REPORT OF VISIT TO ICOT November 28 - December 23, 1983

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SUMMARY

This report outlines my work during the visit to ICOT from November 28 to December 23, 1983. My work, and discussions, involved three main themes: the work of the UK ALVEY Programme and the scope for Anglo-Japanese research collaboration, the importance that I attach for fifth generation research planning of re-introducing distributed computing concepts (previously known as "System A"), and the design of a parallel logic computer. These three themes are each covered by a section of this document:

1. International Collaboration
2. Fifth Generation Planning
3. Fifth Generation Computer

The latter section, is supported by two appendices discussing (in detail) control in a parallel logic computer and the design of a structured memory.

INTRODUCTION

During my visit to ICOT (november 28 - December 23, 1983) I gave two presentations entitled "UK Computing Research - effect of FGCS project" and "the Other Fifth Generation Computer". I visited 2 companies Fujitsu and Mitsubishi, accompanied by Isabel Gouveia Lima and Rikio Onai. And I had a series of discussions concerning the design of a parallel logic computer, mainly with Rikio Onai and Shunichi Uchida.

The presentation on UK computing research give an overview of the organisation of Information Technology (IT) research in the UK. In particular it showed the very significant impact that Japan's FGCS Project has had on the way IT research is conducted in the UK. It described how before the 1981 FGCS conference the three arms of Government: Department of Industry, Ministry of Defence, and Department of Education-Science operated independently, with little exchange of information. Influenced by the FGCS conference, the ALVEY Directorate has been established with a 5-year budget of Y68,000M, to encourage "Japanese-style" coordination of all IT research in the UK.

The second presentation on "the other fifth generation computer" discussed how ICOT's computer architecture research is directed at the design of a logic+database machine. It identified, however, that when we read the very thorough 1981 FGCS Project proposal, we find that an additional computer is described, namely the decentralised computer architecture linking all the specialised component machines that will form a Fifth Generation Computer System. The presentation argued that since this decentralised architecture should be capable of spanning different types of computers (ex. logic, data flow, control flow), it seems a very important research topic. In the decentralised architecture the essential properties are: system structuring of components, co-operation of components, extensibility of structure, diversity of components, and diversity of programming styles. This lecture presented the design of such a decentralised computer architecture based on control flow. And then discussed how this architecture could be re-designed to produce a decentralised logic computer.

Following from these two presentations, in the next three sections we discuss: international collaboration, fifth generation planning, and fifth generation computer design.

INTERNATIONAL COLLABORATION

One of the major effects of Japan's Fifth Generation Project has been to encourage the establishment of similar goverment coordinated research programmes in Europe and the USA. The most notable programmes in Europe are the European Community's ESPRIT programme and the UK ALVEY programme. At present the ESPRIT programme has become a political "football", with certain member governments (ex. Britain, Germany) refusing to re-fund ESPRIT until decisions are made concerning rebates and the farm price subsidy.

However, all EEC member governments are agreed on the importance of funding ESPRIT and it is particularly necesary for the smaller EEC countries whose governments give relatively little funding for new technology research. It is therefore to be expected that the current political problems will be resolved in the next 6 months and that ESPRIT will get fully underway.

The UK ALVEY programme, on the other hand, is rapidly advancing: funding both large and small collaborative projects, and establishing essential infrastructure and communications, such as research computer networks, and databases. There are also discussions concerning the future integration of the ALVEY and ESPRIT organisations, since ALVEY is viewed long-term as being an important component of ESPRIT. Another important problem currently being discussed is the participation of foreign multi-national companies in the Alvey programme; IBM being a prime example.

The ALVEY Directorate will soon be in a position to consider international collaboration, for example, with ICOT or MCC. However, in my opinion a number of difficulties are present: Britain's IT industry is at a relative disadvantage; Britain has no government laboratory comparable to ICOT; and fifth generation computers are considered a possibly <u>too</u> important area for international collaboration. For these reasons (and that ALVEY should be seen within an ESPRIT context), I would recommend consideration of a small joint

European-Japan IT research centre located in the UK. Such a centre could promote the exchange of researchers and information between Europe and Japan, and could start work on a mutually beneficial research topic such as machine translation of foreign languages.

FIFTH GENERATION PLANNING

In this section I wish to address two relatively independent topics associated with distributed computing. The first concerns a communications infrastructure to support international and national (Japanese) collaboration on fifth generation computer research. The second topic concerns the relationship of the INS and FGCS Projects, and the importance I attach to re-introducing concepts of distributed computing into the FGCS project planning.

Computer networks are an important communications infrastructure for research collaboration. In the USA and Britain (and to a lesser extent the other countries in the EEC) the national computer science research communities are well served by computer networks, allowing researchers to interact on a daily or even hourly basis. The ARPA net and UNIX net even allow researchers in the USA, Canada and Britain to internationally exchange documents and program, and schedule visits etc.

Japan, I understand, does not have a research computer network by which Japan's fifth generation research community can interact. Such a national network is a prerequisite for wider international collaboration. May I therefore suggest that the FGCS planners conider a national FGCS network as part of their Intermediate plans, and that as soon as possible this Japanese network is connected to Britain's ALVEY network.

The second topic I wish to address is a "System A" component for the FGCS plans. A study of the very complete 1981 FGCS project proposal reveals two themes for FGCS:

1. In the 1990's when fifth generation computer systems will be in use, information processing systems will provide a "central nervous system" for society.

2. Fifth generation computer systems will be knowledge information processing systems supporting high-level problem solving functions.

In simple terms, the first is concerned with distributed (or decentralised) computation and the second with knowledge (or parallel logic) computation. Both views are clearly part of a spectrum of FGCS.

At the present time there are two major national projects in Japan concerned with identifying the concepts of the future generation of computers, namely INS and FGCS. The INS project is approaching future computers from distributed or decentralised computation, whereas the FGCS project is approaching future computers from parallel logic computation. The decentralised computation research component of the FGCS project, known as "System A", has unfortunately not been included in current planning. Thus INS and FGCS have

equal opportunity to identify (or not) the concepts of the future generation of computers.

It is my (often stated belief) that fifth generation computer systems must encompass both decentralised computation and knowledge computation (e.g. System A + Logic computer). In addition, I believe that the major task for the FGCS project is to identify the concepts of the fifth generation computer model that is to supersede the von Neumann model, and be mirrored both by future languages and architectures. Failure to include both decentralised computation and knowledge computation, restricts the applicability of the FGCS model and may mean that it fails to satisfy the goals of fifth generation computers.

I discuss what I believe to be the essential concepts of the fifth generation computer model in the next section.

FIFTH GENERATION COMPUTER

Since fifth generation computers are to supersede traditional computers, what better place to start than by listing the principles of the von Neumann computer model:

computer	single processor and memory
memory	vector of fixed-size memory cells
addressing	one-level address space of cells
program	low-level machine language (instructions consist of a primitive operator and operands)
communiction	shared memory
exection	sequential control flow instruction execution

The importance of this computer model is that it is "mirrored" both by traditional computer architectures and programming languages, and is general-purpose for sequential computation. However, information processing is moving from sequential centralised computation to parallel decentralised computation where large numbers of computers are to be programmed to work together in systems. Thus for fifth generation computers we require a decentralised and general-purpose computer model, but one that can be mirrored by architectures and languages.

In the model decentralised computation concepts are intended to handle a spectrum of cooperating systems ranging from mainframe computers that are physically distributed, to miniature microcomputers on a single VLSI chip. It should also handle the specialisation of system components. General-purpose computation is intended to handle the efficient representation and execution of logic programs. As discussed above, central to the design is a logic computer model (cf. the von Neumann model) to be embodied in computer architectures and programming languages. I believe its principles are:

computer	computer system is a hierarchy of computer networks
memory	nested, variable-size memory cells
addressing	contextual address space of cells
program	high-level (logic) machine language
communication	shared memory + message passing
execution	"pattern driven" execution of instructions, with non-determinacy

The main work I have undertaken while at ICOT has been to identify the important design and implementation issues concerning these principles of the logic computer model. To do this we have subdivided the principles into: "control in a logic computer" and "general-purpose memory" structures. The former dealing with control aspects of the model, investigates the control of program execution in a fifth generation computer. In particular the representation and execution of (Horn-clause) logic programs on a parallel architecture composed of a network of simple "logic" microcomputers. (This topic is documented by Appendix 1) The latter, dealing with data aspects of the model, investigates how the memory of a fifth generation computer can be made more "general-purpose" to better meet the information representation requirements of very high level languages and operation systems. Three important mechanisms are examined: structure memory, contextual addressing, and the communication of data both by shared memory and message passing. (This topic is documented by Appendix 2)

GRATITUDE

I would like to take this opportunity to acknowledge the very important contribution that Japan's FGCS Project, and ICOT in particular, has made to Information Technology research in Britain. It is to be expected that Britain will soon be in a position to fully collaborate with the FGCS Project.

Finally, Isabel and I wish to thank that many members of ICOT who made our 4 week visit so interesting and enjoyable. In particularly we are grateful to Shunichi Uchida, Rikio Onai and Yumiko Okada. Okada-san even managed to obtain for us two tickets for the Toyota Soccer Cup between Gremio and Hamburg.