A Retrospective and Prospects of the Fifth Generation Computer Project

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Abstract:

Report on the Fifth Generation Computer Systems (FGCS) project undertaken by the Japanese Ministry of International Trade and Industry (MITI) in the period 1982-1992. The Fifth Generation Computer was developed using a framework of parallel processing and inference processing based on logic programming. The project received an investment of ¥54.15 billion ($416.54 million) and employed around 100 young engineers.

Keywords: Fifth Generation Computer Systems (FGCS); Ministry of International Trade and Industry (MITI); computer engineering; Japan

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INTRODUCTION

The Fifth Generation Computer Systems (FGCS) project commenced in 1982 as part of a major research project supported by the Ministry of International Trade and Industry (MITI) in Japan. This project was launched after a three-year preliminary study phase.

MITI'S decision to support such a program was said to be based on the realization that rapid developments in computer technology and radical transition in international politico-economic and social environments have necessitated R & D on a new generation of computers that should be aimed at coping with the transition from an industrial to the information society of the 1990's.

The basic framework of the Fifth Generation Computer is parallel processing and inference processing based on logic programming.

The institute for New Generation Computer Technology (ICOT) was established in April, 1982, as the core organization responsible for planning and executing this project. They have formulated a R & D program that will extend ten years: an initial stage('82-'84), an intermediate stage ('85-'88), and a final stage ('89-'91). At present, the project has just finished the last year of the final stage.

Both in retrospect and prospectively, the great significance of this R & D project placed on advanced technology of new generation computers has evoked strong positive and negative reactions.

REPRESENTATIVE REACTIONS

Among negative reactions, The Washington Post, dated June 2, 1992, said that Japan has completed her 5th generation computer project before she could attain her goal. It further pointed out that this project would have little impact on the global computer market. Japan could not surmount the U.S. in the new world of computer technology nor produce applications that would make a difference.

The Japan Economic and Industry Newspaper (June 8, 1992) also states that the management of the FGCS project could not take advantage of new directions in information sciences, in which studies of neural networks have made noticeable progress. On the contrary, they adhered to basic research in parallel inferences.

The author also insisted that they should undertake a machine translation project as part of the FGCS project for the benefit of international goodwill and information exchange. This area has also been well recognized as one of the advantageous fields in Japan. Dr. Kazuhiro Fuchi, Director of ICOT, however, proclaimed that he had not intended to develop such an applied system as machine translation system from the very beginning.

Instead, he proudly announced the following in the Japan Economic and Industry Newspaper on June 9, 1992:

"While, at first, I was suspicious about pursuing a parallel inference machine, from the intermediate stage of our project, the whole trend of computer technology has shifted to parallel processing. As a result, to date Logic Programming Language, KL1, and Parallel Inference Machine, PIM, etc., has been developed. Prototypes of the parallel inference machine have been completed. We have been proud of our achievements. The only regret I have is not to have achieved better in the area of Natural Language Processing." (A similar view is revealed in Takeshi Koizumi's paper.)

Moreover, S. Sandstrom of the Swedish Institute of Computer Science, which held seven workshops from '84 to '91 with the ICOT says that one of the greatest impacts of the FGCS project is to have given tremendous vitalization and implication in the field of computer science and that parallel inference models are not merely conceptual, but effective in reality. One of his colleagues also mentions that the FGCS project has proved the usefulness of logic programming and artificial intelligence based on logic programming.

Still another point they highlighted is that Sweden IBM developed a software data base interface on the basis of natural language processing. This achievement is indebted to the study undertaken by the ICOT.

COSTS AND BENEFITS

As shown in Figure 1, ¥54.15 billion($0.42 billion or $416.54 million) has been invested for the FGCS project under the auspices of the MITI. About 100 young researchers have gathered from Electro-technical Laboratory, NTT, and major computer manufacturers, including NEC, Hitachi, Toshiba, Matsushita, Mitsubishi, Sharp, and Okidata.

They spent ¥8.27 billion at the initial stage, ¥21.63 billion at the intermediate stage, and ¥24.23 billion at the final stage, respectively.

The scale of this investment is about one-half on the Alvey project in England, about ¥110 billion from '84-'88, about one-fifteenth of the ESPRIT project in EC from 1984-92, and about one-fifth of the SCI(Strategic Computer Initiative) by DARPA from 1984-93. In comparison, the FGCS project by no means surpasses the size of these other investments.

As a result, they have successfully developed the Multi-PSI system consisting of 64 processor elements. PSI(Parallel Sequential Inference Machine) is said to be the world's first inference machine in hardware. A prototype basic software system consisting of knowledgebase programming software and basic software is also new.

Knowledgebase programming software is composed of three modules: a Natural Language Interface Module, a Problem-solving Programming Module, and a Knowledgebase Construction Module. Basic Software is made up of parallel OS and a Knowledgebase Management System.

They also developed Parallel Logic Language "KL1"(Kernel Language 1), a KL1 Processor, and the world's first Parallel OS using a Logic Language, PIMOS.

Moreover, the benefits of the project are said to include the education and training of many engineers who are now equipped with the knowledge and skill on the next generation of computers, including parallel inference machines and related hardware and software technologies. They will become valuable, intangible human resources after they return to each organization. Intrinsic benefits that can accrue include successfully developing such prototypes into realization such as general-purpose parallel inference model systems to be used in industry.

FUTURE BENEFITS

The FGCS project is now being transferred to, what is called, "Four Dimensional Computer" project, i.e., a New Information Processing Technology Development Project again under the auspices of the MITI.

What is left to the ICOT is to evaluate both hardware and software as rigorously and strictly as possible, while the MITI announced publicly 71 kinds of software on a free basis. Since such software cannot run unless on uses PIM or Multi-PSI, ICOT is now arranging to run these through a UNIX machine for those who try to experiment with any of the software which they have developed.

At present, these inference machines developed by the ICOT have not been announced to be commercialized by major participating companies, due, on the one hand, to a strong movement toward downsizing, and, on the other, to a general consensus of the FGCS project being basic research which needs a fertilization period.

Thus, the author has to view the success or failure of the FGCS project on at least two platforms:

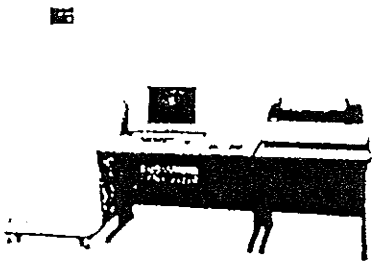
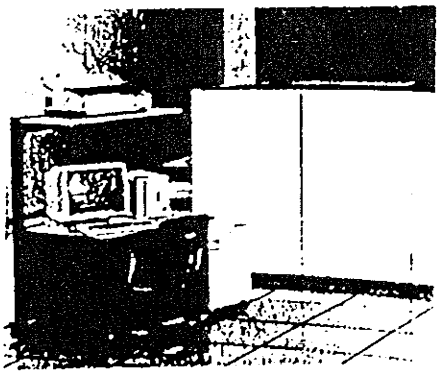
One is whether or not the achievements of the FGCS project may successfully be transmitted to the next project by the MITI on an applicable evolving, and more value-added basis. Another is whether or not the fertilization period may become the real foundation of the succeeding, leaping or realization period for both the private and public sectors. If the ageing is too long, then it would be more likely that the technology developed and human resources trained will be of less use and that the significance of the project will eventually forgotten.

It is the author's earnest desire that the achievements should be fully disclosed so that any individual, Japanese or foreign can get access to the information as openly as possible, as Kazuhiro Fuchi succinctly states in his keynote speech at the International Conference on FGCS '92:

"Although this project is about to end, the end is just another starting point. The advancement of computers and information processing technologies is closely related to the future of human society. For the purpose of launching a new age, I fervently hope that the circle of those who share our passion for a bright future will continue to expand..."

Fig 1. Outline of the Fifth Generation

ICOT has been conducting research and development under the auspices
ICOT has around 100 young reseachers gathered from ETL, NTT and major

	Initial Stage (¥ 8.27 billion)			Intermediate Stage		
Fiscal year	1982	1983	1984	1985	1986	
Budget	¥ 0.43 billion	¥ 2.72 billion	¥ 5.12 billion	¥ 4.78 billion	¥ 5.49 billion	¥ 5.63
Outline of R&D	R&D on Basic Component Technologies → Sequential inference systems based on a logic language			→ R&D on Subsystems → Parallel inference systems based on		
Software Technologies (Language)	◦ Small-scale Experimental Software Systems (Sequential)			◦ Small-scale Experimental (Parallel)		
	◦ Development of Sequential Logic Language "ESP" (Extended Self-Contained Prolog) and an ESP language processor			◦ Development of Parallel Logic Language "KL1" and a KL1 language processor		
(OS)	◦ Development of Sequential Inference Control Software (SIMPOS ; Sequential Inference Machine Programming and Operating System) → The world's first full-scale OS using a logic language.			◦ Development of Parallel Inference Control (PIMOS ; Parallel Inference System) → The world's first parallel OS using a logic language.		
Hardware Technologies	 PSI (Personal Sequential Inference machine) The world's first Inference Machine ..... PSI			 Multi-PSI system consisting of 64 The world's first Parallel Inference system		

Computer Systems Project

of the Ministry of International Trade and Industry (MITI).
computer manufacturers.

(¥ 21.63 billion)		Final Stage (¥ 24.25 billion)			
1987	1988	1989	1990	1991	1992
billion	¥ 5.73 billion	¥ 6.48 billion	¥ 6.97 billion	¥ 7.21 billion	¥ 3.59 billion

R&D on the Prototype System

Integration, improvement & Evaluation of the Prototype

→ Integrated knowledge processing technologies
- Parallel Inference Machine (1,000 processors)
- Parallel OS
- Parallel knowledge programming

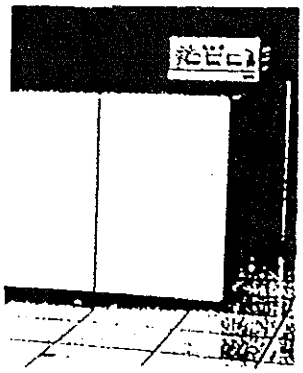
a logic language

Software Systems

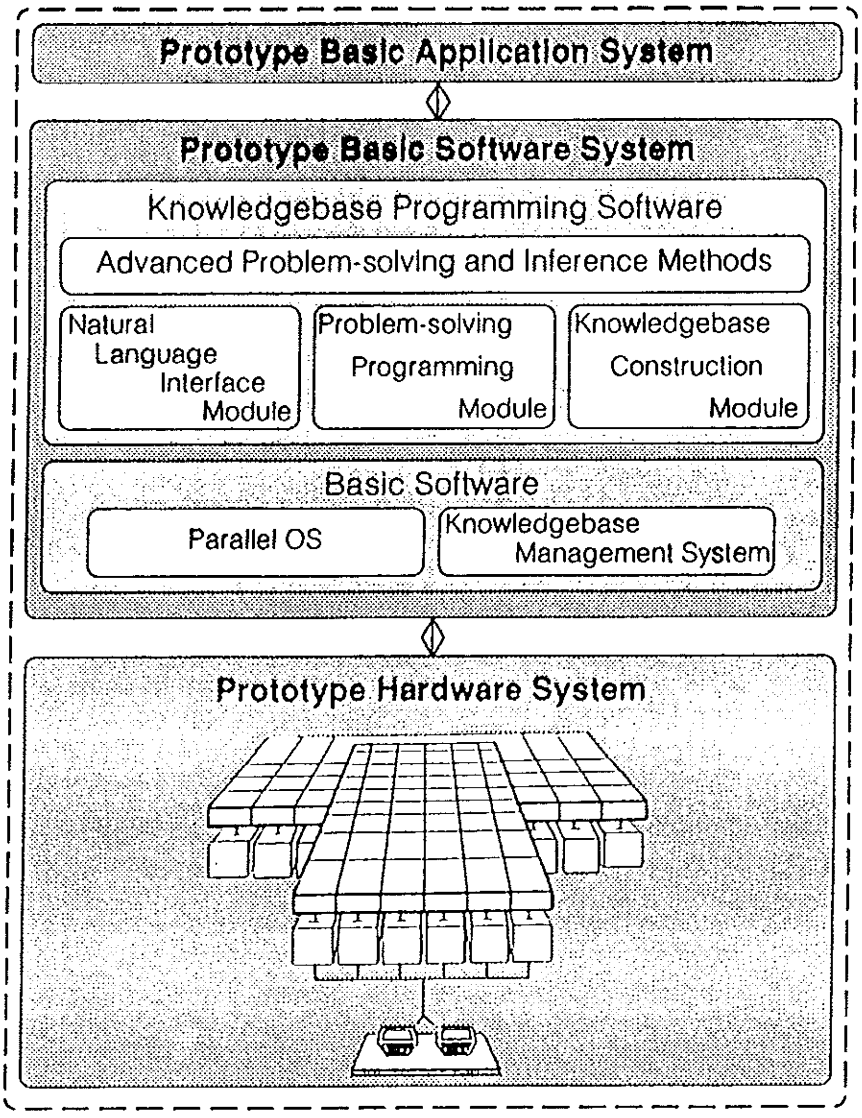
(Kernel Language 1)

Software

Machine Operating



processor elements
Machine ..... Multi-PSI



FGCS Prototype Systems

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7. Nikkei Industry Newspaper, June 9, 1992.

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9. Nekkei Industry Newspaper, "Four Dimensional Computer", October 5-8, 1992.

10. Kazuo Fuchi, "Launching the New Era, "Keynote Speech, International Conference on Fifth Generation Computer Systems 1992, pp. 9-19. Regarding the disclosure project of a group of software on a free basis, since April, 1993, "A Research Kibanka(Fortification) Project of the Fifth Generation Computer has started. This project which includes research and development of knowledge programming software and its applied technology, consisting of management technology of knowledge expression language and knowledgebase, technology related to the high-dimensional inferences, and applied technology of a new knowledge processing, including gene information processing and legal inference systems, will last for two years.