THE FUTURE WITH MICROELECTRONICS

Forecasting the Effects of Information Technology

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INMOS

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FOREWORD

Future of Information Technology

In 1970 a group of prominent people was assembled by the O.E.C.D. Industry group to make a visit to Japan to examine and discuss what was then described as the 'Japanese economic Miracle'. I was one of this group and one of the most profound impressions I carried away was the clear view those responsible for policy had of the future of Japan. They talked in terms of Japan being the world's leader in the 'information based society' — a salutory signal that they at least had a clear view of where the main thrust of technology was going to be and their own place within it. All that has happened since has confirmed the clarity and relevance of their vision.

It is this vision that all of us must share. For as far as any outlook on the future of technology can reach — well into the next century, the ability to gather, record, organise, analyse and act upon information is going to be a dominant factor. What steam, steel, electricity was to the nineteenth century, information management and exploitation will be for the next half century if not very much longer. Not only is it the new 'raw material' of technology, it will inevitably become an essential ingredient of the fabric of the human society.

It is timely therefore to take stock and look to the future, not only in terms of the inner characteristics of the science and the technology of information management itself, but in terms of its impact on employment, education, social management and even political structure. The authors of this book are singularly well placed to undertake this task.

Sir Ieuan Maddock February 1979

PREFACE

This study was carried out at the request of the Computers, Systems and Electronics Requirements Board (C.S.E.R.B.) of the Department of Industry in the United Kingdom. The Research Requirements Boards, of which C.S.E.R.B. is one, were set up following the Rothschild recommendations in 1971 of formalising a customer-contractor relationship into U.K. Government research and development spending, and act as proxy customers for this purpose in relation to governmental laboratories. The Boards include lay members from industry and commerce as well as civil servants with appropriate departmental responsibilities.

The research began in August 1976, with final amendments made in January 1978. Originally conceived as an eighteen-man-month study, to be completed in nine months, the work was carried out by the Science Policy Research Unit (S.P.R.U.) of the University of Sussex, with Iann Barron, Visiting Professor at Westfield College, London, leading. Ray Curnow led the work at S.P.R.U., which drew on overlapping and previous projects carried out there. The brief of the study was to carry out a technological forecast in the computing field with a suitable timespan, in order to provide one reasonably comprehensive and consistent view as to how that field might emerge. Most of the information put forward was based on the personal experience and reading of the two authors supplemented by private discussions, and no commercially sensitive or secure information was used, nor are references given in this early version. One or two of the technical developments foreseen are already well in train, others will probably not now take place — such is the lot of forecasters.

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April 1979

CHAPTER ONE

INTRODUCTORY SUMMARY

The question of future developments in information technology and their impact on the supply industry and the overall economy is of vital importance to everyone. This study is directed towards the technological implications of these developments and their consequences for policy.

INFORMATION TECHNOLOGY

Contemporary information technology embodies a convergence of interest between electronics, computing and communications, which is being promoted by the rapid development of micro-electronics. In the past, information has been handled by a variety of techniques, mainly paper based. The advances in the technology provide, for the first time, a closed system for handling information, and this development is considered to have fundamental importance for the future. Electronics is not essential to information technology; it bears the same relation to information that electricity bears to power — electronics is a convenient, but not unique, method of representation. It is expected, however, that over the next twenty-five years, almost all the important developments in information technology will be based on electronic techniques.

DETERMINANTS OF THE FUTURE

In the past, it was the pattern of technology that largely determined the way computing developed. It is considered that this is no longer true. The technology available within the next five years will be more than adequate to generate great changes in the economic and social order. The sequence and timing of these changes will be determined not by technological factors, but by social and economic factors, and to establish a view of the future it is these that need to be studied rather than technological developments.

MICROELECTRONICS

The development of information technology is based on the tidal wave of microelectronics, which is causing the cost of processing and storing information to fall to a level where these can be applied to everyday uses of information, rather than just to the specialised high-value applications currently satisfied by computers. These reductions in cost have been made possible by the increased complexity of integrated circuits. The technology is now reaching a level where the majority of current and foreseeable high-volume applications could be satisfied by single component systems, so that the demand for further increases in complexity is expected to decline, leading to a stabilisation of the technology. The future pattern of microelectronics is expected to show an increasing divergence between very complex circuits offering high performance at high cost, and high-volume circuits where the emphasis will be on minimum cost.

THE MICROCOMPUTER

The microcomputer — a complete computer on a chip with processor, memory and interface — is seen as the key technological development. At present, semiconductor technology is inadequate to make an effective microcomputer, but this constraint will disappear in the next two or three years. The microcomputer is important because it enables single-component information systems to be achieved. These will be easier to design and cheaper to manufacture than multiple component systems.

The microcomputer is also important because it provides a new level of abstraction in the design process. Instead of designing at the circuit level using electrical parameters, or at the gate level using logical parameters, the designer will work at the system level using information parameters. As yet, the theoretical basis for such design techniques is lacking: there is no ready-made calculus at this level, as there is at the logical level, but such a basis may be expected to emerge from theoretical developments in programming languages.

SILICON PRODUCTS

At present, there are a large number of different microcomputer architectures on the market. Market forces are expected to generate *de facto* standardisation leading to one or two preferred architectures, as has already happened with computers and minicomputers. There is a risk that *de facto* standardisation will cause the perpetuation of current architectures, even though they are unsatisfactory. Although standardisation of architecture will occur, it is expected that there will be increasing diversity of silicon products. These products will be obtained by integrating various standard system components like processors, memory, interfaces and peripherals onto single circuit to provide customised configurations for specific types of application, just as customised computer configurations are built from standard system components today. Many of these products will consist primarily of memory, with a microprocessor to provide some specialised forms of access, for example as in a silicon diary.

PROGRAMMING LANGUAGES

Programming languages should be seen as the theoretical basis for information technology. There is room for considerable development in the structure and organisation of languages, particularly to provide open programming languages capable of intercommunicating with completely independent computer systems. Such developments will improve the design of computers and the efficiency of systems, but are unlikely to have substantial impact on programmer efficiency. Programming is intrinsically difficult. Eliminating the mechanical aspects of programming will leave the programmer with the hard part, which is the formal expression and solution of a problem, so programming will become harder rather than easier. What technological development will do is reduce the need for the programmer to have any special expertise in computing.

SOFTWARE

Technological developments are making the concept of the stored-program computer uneconomic. The high cost of software can best be reduced by selling multiple copies. This will lead to the development of a market for programmed information products, providing the functions currently performed by the computer. The implication is that the concept of the customer/programmer will disappear, while the software industry will move from a service to a product orientation, with a sharp change in competitive pattern. Since software products will have a high cost of development and a low cost of delivery, the competitive pattern will be similar to that of the semiconductor industry, with strong price competition, the need for large active markets, *de facto* standardisation and pressure to innovate.

THE COMPUTING INDUSTRY

The structure of the computing industry has already changed substantially, with a large decline in the importance of the mainframe-computer manufacturers. This change is obscured by the visible nature of the mainframe computer itself. The developments in the technology are expected to accelerate these changes, leading to a destabilisation of the present computer industry under the competitive threat of plug-compatible products, minicomputers and programmed products. The existing capital investment in large-scale computers for data processing means that this area will be relatively slow to adapt and take advantage of the new technology, and will be overtaken in innovation and size by other markets.