of operant behavior.

Operant behavior is concerned with the actions an individual performs on its environment. It encompasses everything from why an infant wiggles to how an adult applies his reasoning power. Studies in this field are extremely valuable in uncovering fundamental information about human motivations and learning processes.

In recent years, a fully-automatic operant-behavior laboratory has been set up to study the effect of drugs upon the operant behavior of animals and human beings.

The laboratory is designed for experiments extending over long periods of time. During these periods, data is continuously collected and analyzed. The key tools in the laboratory are two computers......special-purpose computer and a generalpurpose computer.

Sociological planning is inextricably joined to economic development. The present and future roles of the computer in this area are best demonstrated by an application in Southeast Asia. Here, a computer is being used to determine the best way of exploiting the lower Mekong River Basin in Cambodia and South Vietnam. A mathematical model is being built of the immensely complicated delta area to determine, initially, the feasibility of a proposed flood-control dam site. The computer will also be used to determine the effects of the dam on crops, navigation, and on the development of forestry, fisheries, and power production.

Mr. U. Thant, Acting Secretary-General of the United Nations, has said the computer is the tool with which the developing countries can bootstrap themselves to reach the technological level of the industrialized countries. There is no doubt about the accuracy of his statement. The computer can be used to accomplish this. But we are not yet using it for this purpose on a scale that will have a significant effect on the problem.

Obviously more can be done in this and other areas. At 12: 15 (G.M.T.), one example of our opportunity will be passing overhead. Telstar, the first communication satellite, will be passing over Central Europe. This satellite is intended primarily for data transmission, not for radio and television transmission. I predict that within 20 to 30 years we will have an international information service operating via communication satellites such as Telstar. This service will be comparable in scope and magnitude to the telephone network that now links all parts of the globe.

A network of this type would lease facilities to government, corporate, and scientific organizations. The regulatory branches of the government could use the service as a central information file for its myriad of computer applications. Planning factors could be generated to assist all industries using the information service.

The transportation companies of the world could use the facilities for an international central reservaions system. This would save each of them the expense of setting up their own complex systems. The service could provide insurance companies with a master file on the physical condition of all policy holders. Banks could use the information service to transfer information pertaining to withdrawals and deposits.

Other applications for such a service are a store-and-forward system for all international communications and a storage-and-retrieval system. The store-and-forward system would increase the speed and quantity of the world's data flow. The storage-and-retrieval system would solve the world's giant library problem. Output devices, such as facsimile or extremely high-speed printers, at the end of data-processing links would make it possible to conduct mass library searches in a fraction of the time required today.

Needless to say, the indexing problem in a storage-and retrieval system of this magnitude is enormous. But the benefits to be realized from this type of system are also enormous; man finally would be able to use the full amount of intellectual power contained in his vast library of information.

It is conceivable that the method for implementing the information network would involve a series of very large computers, with file storage of billions of words. Satellite computers would serve as data concentrators and would handle local traffic. Remote input-output peripheral equipment could be located in the satellite centers or remotely.........for example, in the facilities of the subscribing organizations. Interrogator units, manual input devices, and various forms of print-out equipment would be in subscriber facilities. The mass files, as well as the processors, probably would be centralized for maximum utility at minimum cost.

Here is a tremendous opportunity, but you...... everyone sitting in this audience, and your colleagues......are the ones who must bring it to fruition.

I think you will agree, on the basis of the examples I have shown, that the computer has been, in a quiet, unglamorous way, an extremely beneficial tool, that its promise exceeds even its accomplishments. But what about the dark side of the picture? If, as I've tried to show, we are really in the early stages of a revolution that encompasses our industry, science, sociology, and economics, what will be the secondary effects? And can't some of these effects be dangerous?

A look at the present uses of the computer in government shows most clearly that this tool is a double-edged sword. Wielded in one manner as a means of simulating the economy, it can be an invaluable aid to economic planning for the benefit of everyone. Wielded in another manner, it can be used to run a nation with a tight, efficient hand that has little regard for the liberties of the individual citizen. Let's look first at the positive contributions computers are making to government efficiency. Computer applications in government are extremely diverse and are found at all levels. Computers are being used to determine the most economical right-of-ways for highways. They are being used to keep track of the physical characteristics and operating methods of criminals. They are even performing such mundane jobs as laying out the most economical garbage-collection routes.

They are also doing government bookkeeping: writing checks, issuing bills, entering credits, breaking down the national census, storing patents, and managing the purchasing, stock piling and flow of goods for governmental agencies.

The U. S. Coast Guard uses a computer to keep track of the location, speed, and destination of every ship and plane crossing the ocean. When a distress call is received, the computer provides an alert list of the particular ships or planes in the best position to provide aid.

The U.S. Internal Revenue Service has already begun installing a system for automatically processing and auditing income-tax returns. Magnetic tapes containing the names and salaries of employees and the names and dividend payments of stockholders will be borrowed from corporations and copied by the Internal Revenue Service. This information will then be used to automatically verify the amounts of income declared on the tax returns of all employees and stockholders.

When this system is completed, some hundred-million income-tax returns will be compared with some 450-million documents pertaining to personal finances. And American citizens will, without a doubt, be the most tax-law-abiding citizens in the world. There is no reason why the system can't eventually be expanded to include charge and credit-card accounts, the records of charities, hospitals, and hotels, even the deposits and withdrawals in personal checking accounts.

Nor is it inconceivable that eventually some governments will have one huge on-line computer that will receive information from every government, bank, and corporation computer in the country on every transaction that takes place every day. A system of this sort could be used to detect unhealthy economic trends while the trends were still in their infancy and could easily be corrected.

Various informaion-processing systems can provide a government with quick access to a complete file of accurate information about its citizens and its natural, financial, and industrial resources. This information will enable the government to quickly make complex decisions that will have a precisely calculated effect. The results can be a much more efficient economy and the elimination of the traditional business cycle. It should be obvious that there can be other, less desirable results too.

The computer outputs are determined by its inputs. The people preparing input data and planning factors will be in a position to exert great influence on national decisions. Serious economic consequences could result from the manner in which data is interpreted and entered into the information-processing system.

Then too, who is going to determine the criteria for a satisfactory solution to the problems that will be solved by the computer ? Is the efficient economic performance to be the sole criterion ? Or will human considerations also be taken into account ?

Who will be interpreting the computer outputs ? Whose value judgments will be the controlling one ? Are the judgments going to reflect narrow, specialized interests or broad humanitarian interests ? In other words, who is going to control the computer that controls the economy that eventually controls us.

In addition to the danger of restriction and regulation of the individual, there is the danger of the economic obsolescence of many individuals. Information-processing technology is already evolving faster than our educational techniques. As the computer is more widely applied to all the other sciences and technologies, it will greatly accelerate their rates of advancement. The technical education we received did not prepare us for the innovations in science that we deal with today. What will happen 20 years from now to people who have a 1960 education in a world whose technological development has made a large part of that education obsolete ? What will happen as job-skill requirements demand more creativity and more specialized training than most people can offer ?

The fundamental question is what can we do as individuals and as a group to realize the great benefits and prevent the dangers that information-processing holds in store for all mankind.

The information revolution like the industrial revolution is a quiet, sometimes unglamorous force that is not adequately understood by the leadership of government or industry. It is therefore incumbent on us to expose and educate these people to the benefits and dangers that information-processing will bring. We must also assist in every possible way, and on an international basis, in the education of people in the application of information-processing to other fields of science. To educate, we must have a precise, standardized international computer language or glossary that will permit the rapid, unambiguous exchange of information between scientists from different language groups.

In recognition of this, the International Federation for Information Processing, the organization sponsoring this Congress, has addressed itself to the two basic language problems: the man-to-man language and the man-to-computer language. Under the aegis of IFIP, two international technical committees have been organized.

The first IFIP TC-1 is working to develop a multi-lingual glossary, one of the most important requirements for a freer exchange of technical information between the scietists of different countries and languages. IFIP, in fact, has established a joint committee with the International Computation Centre in Rome to further this work. This joint IFIP-ICC committee has been asked by the International Standards Organization to submit its glossary to one of the ISO working groups for consideration as an international standard, This endeavor is being conducted under the very able leadership of G. C. Tootill, of the United Kingdom, whose leadership and devotion to this task have already won him the respect and appreciation of his scientific colleagues.

A second technical committee, on Programming Languages for man-to-computer communication, is much newer. Here the activity has been to assist in the formulation of plans for dealing with programming languages on an international basis. One working group of this committee is directing its attention to ALGOL. Dr. Heinz Zemanek of Austria is chairman of the technical committee on Programming Languages and Prof. van der Poel of the working group on ALGOL. Under their direction we look forward to significant technical contributions.

One of the contributions that IFIP can make in these language areas is to resolve international differences of technical opinion in the early stages of work......that is, before hard positions have been established. Through these two technical committees, IFIP can provide the necessary aid toward broadening the base for educating larger groups of technologists in countries throughout the world.

But you must remember that IFIP is a society of societies. Its strength comes from you, the members of the national societies that are affliated with it.

Although just 2-1/2 years old, IFIP already numbers twenty national technical societies. If this organization is to continue to grow and be of service to all of us, it is important that we be joined by national technical bodies in more of those countries where information-processing sciences are being actively pursued. In that way, they will have the benefit of both participating in and sharing the results of the work of the federation.

The other requirement is an educational program for training people, particularly those from developing countries and from other scientific disciplines, in electronic information-processing techniques.

As the first step towards a solution to the education problem, I have proposed that IFIP and the International Computation Centre establish a Committee on Education. This committee's work on the general problem of education would include recommendations in two key areas. One of the areas is the education of people from the developing countries in the informaion-processing skills. A program that accomplished this would be a big step forward in enabling these countries to make the technological and economic progress that is essential to their citizens' well being.

The other key area is the education of people from other scientific disciplines in electronic information-processing techniques. These people know the problems to be solved in their particular fields; once they know what the computer can accomplish, they will be quick to apply it to the fullest possible extent.

The Technical Committee on Education should establish comprehensive training programs and suggested curricula for the education of technical people from all of the fields in which computers can make a significant contribution. It should also generate material to acquaint the public with the cmputer and its impact on the various aspects of society. The committee would, in fact, serve as a central clearing house on all educational material pertaining to information processing. In this capacity it could assist or provide translations, lists of available material and other necessary information services.

Educational programs of the type proposed are critically needed. It is imperative that we start working, now, to make sure that mankind will reap the benefits that can be achieved through information processing.

Finally, all of us as scientists have the responsibility of educating our own leaders in government and industry; exposing them to both the benefits and the dangers of information processing. This is a task for individuals to do at home and not a responsbility for an international scientific federation.

During this week you are going to get an extremely comprehensive view of the information processing field. Scientists from twenty-six countries will be making presentations at the Congress.

Ideas have no boundaries. Wherever technically proficient people are working, they create, invent, and develop ideas. One group may be specially proficient in mathematics, another in logic, a third in industrial applications, a fourth in hardware development…each has something to contribute to the total body of knowledge. The IFIP Congress 62 provides that invaluable opportunity to meet people from all parts of the world, with whom we can exchange thoughts on our work. These person-to-person meetings enable us to learn about and appreciate the work being done in other parts of the world, and they are of inestimable value in promulgating technical knowledge. I hope you take full advantage of the opportunity and I sincerely hope you have a wonderful time while doing so.