PROCEEDINGS OF THE INTERNATIONAL CONFERENCE
ON FIFTH GENERATION COMPUTER SYSTEMS 1984,
edited by ICOT. © ICOT, 1984

CURRENT STATUS AND FUTURE PLANS OF THE FIFTH GENERATION COMPUTER SYSTEMS PROJECT

Kazukiyo Kawanobe
ICOT Research Center
Institute for New Generation Computer Technology
Tokyo, Japan

ABSTRACT

In april 1982, ICOT began research and development for Fifth Generation Computer Systems (FGCS) under the auspices of Japanese Ministry of International Trade and Industry (MITI).

This project will span a period of ten years: three years for the initial stage, four years for the intermediate stage, and three years for the final stage. The initial stage is now approaching its conclusion.

This report describes the current research and development (R&D) status as well as tentative plans for the intermediate stage. These plans, however, still include uncertain factors, such as VLSI techniques, and so on. Plans involving these areas will be introduced later in the ICOT Journal or some other publications.

1 INTRODUCTION

The Fifth Generation Computer Systems (FGCS) development project was first conceived in Japan in 1979. Based on an idea suggested by the Ministry of International Trade and Industry (MITI), the Japan Information Processing Development Center (JIPDEC) founded the Committee for Study and Research on FGCS, and started to plan R&D to implement FGCS.

The Committee then conducted surveys and researched concepts related to FGCS. In the following year, it examined goals and appropriate areas for R&D. As a result of two year survey and investigations, the overall concept of FGCS was clarified; they are essentially defined as complex systems for processing voluminous quantities of knowledge.

In 1981, based on these results, MITI planned a national project for the development of FGCS. It held a 4-day international conference from October 19 to 22, 1981 to discuss FGCS and to exchange opinions on the project.

In 1982, the Institute for New Generation Computer Technology (now commonly known as ICOT) was established as the central organization to carry out R&D of FGCS under the auspices of MITI.

This project will span a period of ten years: three years for the initial stage, four years for the intermediate stage, and three years for the final stage. In the R&D for the initial stage, emphasis has been placed on accumulating the results of past studies in the area of knowledge information processing, as well as evaluating and restructuring them to develop basic techniques to be applied in the intermediate stage.

Based on these results, R&D for the intermediate stage will focus on designing computational models, implementation algorithms, and basic architectures, all of which form the basis for fifth generation hardware and software. Small to medium scale subsystems will then be built. Emphasis in the R&D for the final stage will be on dividing functions among software and hardware systems and building a prototype of a total system configured from these systems.

Currently R&D is being carried out on the kernel language, a major research theme. The kernel language specifies the interface between hardware and software, and, therefore, is considered to embody, in an intensive manner, the achievements in the areas of both hardware and software development. Accordingly, the specifications of the kernel language are subject to change. The specifications for Kernel Language Version 0 (KL0) and Version 1 (KL1) have been established in the initial stage, and those of Version 2 (KL2) will be established in the intermediate stage. The prototype of FGCS to be constructed in the final stage will be based on KL2.

The following discussion focuses on the current status and future plans for R&D. It should be noted that the future plans are still under investigation and may be changed in the course of our study.

The progress status described in the next chapter is to be clear the alternation on our prospects for our research and development. It can be shown with the compensation on the objectives in the initial stage at the start of our project.

2 CURRENT STATUS OF R&D

To attain the goal of establishing basic techniques, R&D in the initial stage has been conducted independently for the inference subsystem, the knowledge base subsystem, the basic software, and the pilot model for software development. The following describes research on each subject assigned in the initial stage, and how far work in each area has progressed.

2.1 Inference Subsystem

The inference subsystem, together with the knowledge base subsystem, forms the kernel of the FGCS hardware. In the initial stage, R&D has been conducted for the parallel inference basic mechanism, data flow mechanism, and abstract data mechanism with the purpose of developing basic techniques for hardware architecture.

2.1.1 Parallel Inference Basic Mechanism

- Goal in the initial stage

The goal of research in the initial stage is to select, in addition to the data flow scheme, several candidate schemes that can be applied as the parallel inference mechanisms for FGCS, and to evaluate their characteristics by simulation.

- Current status of R&D

Those selected as candidate parallel inference mechanisms were: the reduction scheme, the complete copying scheme (which is a modification of the reduction scheme), and the clause unit scheme.

For the reduction scheme, an experimental 64-parallel software simulator was constructed to perform overall evaluation. Also, to obtain more accurate data, a prototype hardware simulator, consisting of eight processing elements, is being produced for the reduction scheme. This prototype is to be completed within fiscal 1984, after which, evaluation will begin.

For the complete copying and clause unit schemes, a prototype hardware simulator, consisting of 16 processing elements, is now being developed. This simulator is capable of simulating both schemes with a slight adjustment of its software. The prototype is planned for completion during the current fiscal year, and evaluation will start immediately afterwards.

No reference will be made in this report to the evaluation of each scheme, as the final results have not yet been determined. However, investigations have so far revealed that each scheme is quite capable of deriving parallelism from inference operations.

2.1.2 Data Flow Mechanism

- Goal in the initial stage

The goal of research in the initial stage is to evaluate the data flow scheme using a simulator. A prototype experimental system, consisting of ten processing elements, will then be built for further evaluation and to determine the basic architectural requirements of the data flow scheme.

- Current status of R&D

A prototype 64-parallel software simulator has been produced to perform overall evaluation of the data flow scheme. An experimental system consisting of eight processing elements is also being built. The experimental prototype system is planned for completion during the current fiscal year; evaluation of the data flow scheme will follow immediately.

2.1.3 Abstract Data Type Mechanism

This research was included in the study on the inference subsystem, for the purpose of establishing a hardware architecture to support the modularization mechanism and object oriented mechanism called for the kernel language specifications. However, it is still early enough in the project, as well as more appropriate, for the concept of abstract data type to be embodied in the hardware architecture in and after the intermediate stage. Consequently, the scope of the research in the initial stage has been limited to the study of linguistic aspects of the kernel language for the basic software. Also, R&D for the inference subsystem is limited to the study of language specifications with respect to the hardware architecture. This research has achieved good results, as described in the progress report on kernel language development.

2.2 Knowledge Base Subsystem

The knowledge base subsystem, together with the inference subsystem, forms the kernel of the FGCS hardware. In the initial stage, R&D was begun on three research items for the purpose of establishing basic techniques for developing a large capacity knowledge base machine. The three items are knowledge base basic mechanism, parallel relation and knowledge operation mechanism, and relational database mechanism. This machine is envisioned as being capable of the acquisition, retrieval, and updating of knowledge data described in a knowledge representation language or kernel language.

2.2.1 Knowledge Base Basic Mechanism

The goals set for this research in the initial stage were to clarify configuration and management methods for the knowledge base using theories of knowledge representation languages, kernel languages, and knowledge bases, and at the same time, to evaluate the knowledge base basic mechanism by designing and implementing a simulator. However, the decision was later made to continue basic research and delay development of the simulator until the intermediate stage, for several reasons. For one, developmental approaches to the knowledge representation language have been modified (as explained in the section on the intelligent interface software module of the basic software system), and the acquisition of a various kinds of feedback information from actual knowledge base applications is necessary to fully understand the concept of the knowledge base. As research on the knowledge base basic mechanism is an important theme in the final stage, it will be intensive research in the initial stage that will lead to smooth development of the mechanism in the intermediate and final stages. Therefore, changes in goals set in the initial stage are not considered to adversely affect the future development of the knowledge base basic mechanism.

2.2.2 Parallel Relation and Knowledge Operation Mechanism

- Goals in the initial stage

The goals of research in the initial stage are to select a basic architecture to implement parallel type relational algebraic operation as well as knowledge operation; to produce experimental functional modules, to evaluate them, and to establish a basic architecture for parallel relational operation and knowledge operation.

- Current status of R&D

The basic architecture for implementing the parallel relational algebraic operation mechanism has been selected, and experimental hardware functional modules have been built. The functional modules are incorporated in the relational data base machine to be described later. They will be evaluated in the relational database machine by the end of fiscal 1984.

2.2.3 Relational Database Mechanism

- Goal in the initial stage

In the initial stage, this research aims at selecting a basic architecture for the relational database machine by means of simulation. Then, an experimental relational database machine with about eight element processors will be produced and evaluated. Although this machine is an experimental system, it will be designed so that it can be connected to the Sequential Inference Machine (SIM) and used as an experiment tool for software development.

- Current status of R&D

The basic architecture for the relational database machine has been selected. A prototype of the relational database machine, with a capacity of 5 GB, was completed at the end of fiscal 1983 (Figure 1 in appendix). In the current fiscal year, attempts are being made to expand its functions, after which evaluation is planned. The relational database machine incorporates a relational algebraic operation mechanism as a relational database engine. As a unit, machine and engine is characterized by the following:

(1) 4-parallel relational database machine consisting of eight element processors;

(2) Greater flexibility in data retrieval than conventional relational databases to cope with the requirement of knowledge processing;

(3) Maximum capacity of 20 GB.

2.3 Basic Software System

The basic software system is the kernel of the FGCS software. In the initial stage, R&D for the system has been divided into five research areas: the fifth generation kernel language, problem solving and inference software, knowledge base management software, intelligent interface software, and intelligent programming software.

2.3.1 Fifth Generation Kernel Language

- Goals in the initial stage

KL0 specifies the interface between the hardware and software of the pilot model for software development. Design and implementation of KL0 was completed in fiscal 1983. KL0 is a logic programming language with some extensions that conventional PROLOG language lacked. They are, for example,

(1) Modularization of programs

(2) Relational database interface

(3) Parallel processing

(4) Data type checking

KL1 specifies the interface between the hardware and software of the inference subsystem to be developed in the intermediate stage. The language specification is scheduled to be finalized by the end of the initial stage. KL1 is reduced by adding the following features to KL0:

(1) Refinement of various features of KL0

(2) Reconfiguration of the language for the parallel execution model

(3) Basic data abstraction mechanisms

(4) Meta inference mechanisms

- Current status of R&D

For KL0, language specifications, including target functions, and a language processor were completed at the end of fiscal 1982. The specifications of KL1 are being designed now; They are scheduled for completion by the end of fiscal 1984.

2.3.2 Problem Solving & Inference Software

- Goal in the initial stage

The final goal of this research involves a number of techniques that have not yet been achieved, such as the deductive inference function, which performs completely logical inference, the inductive inference function, which involves guess-work based on incomplete knowledge, and the cooperative problem solving function by which systems cooperate with each other to solve a given problem. Thus, this research area is a challenging one with much emphasis placed on the final stage of development. In the initial stage, accordingly, experimental creation of a variety of problem solving software is planned so that clues and understanding can be obtained to achieve the final goal.

- Current status of R&D

Two approaches have been applied to carry out R&D for this software.

One is a theoretical approach. An example of development using this approach is the development of a software prototype with extended functions which are capable of solving problems described in higher order predicate logic. Another example is development of a software prototype for implementing a meta inference mechanism, which performs inference based on control information provided in a parallel execution environment (including individual rules and more general rules to use the individual rules).

The other approach is to derive the problem solving and inference function from actual application examples. In this approach, studies of problem solving strategies, meta inference functions to determine these strategies, and cooperative problem solving strategies have been made through production of an experimental automated layout system for electronic circuits and a PLA (programmable logic array) design system. Prototypes for both the layout and design systems are being built now; Their completion is planned within the current fiscal year. It is therefore, quite possible to achieve the goal initially set for this research area.

2.3.3 Knowledge Base Management Software

- Goals in the initial stage

R&D for knowledge base management software falls into three categories: a large scale relational database management program with which methods to connect the knowledge base machine to the inference machine can be studied; a knowledge representation system to represent complex knowledge; and a knowledge utilization system with which experimental systems to use knowledge can be designed and developed to evaluate the research results.

The goal of developing a large scale relational database management program in the initial stage is to develop, using SIM, a system for managing a large volume of data and, at the same time, to attain understanding of the distributed knowledge base machine by studying methods of connecting SIM with the relational database machine. R&D for a knowledge representation system in the initial stage aims at developing a language to represent knowledge in specific domains. The knowledge utilization system is to be developed to acquire understanding of knowledge utilization. This has recently been added as a project research area.

- Current status of R&D

A program consisting of the following five software modules listed below is now under development as a large scale relational database management program. The program will be run and evaluated on SIM by the end of the current fiscal year.

(1) Knowledge acquisition module

(2) Knowledge conversation module

(3) Knowledge interface module

(4) Knowledge manipulation module

(5) Knowledge storage module

The software interface between SIM and the relational database machine is studied in the third item.

The initial target of the knowledge representation system was to develop an experimental knowledge representation languages for specific domains. However, development of these languages requires not only knowledge of the particular domain concerned, but also accumulation of knowledge and experience concerning knowledge utilization. It is also expected that the knowledge representation language will vary with its area of application. Accordingly, an urgent theme of development at this point is to prepare a tool that will facilitate the creation of knowledge representation languages. As such a tool, a knowledge programming language, Mandala, is being developed. Design and development of the prototype language is scheduled for completion within the current fiscal year. Development of experimental knowledge representation languages for specific domains is planned in the intermediate stage: they will be developed using the knowledge programming language based on experience gained through the development of the knowledge utilization system prototypes, to be described below.

A Japanese proof reading support experimental system and an experimental system for logic design support are under development as knowledge utilization systems. The experimental system for Japanese proof reading detects errors in words, proper nouns, and sentences using knowledge based on previously input words and sentences. The experimental system for logic design support produces logic circuit diagrams using logic specifications written in the functional specification description language.

2.3.4 Intelligent Interface Software

- Goal in the initial stage

The final goal of this research is to implement flexible functions between man-machine interaction. In the initial stage, it was decided that R&D for intelligent interface software should be divided into three categories: natural language processing techniques aimed at developing a database for natural language processing, language analysis techniques, and studying the cognitive science of the intelligent interface. Speech processing techniques aim at establishing a speech recognition method and at experimentally creating a speech synthesis system. Image processing techniques aim at the conceptual design of a language dedicated to visual data processing and an image processing machine.

- Current status of R&D

In the two sub-areas of intelligent interface software, that is, speech and image processing techniques, private companies are now actively competing with each other to take a lead in their R&D. Therefore, during the initial stage, it was decided that software research should be left to private attempts. R&D at ICOT will start from the intermediate stage, making full use of the results obtained by them.

In natural language processing techniques, it seems important to establish language analysis techniques and basic techniques for semantic understanding prior to the development of a natural language processing database. From this standpoint, a prototype high level parsing program was developed, and development of a prototype semantic analysis system pilot model is now underway. The parsing program was completed in fiscal 1982, and it was supplied with additional functions in fiscal 1983.

The semantic analysis system is based on situational semantics, and its prototype is being developed with the aim of implementing the function to understand sentences in Japanese texts for lower grade elementary school students. The prototype is scheduled to be completed and evaluated within the current fiscal year.

For the reasons stated above, the development of a natural language processing database is limited to the minimum required level. Accordingly, in the initial stage, study is being continued to determine the framework of the database. A full scale study of the intelligent interface from the standpoint of cognitive techniques will also be carried out in and after the intermediate stage.

2.3.5 Intelligent Programming Software

- Goal in the initial stage

The final goal of this research is to implement a function that automatically translates a given problem into an efficient computer program (at the kernel language level). The goal in the initial stage is to develop and evaluate advanced modular programming software and an advanced verification management program. The former will be used to facilitate modular programming, which is the basis of intelligent programming. The latter provides intelligent support to improve the efficiency of program production in each stage of programming, such as design, coding, test, debug, correction and improvement, and maintenance and management.

- Current status of R&D

In the study of advanced modular programming software, modular programming in logic programming is performed for the operating system which runs on SIM. The following experimental programs were created for the modular logic programming system.

(1) Logic programming language with object oriented features (ESP)

(2) Program optimization system designed to overcome the problem of poor execution efficiency, a disadvantage common to all object oriented languages

(3) Programming support and management program consisting of SIM's library subsystems that control the information from debugger

(4) Editor, user process management program, etc.

The following five subsystems have been considered as a general framework for the advanced verification management program.

- Design, description, and understanding system
- Test, verification, and evaluation system
- Generation, modification, and correction

system

- Maintenance and management system
- Development support system

An integrated programming environment will consist of cooperative expert systems processing the above functions.

From this standpoint, prototypes for the following three types of experimental systems are being developed in the initial stage; they are scheduled for completion by the end of the current fiscal year.

(1) Consultation system for use in software development

This is an experimental system for design, description, and comprehension. Using natural language specification descriptions, it will synthesize programs semi automatically through interaction with the user.

(2) Hierarchical logic program verification system

This is an experimental system for test, verification, and evaluation. It is a program verification system based on the Boyer-Moore theorem proving system.

(3) Basic experimental system for developing reusable software modules

This is an experimental system which is not only capable of generation, modification, and correction, but also of maintenance and management. It is a consultation system in which behavioral models of human operators' software reuse patterns are stored, and programs are reused by means of blackboard type inference schema.

2.4 Pilot Model for Software Development

The pilot model for software development is a sequential inference machine (SIM) having an architecture made by improving an existing Von Neumann type architecture. It is a tool for efficiently developing FGCS software. The development of the pilot model is scheduled to be completed in the initial stage and is proceeding with two major research items: SIM hardware and SIM software.

2.4.1 SIM Hardware

- Initial stage goal

The goal in the initial stage is to build a prototype of a firmware based machine which supports KL0. To execute programs written in KL0, this machine should have a processing speed ten times faster than that of a large scale general purpose computer, and 10 MB or more of address space. The development of the machine will be completed in the initial stage.

- Current status of R&D

A prototype machine which executes KL0 directly was produced at the end of 1983 (Figure 2 in appendix). This machine has a processing speed of 30 KLIPS (logical inference per second) and a maximum storage capacity of 80 MB. A prototype extension machine is being constructed in fiscal 1984. Construction is planned to be completed within the current fiscal year. The extension machine will have a processing speed of 150 KLIPS.

2.4.2 SIM Software

- Initial stage goal

The SIM software, SIMPOS, is the programming and operating system of SIM. Completion of software development is scheduled for the end of the initial stage. The programming system is described in the section on intelligent programming.

- Current status of R&D

An operating system consisting of modules forming three hierarchical layers is now under development. Completion is planned within the current fiscal year. The three layers are Kernel, Supervisor, and I/O management. I/O management is a collection of software modules, such as the window subsystem, which has a multi window feature, and the network subsystem, which provides basic interface functions between two SIMs or between SIM and the relational data base machine.

3 INTERMEDIATE STAGE PLANS

3.1 Basic Principles

The R&D for FGCS, started in 1982, has achieved steady progress as described above, and plans for the initial stage are expected to conclude with expected results. In the intermediate stage, subsystems will be developed based on the basic techniques developed in the initial stage. The results will be studied from the standpoint of various applications so that the direction of the technology can be determined. Thus, the intermediate stage is a decisive phase for the success of FGCS project. Accordingly, in conceiving plans for this stage, it is necessary to consider both expansion of R&D and the integration of various avenues of research. The following describes the basic policy by which plans for the intermediate stage are decided.

3.1.1 Succession of Initial Stage Results

The R&D for each subject in the initial stage is expected to attain the goals initially set, resulting in substantial advancements in software, hardware, and basic theories required to develop new computer technology. Generally speaking, no modifications are required to achieve the final goals assigned at the start of the project, although a few changes are unavoidable in the course of development. Accordingly, the R&D in the intermediate stage will be carried out basically according to the overall plans made originally.

3.1.2 R&D Themes in the Intermediate Stage

R&D in the intermediate stage will focus on three major areas. Two of them have been studied since the initial stage:

- Hardware systems (Inference subsystem, knowledge base subsystem)
- Basic software

The following subject has been recently added to the intermediate stage:

- Development support system

The following rules are applied in the development of R&D activities:

(1) R&D will be carried out from the standpoint of expanding R&D on basic research items and integrating various research results.

(2) Problem solving methods, knowledge representation, and semantic comprehension that can be applied to various areas of application are significant subjects of R&D. Therefore, R&D will be conducted systematically from the twin standpoints of component technology and systems.

(3) Ascertaining parallelism in knowledge information processing, construction of a practical size experimental system, development of man-machine interface techniques, development and accumulation of techniques related to knowledge data and so on in order to obtain clues to help put FGCS into practical use.

(4) R&D will make full use of the initiative of each R&D group, exchanging information between universities and national research institutions, and gathering expertise from various areas.

3.1.3 Improvement of the Infrastructure

An appropriate infrastructure is important for high level research and development, and many useful R&D ideas can be gathered from the development of an infrastructure itself. The prototypes of basic tools for the development of the infrastructure have been developed in the initial stage. In the intermediate stage, these tools will be improved and expanded so as to further facilitate R&D. The computer network will also be improved to construct an infrastructure suited for R&D. The infrastructure is where the results of R&D are accumulated, strictly evaluated, and where next new ideas are experienced. It is also the means by which cooperation with various domestic and overseas activities are realized and efficiently established.

3.1.4 Expansion of the Organization

ICOT was founded as the kernel organization for FGCS project for the purpose of carrying out systematic research and development, securing sufficient manpower, and achieving the organizational flexibility required to respond to the requirements of an advanced scientific endeavor. It accordingly played the central role in R&D of the initial stage. The role of ICOT as the kernel organization will become even more significant in the intermediate stage due to the requirements of R&D subjects and the necessity to train and make full use of manpower, to establish substantial cooperation with universities and national research institutions, to enhance international cooperation, and to disseminate the results. It is also important to apply the results in various areas to prove their usefulness in practical application. Thus, a wide range of backing is required, and it is necessary to expand and improve the R&D system further.

3.2 R&D by Research Subject

3.2.1 Inference Subsystem

- R&D goals

The final goal for FGCS hardware is unification of the inference subsystem and the knowledge base subsystem, with the aim of achieving an inference execution speed of 100 MLIPS to 1 GLIPS. In the intermediate stage, R&D for the inference subsystem aims at establishing the architecture of the parallel inference machine, which efficiently executes KL1 and contains about 100 processing elements. The processing elements must be designed to carry out low level parallel processing in themselves, which will allow the implementation of large scale parallel processing.

- Proceeding for R&D

R&D will be carried out mainly for the following items.

(1) Parallel inference machine architecture

To establish the architecture of a parallel inference machine, a prototype parallel inference machine experiment system (or a hardware simulator), consisting of 100 processing elements, will be built and evaluated.

(2) Component module

A processing element to carry out low level parallel processing will be experimentally constructed to establish the processing elements architecture at the level of KL1. A prototype component module configured from two or more processing elements will be built and evaluated to supplement R&D for a 100-element parallel inference machine architecture.

(3) Large scale parallel inference machine architecture

In preparation for prototype creation of FGCS hardware having 1,000 processing elements, software simulation will be conducted using a model of comparable size. At the same time, study will be made on a mechanism to interface the parallel inference machine with the knowledge base machine.

3.2.2 Knowledge Base Subsystem

- R&D goals

The final R&D goal for the knowledge base machine (KBM) is to develop hardware that can respond to requests from the knowledge representation system or the large scale knowledge base system and can efficiently support accumulation, retrieval, and updating of voluminous knowledge data. The target hardware has a maximum database storage capacity of 100 to 1,000 GB and functions to retrieve knowledge bases required for inference within a few seconds. Accordingly, R&D for the knowledge base subsystem in the intermediate stage aims at establishing a knowledge operation mechanism, parallel architecture, and distributed knowledge base control mechanism, on the basis of the initial stage results.

- Proceeding for R&D

The following are the major research themes.

(1) KBM architecture

The relational database will be improved and miniaturized based on the research results of the initial stage. It will be run with programs developed separately so that data for studying KBM architecture can be collected, evaluated, and structurized.

(2) Distributed knowledge base control mechanism

A model of the distributed relational data base will be built and run with programs developed separately, so that data on the distributed knowledge base architecture and control mechanism can be collected, evaluated, and structurized.

(3). Large scale KBM architecture

In preparation for prototype construction of FGCS hardware in the final stage, software simulation will be carried out for a machine model of the same size. At the same time, hardware algorithms for knowledge acquisition and structurization will be studied and evaluated.

3.2.3 Basic Software

- R&D goals

With the final goal set at the development of software products, which will be the kernel of FGCS software, R&D for a basic software system in the intermediate stage aims at improving KL1 based on the results of developing basic techniques in the initial stage. It also aims at developing new parallel processing software techniques, such as parallel inference control, evaluating element techniques developed in the initial stage, and upgrading KL1 to KL2 through prototype creation of a full scale system.

Besides the above, basic research will be conducted on high level inference and distributed knowledge base management functions, which are necessary for implementing the cooperative problem solving system, that is, the final goal of the basic software system.

Of the R&D goals assigned for the intermediate stage, particular emphasis is placed on the establishment of techniques to implement the software module based on the parallel processing to control and manage the hardware of the inference subsystem and the knowledge base subsystem.

Also important is the clarification of techniques to implement the knowledge base management function, which involves a number of unknown factors, such as the knowledge acquisition mechanism. Furthermore, it is important to establish techniques to implement the intelligent interface and intelligent programming functions in a full scale system based on logic programming.

R&D for the basic software will be carried out with the following six items in the intermediate stage:

(1) Fifth generation kernel language

(2) Problem solving and inference software module

(3) Knowledge base management software module

(4) Intelligent interface software module

(5) Intelligent programming software module

(6) Demonstration system for basic software

• Proceeding for R&D

The following are the major R&D themes.

(1) Fifth generation kernel language

For KL1, a practical language processor and program generation support system will be built. Also, parallel execution environments and programming environments will be established for other research themes. At the same time, KL1 will be evaluated, so that the results can be reflected in the specifications of KL2.

In creating KL2 specifications, functions to check contradictions and redundancy in knowledge, as well as knowledge base management function, such as an inductive inference function, and the concept of equality will be incorporated. Specification design will be completed by the end of the intermediate stage.

(2) Problem solving and inference software

This research aims at developing parallel inference software, cooperative problem solving basic software, and high level inference basic software.

For the parallel inference software, attempts will be made to develop system modeling methodology with which parallelism of 100 on average can be achieved for a wide range of applications and to develop hierarchical system configuration methodology. Along with this, various parallel processing algorithms will be developed.

For the basic cooperative problem solving software, a prototype multi expert system will be constructed to establish basic techniques.

For the basic high level inference software, attempts will be made to develop high level artificial intelligence including inductive inference, analogy, and learning functions.

(3) Knowledge base management software

This research aims at developing a knowledge representation utilization system, basic knowledge acquisition software, and basic distributed knowledge base management software.

For the knowledge representation utilization system, knowledge representation languages for specific domains will be designed and experimentally created based on the knowledge programming language developed in the initial stage. In addition, the large scale relational data base management program developed in the initial stage will be enhanced with additional functions, and a prototype knowledge base creation support system will be built and evaluated.

For the knowledge acquisition basic software, a tool to acquire knowledge from experts will be developed. At the same time, attempts will be made to develop techniques to make rules by means of inductive inference.

For the distributed knowledge base management basic software, a distributed knowledge base model will be constructed using large scale relational data base management software developed in the initial stage, and algorithms will be established for managing a number of knowledge bases as a logically unified whole.

(4) Intelligent interface software

In this area, R&D will be focused on a semantic dictionary and semantic analysis system, sentence analysis and composition basic software, conversation system pilot model, and a pilot model of speech, graphics, and image processing interactive system.

Development of the semantic dictionary and semantic analysis system aims at enhancing the semantic analysis system pilot model developed in the initial stage, creating dictionaries (Japanese, English, etc.) for semantic analysis, and investigating natural language comprehension.

In developing the sentence analysis and composition basic software, experimental software for analyzing sentences and composing sentences or even many texts will be created and evaluated.

In the R&D for the conversation system pilot model, an experimental system that models state transitions occurring during conversation in the human knowledge base will be built and evaluated. Along with this, various techniques for data input and output using voice or graphics and images used as supplementary means of I/O will be studied.

(5) Intelligent programming software

For this research, attempts will be made to develop a specification description and verification system, software knowledge management system, program transformation, proof, synthesis basic software, and a pilot model for a software design, production, and maintenance system.

For the specification description and verification system, a full scale experimental specification description language and verification system will be designed and built, based on the findings of the initial stage.

For the software knowledge management system, a prototype maintenance system for the SIM software designed in the initial stage will be built, operated, and evaluated.

For the program transformation, proof, and software synthesis basic system, an experimental system that optimizes programs by transformation, proves the validity of transformation, and synthesizes programs in an integrated manner based on transformation results will be constructed and evaluated.

For the pilot model of the software design, production and maintenance system, an experimental system that controls all the processes from development to maintenance not only of logic programs, but also of programs written in conventional languages, will be developed and evaluated.

(6) Demonstration system for basic software

The results of various R&D themes will be put into practical application for demonstration. Also, a variety of demonstration systems will be built and evaluated for the purpose of acquiring feedback information in each research area.

3.2.4 Development Support System

- R&D goals

An appropriate development support system is indispensable to high level R&D. In the initial stage, a prototype software development pilot model was constructed as a basic development tool.

In the intermediate stage, attempts will be made to develop a pilot machine for a parallel software development and a development support computer network.

- Proceeding for R&D

In developing the pilot machine of a

parallel software development, a prototype hardware system will be constructed by tightly coupled SIMs developed in the initial stage. At the same time, control programs based on KL1 will be created for the system.

As a development support network, a global computer network system connecting a number of research groups will be established.

4 CONCLUSION

This report describes the current status of R&D as well as tentative plans for the intermediate stage. Plans for the intermediate stage, however, still involve uncertain factors, such as the method of studying interface among the inference subsystem, VLSI techniques, and the techniques for handling of speech, graphics, and image processing. It is possible that R&D strategies for these items, when determined, will affect other areas of research. Plans for these currently undecided items will be introduced later in ICOT Journal or other publications.

We hope you will watch for the future progress reports in the published literature. The continuous interest and support of the international research community is a source of great encouragement to those of us working toward Fifth Generation Computer Systems at ICOT.

ACKNOWLEDGEMENTS

The author has a great debt to Mr. Takagi, Mr. Takei, Mr. Kaneko, and Mr. Kusama for preparing and typsetting this article. Special thanks to Mr. Locke to polish my poor English.

REFERENCES

Motooka et al., Challenge for Knowledge Information Processing Systems (Preliminary Report on Fifth Generation Computer Systems), Proc. of FGCS '81, Tokyo, 1981

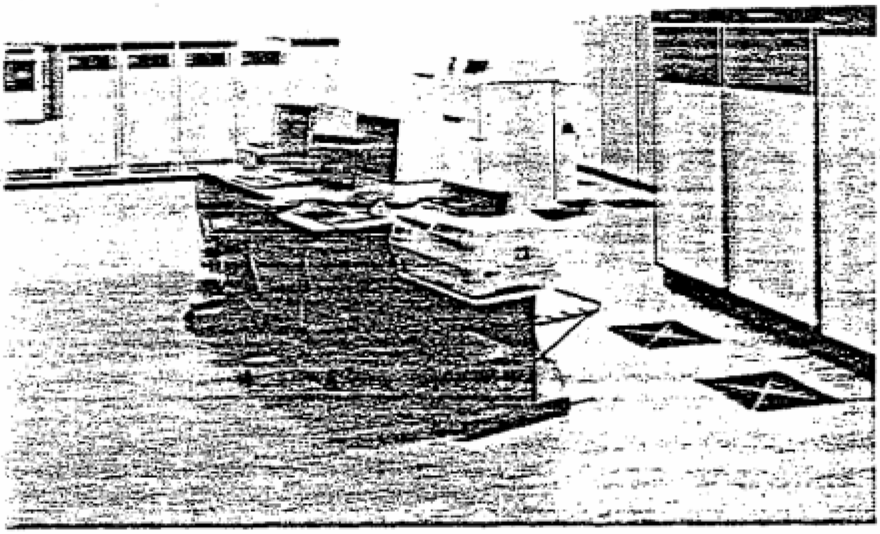

Figure 1 Relational Database Machine

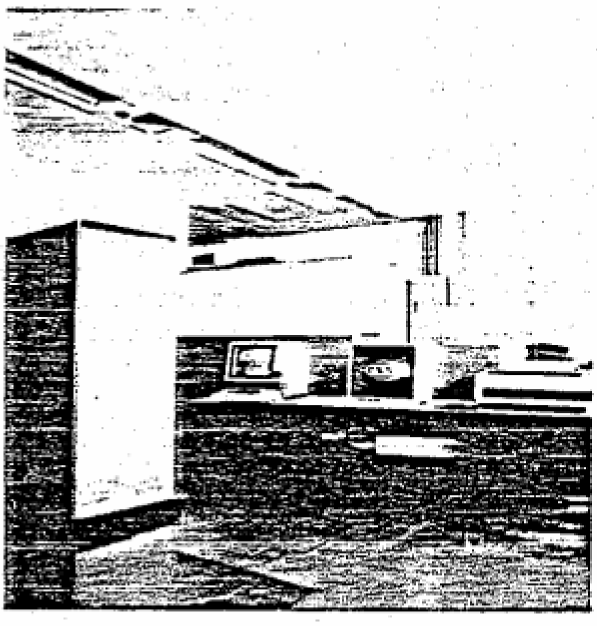

Figure 2 Sequential Inference Machine (SIM)