# FUTURE COMPUTER & INFORMATION SYSTEMS

## The Uses of the Next Generation Computer and Information Systems

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# Preface

What will be the key characteristics of the new generation computer and information systems under development in the United States, Japan, the United Kingdom, the European Economic Community, and other countries? What will be the application areas as a result of the development? What impacts will they have on society? Will such systems enrich our lives and help identify more profound meaning in our lives? Will such systems augment world peace, justice, and the wellbeing of our society? These are some of the basic questions many of us have when facing the new information society, regardless of our interests.

This book seeks the answers to these questions directly or indirectly, focusing particularly on the Fifth Generation Computer Project under development in Japan. The materials I have referred to, therefore, are the various reports published by the Institute for New Generation Computer Technology, the core institute for developing the next generation computer and information systems.

To achieve the above objectives, the scope of this book is concerned with future computer and information systems from the viewpoint of users of such systems, by reviewing the evolution of computer systems in contrast with information systems, by summing up the present state-of-the-art of such systems, and by uncovering the background, objectives and scope, and functions of the next (the fifth) generation computer and information systems.

Also, I will explore the uses of the new generation computer and information systems under development by identifying 15 application areas: research and development, production, decision making, information processing, communication, international relations, transportation, labor, distribution, education, welfare, health, cultural life, environment, and security. I assess the impact effects of such new systems and envision the transition into the era of the new generation computer and information systems. Naturally, as time goes on, these views must be examined by continuing in-depth analysis and study.

Finally, future prospects and some remaining issues are discussed along with my concern with disparity and uncontrollability. At one extreme, we are approaching the brink of human annihilation, and, at the other, we may be nearing the highest and seemingly most enjoyable level of scientific and technological civilization, if we are wise enough.

The intended audiences for the book include not only professionals in information systems, computer sciences, engineering, and business and public administration, but also laypersons in those areas, including those in the sciences of communication and control, effective organization, experimental epistemology and many others.

Because this book deals with the extent to which we use our valuable knowledge and intelligence under the changing environment, facing knowledge machines and artificial intelligence, we can envision, or are forced to envision, more realistically the facets and contents of the future information and computer society. This means that we have to create better discipline in communication and control in order to survive and enrich our forthcoming society.

While future computers may be optical or biological in nature, I have not covered such computer and information systems at this time, since my vision stretches mainly into the beginning of 1990s rather than after that period.

I acknowledge uncountable help by many scholars and practitioners. Special thanks go to Dr. Kazuhiro Fuchi, Director of the Institute for New Generation Computer Technology, for providing me with much reference material, allowing me to have discussions with members of the institute, and permitting me to include a March 1984 Report on the Fifth Generation Computer Systems Project as an Appendix. In addition, research funds through the Rutgers-Fukui University Exchange Program have been of great help from the very beginning in proceeding with this project.

Since this is a tentative summary of on-going studies, the readers' comments and suggestions will be greatly appreciated.

# Contents

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# 1 Introduction

Because it is a major, long-term project that is financially supported by the Japanese Ministry of International Trade and Industry, the Next or Fifth Generation Computer Project merits the attention of scholars and practitioners in the well-developed countries, particularly in the United States.

The objective of this study is to put this Japanese project into proper perspective for the potential users of such a system. The book covers six topics: (1) The evolution of computer and information systems in general, (2) how the Fifth Generation project compares with other computer and information systems, (3) the background, goals, scope, and functions of the Fifth Generation Project, compared with the project of the Microelectronics and Computer Technology Corporation (MCC) in the United States, (4) recent developments of the project, (5) the project's application and potential impact, and (6) future prospects and remaining issues of the Fifth Generation Project, focusing on the users of the system.

It should be noted that the Fifth Generation Project has reached the first year of its interim period, a period of the development of sub-systems. This interim stage is to be succeeded by the final period, called the period of total system development. The interim stage will last until 1988. From 1988 to 1990, in the final period, a prototype system will be developed. The overall research and development activity is undertaken by (1) the

Institute for New Generation Computer Technology (ICOT), (2) the Project Promotion Committee, which includes five working-groups (Parallel Processing Development, High-Level Inference and Kernel Language Development, Natural Language Processing, Consultation System and Basic Theory, and the New Language Study Group), and (3) the International Exchange of Research and Development.

The book emphasizes applied cybernetics or cybernetic methodology. Applied cybernetics refers to the applied science of communication and control, the applied science of forms and patterns, the applied science of effective organization, and the applied science of epistemology.

# 2 Evolution of Computer and Information Systems

As shown in Table 2.1, we can design a table that highlights the evolution of the system performance of computer systems on each row, as compared with the evolution of information systems on each column. By so doing, we can review the present status of one company, one industry, or even one country, determining whether the quality of the information system is matched with the system performance of the computer system.

This method of assessment may be used to match hardware and software, conceptual development and realized performance, and system requirements and the degree of satisfaction. In cybernetic terms, the direction of efforts between computer and information systems has been and will be toward enhancing the quality of communication and control among system designers, analysts, and users.

Reviewing the evolution of information systems, at the stage of primitive data processing systems (primitive DP systems), we concentrated on processing information (transaction data), particularly routine information—as much and as fast as possible within a given time, maintaining a minimally required credibility. Communication was not effective because data processing was on a batch-mode (off-line) basis, and the output did not facilitate decision making, as expected. Because no common data-base existed, relational or cross-sectional data could hardly be obtained.

**TABLE 2.1. Development of Information System**

| *Approximate Dates* | *System Performance on Computers* | *Transition of Information Systems* | | | |
|---|---|---|---|---|---|
| | | *Primitive (Basic) DIS*[a] | *Integrated DP Systems*[b] | *Management Information and CP and CMS*[c] | *Decision Support Systems*[d] |
| *Early 1950s* | *First Generation:* | *AREA B:* | *AREA C:* | | |
| | • Use of vacuum tubes for internal operations<br>• Heat and size problems<br>• Frequent and large amount of maintenance requirements<br>• Limited main storage capacity<br>• Punched card oriented (even for files)<br>• Slow I/O<br>• Mostly symbolic language programming<br>• Little or no applications software | The quality of the system is matched with its system performance on computers | The quality of the systems (integrated, management information and decision support functions) surpasses the corresponding computer technology (system performance with respect to computers.) | | |

| | | | | |
|---|---|---|---|---|
| *Late 1950s* | Example: IBM 650 | | | |
| *Late 1950s* | *Second Generation:*<br>• Use of solid-state components (transistors and diodes)<br>• Greater reliability<br>• Less heat<br>• Increased main storage capacity<br>• Faster I/O<br>• Use of tape files<br>• Procedure-oriented programming languages (FORTRAN, COBOL, etc.)<br>• Beginnings of utility software | *AREA A*<br>Computer technology (hardware aspects) constraints software application, and firmware oriented system performance | *AREA B* | |
| *Mid-1960s* | Example: IBM 1401 | | | |
| *Mid-1960s* | *Third Generation:*<br>• Use of integrated circuitry<br>• Smaller size<br>• Greater speed, reliability, maintainability, performance, versatility<br>• Faster and more versatile I/O<br>• Use of disk and drum files<br>• Packaged applications software and advanced software<br>• Beginnings of time-sharing | *AREA A* | *AREA B* | *AREA C* |

**TABLE 2.1.** *(continued)*

| | | *Transition of Information Systems* | | | |
|---|---|---|---|---|---|
| *Approximate Dates* | *System Performance on Computers* | *Primitive (Basic) DIS*[a] | *Integrated DP Systems*[b] | *Management Information and CP and CMS*[c] | *Decision Support Systems*[d] |
| *Early 1970s* | Example: IBM 360 | | | | |
| *Early 1970s* | *Evolving Fourth Generation*<br>• Use of LSI to VLSI circuitry, increased speed, storage capacity<br>• Ease of use through user Interface<br>• Faster file devices<br>• More applicatons software<br>• Increased use of time-sharing<br>• Widespread use of minicomputers and microcomputers<br>• Distributive processing with Data Communications | | *AREA A* | | *AREA B* |

[a]Primary (Primitive or Basic) Data Processing System.

1. Each separate processing job is limited to an independent and rather simple function, such as payroll or summary of accounts receivable.
2. An independent data-base is maintained for each job. No common data-base exists.
3. Output is ordinarily a summary based on the processed transactions.
4. Reports are provided to all management levels. Few, if any, are usable in decision making for middle or top management.
5. There are very few cases in which a decision-making model is used.

[b]Integrated Data Processing System.

1. Many jobs are starting to use two or more data files, and the same input data are used for two or more applications. (A partially common data-base is starting to emerge).
2. Most jobs still have to do with processing transaction data, and reports are of use mostly to lower management personnel.
3. Note that models for rather simple decision making, such as inventory control and capital budgeting models, are starting to be utilized.

[c]Management Information Systems and Corporate Planning and Control Model Systems.

1. This is the stage where a consolidated data-base in some way has been established and is partially or wholly usable.
2. The reports include demand forecast, operational and budgetary planning and control, and are beginning to respond to the information requirements of top management.
3. Emphasis is on building a system that deals with corporate and strategic planning so that it can partially respond to the information requirements of top management.
4. Decision support systems are beginnning to be used on a case by case basis, but without adequately being incorporated into the existing system.

[d]Decision Support Systems.

1. Construction of a decision-making model that can offer real support to a decision and timely utilization of the model are at the core of the information system.
2. To obtain these objectives, the consolidated data-base should include not only transactions data but also external, internal, and subjective information.
3. The system must be arranged so that a user can easily get access to and use the decision-making models and data-base systems.
4. Thus, the decision-making model, data-base and user are the main components of the decision support system. Continuous pertinent interactions will enable the system to develop in the desired direction. The user's endurance, continuous insistence on implementation, and realizable direction will greatly increase the likelihood of evolving a viable decision support system.

At the stage of integrated data processing (DP) systems, however, common data-bases were starting to emerge. Notwithstanding this development, most jobs still had to do with processing transaction data, and useful reports were mostly limited to lower-management personnel. Note that in the United States models for rather simple decision making, such as inventory control and capital budgeting models, were starting to be utilized.

From the end of the 1960s to the middle of the 1970s, the next stage of information systems was best represented by the corporate financial model or corporate planning and control model systems (Gershefski 1969; Ishikawa 1975), while the term management information systems was fairly well recognized. This was the stage where a consolidated data-base in some way or another was established and was partially or wholly useable.

Also, integrative efforts of varied logico-mathematical models emerged, which may be called model systems, including demand forecasting, budgetary planning, portfolio management, production planning, and more advanced inventory control models. It should be noted that the reports were beginning to respond to the information requirements of top management. Thus, the quality of communication was further enhanced, and more effective control, which was impossible up to that time, was exercised.

However, from the viewpoint of strategic planning and management, the use of information was seriously limited despite the fact that it was very costly and needed a vast amount of man-hours. The time lag between requests and responses was, in many cases, intolerable.

In order to remedy such weaknesses, efforts were made to build a decision-making model, rather than a whole model system, by use of mini- and micro-computers. This direction was welcomed, given the pressure of realizing short-term profits with less active investment in an environment where inflation and successive stagflation prevailed towards the end of the 1970s to the beginning of the 1980s.

Consequently, the term decision support systems (Keen and Morton 1978; Alter 1980) has gained acceptance with the following rationalization and emphasis:

1. Construction of a decision support model, even one time use, should be the core of the information system.
2. To attain this objective, the consolidated data-base should include external, internal, and subjective information as well as transaction data.
3. The system should be very easily accessible for the decision maker to use decision support models and related data-base systems.
4. Accordingly, the decision support model, data-base, and user are the main components of the decision support system.

This means that continuous and pertinent interaction will be the key factor in developing a decision support system in the desired direction. The user's endurance and understanding, as well as the implementation and identification of realistic goals, are required to increase the likelihood of forming a viable decision support system.

One of the important questions raised has been what is the unique feature of the decision support system in the framework of management information systems or corporate planning model systems. Naylor (1982) asserts that decision support systems are not based on any formal conceptual framework and that they exist primarily in the minds of academic visionaries and overly aggressive sales and marketing people. Indeed, in the history of management information systems, we have never regarded less the importance and significance of the nature and process of decision making.

In response to these questions, Blanning (1983) identifies five principle areas of the decision support system (DSS) research that are unique and describes how this research has been accomplished. The five areas are:

1. The construction of knowledge-based interactive systems.
2. The development of frameworks for model management systems similar to those for data-base management systems (DBMS).
3. The integration of data management and model management to produce an emerging science of information management.
4. The enhancement of current concepts in information eco-

nomics to provide relevant criteria for evaluating proposed or existing DSS.

5. The investigation of behavioral issues relevant to the design and implementation of DSS.

While the fourth and fifth areas are commonly applied to both DSS and management information systems (MIS) and therefore do not seem to be of help to identify the uniqueness of DSS, the first three areas have some implications and significance because of the pursuit of knowledge-based and model management systems which have not been forefront issues.

If we are to envisage the evolution of information systems from data-based to information-based, and from information-based to knowledge-based or intelligence-based systems, the unique feature of DSS is its symbiotic nature of information-based and knowledge-based systems. It now plays a transitional role in view of the present state-of-the-art.

More concretely stated, the knowledge-based DSS captures the knowledge of the member of an organization about causal relationships and draws inferences and conclusions from this knowledge, as exemplified by the set of logistical relationships found among orders, production, inventories, shipments, and returns (Bonczek, Holsapple, and Whinston 1981).

Techniques or principles studied include those related to artificial intelligence, expert systems, natural language processing, metaprogramming, resolution principles, AND/OR graphs, semantic nets, SI nets, and frames (Bonczek, Holsapple, and Whinston 1979, 1980; Elam and Henderson 1980).

Model management systems are also the conceptual and applicable extension of data-base management systems. DSS needs not only data, but also relevant models through which desired output may be obtained. Such an output may be collated using data already obtained or further processed, with a set of data via another model or model systems. Thus, model management systems encompass both serial and parallel processing among and between models, and also models and relevant data, which is related to the integration of data management and model management. (See the efforts in line with this area, for example, in terms of a DSS generator (Sprague 1980; Sprague and Carlson 1982; Konsynski and Dolk 1982).