Overview of
The Fifth Generation Computer Systems Project

Aim of the Project

The Fifth Generation Computer Systems (FGCS) project is a Japanese National project aimed at new computer technology for knowledge information processing.

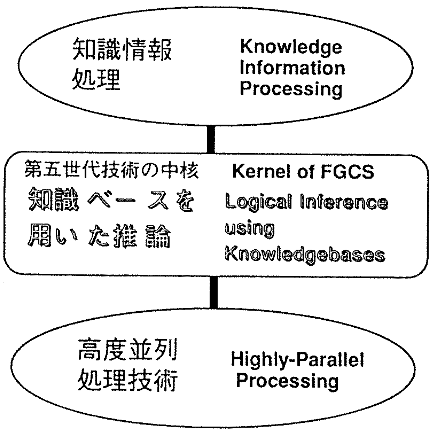
This project proposed that "logical inference using knowledgebases" is the kernel function of future knowledge information processing, and adopted logic programming as the kernel programming language of the FGCS.

The project aimed at creating a new computer technology combining knowledge processing with parallel processing using logic programming.

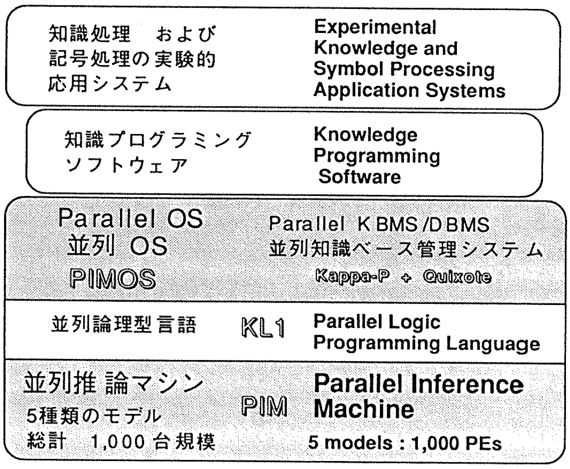
FGCS Prototype System

To evaluate the various element computer technologies to be developed in the project, an FGCS prototype system was to be built by the end of the project. Since 1982, the Institute for New Generation Computer Technology, ICOT, has been conducting research and development on new theories and technologies for the FGCS project.

Now, the FGCS prototype system has been completed, integrating the major research and development achievements of the past 10 years, and is ready to challenge new and larger knowledge processing applications.



技術的枠組み Technical Framework



プロトタイプシステムの構成 Prototype System of FGCS

R&D History of the FGCS Project

R&D Plan and Budget

The goals of the FGCS project were set at the frontier of computer science. The project period was divided into three stages, namely, the initial, intermediate and final stages. Detailed plans for each stage were to be made at the end of the previous stage, so that the plans would reflect the achievements of the previous stage. The research budget was to be decided depending on the achievements. After all, R&D has solved many difficulties with the help of many researchers from around world and has never ceased in making progress.

R&D History of the Parallel Inference System

PIM and PIMOS are now working successfully together as the fastest symbol processing machine. They are built on top of the various element technologies which have been developed and accumulated step by step in the past 10 years.

In the initial stage, sequential inference technologies were mainly developed and accumulated. In the intermediate stage, we jumped from the sequential world to the parallel world using sequential inference technologies as the springboard. In the final stage, we developed software technologies for parallel inference and made our best effort to cultivate new applications for parallel knowledge processing.

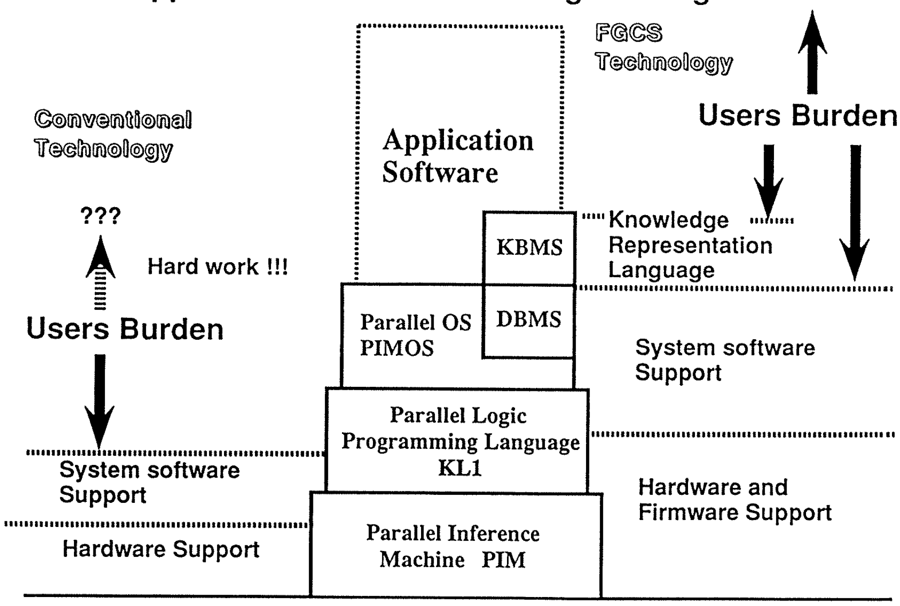
第五世代コンピュータプロジェクトの計画 **R &D Plan of FGCS Project**

Fiscal Year	各期の目標	Goals of Stage	予算額	Budget
'82 ~ '84 昭和57 - 59	**前期** 要素技術とツールの開発	Initial stage **R & D of Basic Component Technology and Tools**	¥8.3 B	Billion Yen x 1 0億円
'85 ~ '88 昭和60 - 63	**中期** 実験的中規模サブシステムの開発	Intermediate stage **R & D of Experimental Medium-scale Subsystems**	¥21.6 B	¥54.2 B
'89 ~ '92 平成1 - 4	**後期** 総合的プロトタイプシステムの開発	Final Stage **R & D of Experimental Prototype System**	¥24.3 B	

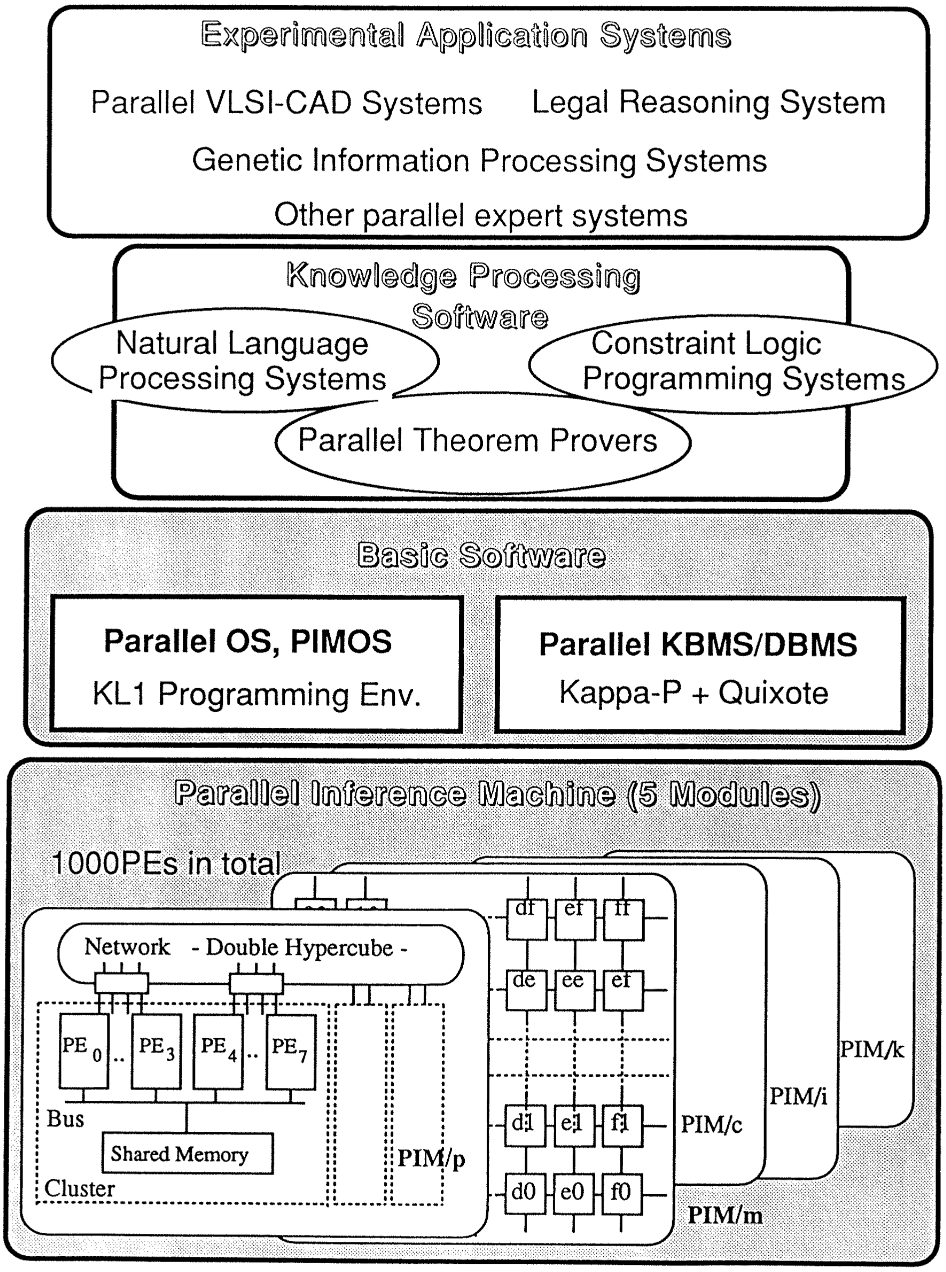
第五世代コンピュータの 開発過程　　Developing the FGCS prototype system

	逐次 推論の技術　Sequential Tech.	並列 推論の技術　Parallel Tech.
'82-'84 Initial Stage 前期	Sequential Logic Programming Languages, KL0 and ESP 逐次論理型言語、KL0とESPの設計 Sequential Inference Machine, PSI-I and SIMPOS, 35K LIPS for KL0 逐次型推論マシン、PSI-Iの開発	Parallel Logic Programming Languages GHC and KL1 並列論理型言語、GHCとKL1の設計
'85-'88 Inter-mediate Stage 中期	New model of PSI, PSI-II, 330K LIPS for KL0 第２版、PSI-IIの開発	Experimental Model of PIM, Multi-PSI System, 5M LIPS / 64PEs for KL1 PIMの実験機、マルチPSI, 64台版 Parallel OS, PIMOS and Small Application Programs 並列OS, PIMOSと小規模応用ソフト
'89-'92 Final Stage 後期	New model of PSI, PSI-III (PSI-UX), 1.4M LIPS for KL0 第３版、PSI-IIIの開発	Prototype of FGCS, PIM, 1000 PEs total, 200M LIPS / 512PEs for KL1 FGCSプロトタイプマシン、1000台規模と並列基本ソフト

System's Support Levels for Parallel Programming



Structure of FGCS Prototype System



Achievements of the FGCS Project

Introduction

The achievements the FGCS project have been formed around the project's technical backbone of parallel logic programming. Major achievements have also been integrated into the FGCS prototype system, which is an actual operational system, and there usability and effectiveness have been examined and evaluated by applying them to practical application problems.

As a consequence of successful evaluation results, it has been proved that the project has established the basic technologies for building large-scale parallel knowledge processing systems which could not be attained by simple extension of any conventional sequential computer technologies oriented to numerical computation.

The achievements provide the new technologies that follow;

Large-scale parallel symbol processing

1. The parallel logic language, KL1, enables us to efficiently and freely produce parallel programs of knowledge or symbol processing application problems with irregular computational structures without concern for detailed system restrictions.

   Thus, this makes it possible to quickly develop application programs which make full use of parallel machines with hundreds to thousands of processors.

2. The parallel inference machine, which executes KL1 programs efficiently, is now providing the most powerful symbol processing capability in the world, using about 1,000 processors in total.

3. The parallel operating system, PIMOS, is the first truly practical parallel operating system. It has the capability to control dynamic load-balancing and data reallocation for large-scale parallel or distributed systems. It is basically applicable in systems with to a million processors. The technology of PIMOS as well as of the KL1 language processor is generally applicable to most MIMD-type parallel machines.

High-level knowledge information processing

1. New methodologies to describe knowledge information with a logical for-

mula, algebraic constraints or logical constraints have been developed and provided as a knowledge representation language, Quixote and a parallel constraints logic language, GDCC. These greatly improve efficiency and enhance freedom in describing various useful knowledge information existing in our social systems and in translating them into computer understandable forms.

2. A high-level knowledge base management system, Quixote, has been designed based on the deductive and object-oriented database and implemented on top of a parallel nested relational database system, Kappa-P.

   The Quixote and Kappa-P systems enable us to use high-level description and to handle large capacities of knowledge and data. These systems are the largest systems actually built on a parallel system using a parallel language.

   Both of these systems have been built on the parallel inference system, with their effectiveness and evaluated using practical biological information databases.

3. The basic technologies of high-level inference mechanisms have been developed. Some of them are provided as useful software tools which are indispensable for building intelligent application systems making full use of knowledge bases described in logical forms.

   A parallel theorem prover, MGTP, is one of the software tools which are supported by the sufficient symbol processing power of the parallel inference system. These technologies and tools enable us to improve the intelligence level of application systems more effectively than any conventional tool.

Practical system evaluation and exploration of new application fields

1. The comfortable programming environment provided by KL1 and PIMOS has enabled us to exploit sufficient parallelism in many knowledge and symbol processing application problems. Most parallelism is derived from the irregular computational structures of the problems. Thus, they had never before been exploited by any conventional programming methodology.

   The parallel processing of the problems has successfully attained processing speeds several dozens to hundreds of times faster than that of a single processor. This has proved the effectiveness and wide applicability of the programming language and environment.

Programming in KL1 has also provided us with much higher productivity and parallel program maintenability than any conventional language.

2. The methodologies of high-level knowledge representation and high-level inference mechanisms have enabled us to build intelligent systems, such as a legal reasoning system and a program generation expert system which have functions and performance significant for practical use.

   Some of these systems are actually using high-level inference mechanisms such as a rule-based reasoner backed up with the power of the parallel inference system. They have actually realized some sophisticated automated reasoning operations, which are leading-edge examples of transforming the high power of parallel processing into enhancement of the intelligence of expert systems.

3. Our search for application problems to evaluate the FGCS prototype system naturally leads to exploration of the frontier of computer applications, an area unexplored by conventional technologies.

   The High-level knowledge information processing technologies will continuously be applied to new fields such as legal reasoning, genetic information processing, automated program generation, and natural language processing. This will create many new application fields and interdisciplinary research areas in the near future.