Panel Discussion:

International Research Activities for New Generation Computers

—Their Plans and Social Impacts—

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Chairman: Welcome to the panel on international research activities for new generation computers. The purpose of this sessions is to place the various national programs in their perspective, relative to each other. We would like to discuss their limited resources in people, money and equipment and to touch upon the prospects for international cooperation. One does not set off to redefine the technology base, as we have around the world, without expecting some major upheavals in the markets and the work place. So we also want to examine the social and economic impacts of new generation computer technology. The panel members are Dr. Cadiou, the Director of the ESPRIT Program in the European Economic Community, Mr. Tsutomu Makino, Director of the Electronics Policy Division of MITI, Mr. François Salle representing Dr. J.L. Lions, President of INRIA, France, Mr. Brian Oakley, Director of the Alvey Program for the United Kingdom, and Dr. Norberd Szyperski, Director of GMD, a computer research organization in West Germany.

I'd like to begin with some comments on the topics as shown in Fig. 1, the research subjects of fifth generation projects. You will find all of the speaker both today and the rest of the week, referring to these topics, sometimes under different labels, but usually referring to the same topic.

Fig. 1 THE TECHNOLOGIES IN FIFTH-GENERATION COMPUTERS

- Artificial Intelligence
- Advanced Software Methodology
- Computer Architecture
- Computer Communications
- VLSI (Gallium Arsenide, JJ)
- Intelligent Man-Machine Interfaces
- Related Supercomputer Technology

Fig. 2 RELATED TECHNOLOGIES

- Materials, e.g., Si-Based Sensors (Strain Gauge, Smart Cards, CW Sensors)
- Networking, e.g., Packet Switching (Decentralized Processing, Management, Reliability)
- Local Area Networks, e.g., Ethernet (Networks of P/C's and Workstations)
- Software Engineering, e.g., Programming Environments (Software Productivity, Quality, Reliability, Maintainability)
- Supercomputers, e.g., NEC S1/2 (Mathematical Modeling, Simulations, Graphics)

Some related research subjects are in Fig. 2. Some of these topics you find frequently discussed in fifth generation research programs, such as software technology. Others you find discussed in related research programs. One example is "work and materials" being conducted under the Next Generation Industries Project by MITI. Another on "work and super-computers" is being conducted by MITI as part of the National Superspeed Computer Program. So it should be apparent that it will be very difficult to compare the different national programs. Different resources are applied to different programs, and the measurements are different. What constitutes one dollar here may be ¥240 somewhere else, and they may not use the same accounting systems.

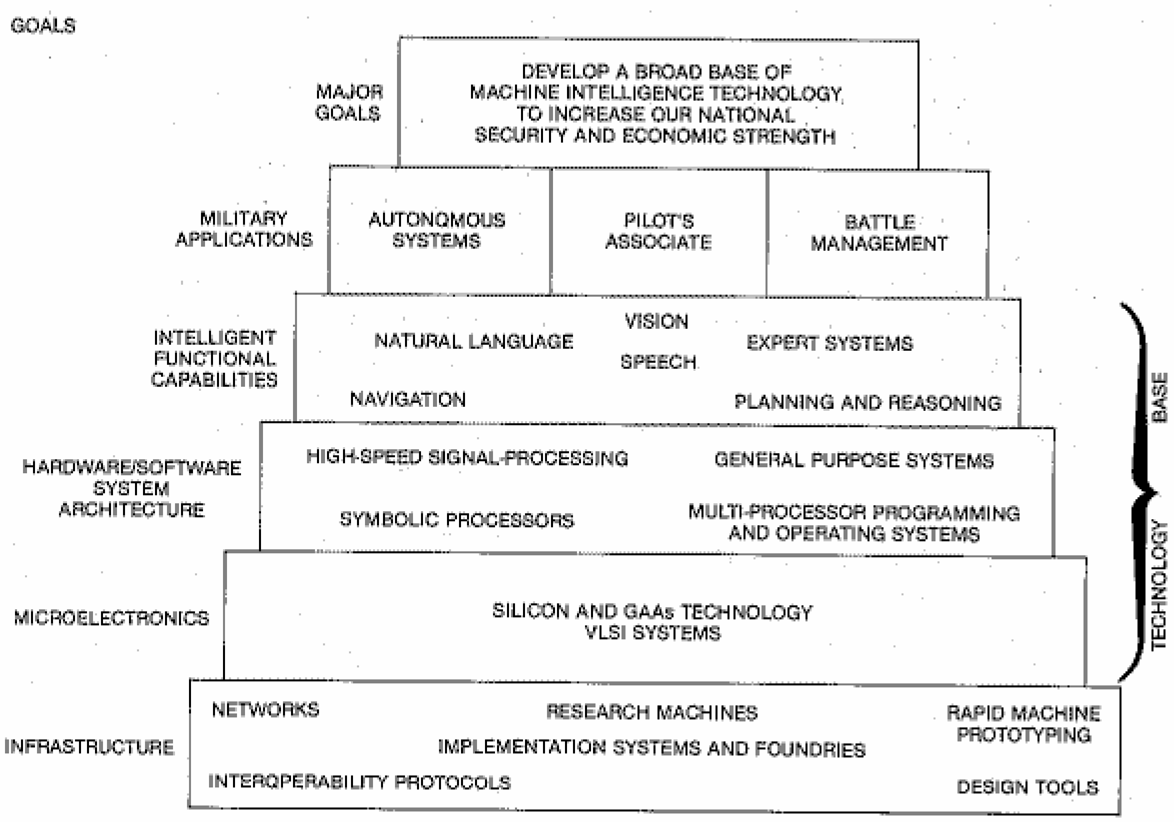
Since I'm the only American on the panel I'll very briefly describe a few of the American programs. In the last 5 months the American programs in computing have been very widely reported, starting with the National Computer Conference in the States and extending through several conferences in Europe, including the ESPRIT Contractor's Meeting, a meeting at Cambridge, a meeting in London and the Annual Meeting of the Association for Computing Machinery. I only want to refresh everyone's memory on the Strategic Computing Program.

Fig. 3 KEY AREAS OF ADVANCES THAT CAN BE LEVERAGED TO PRODUCE HIGH-PERFORMANCE MACHINE INTELLIGENCE

- Expert Systems: Codifying and mechanizing practical knowledge, common sense, and expert knowledge
- Advances in Artificial Intelligence: Mechanization of speech recognition, vision, and natural language understanding.
- System Development Environments: Methods for simplifying and speeding system prototyping and experimental refinement
- New Theoretical Insights in Computer Science
- Computer Architecture: Methods for exploiting concurrency in parallel systems
- Microsystem Design Methods and Tools
- Microelectronic Fabrication Technology

The Strategic Computing Program is a program that has been established under the Department of Defense, DARPA, the Defense Advanced Research Projects Agency. Fig. 3 intends to show recent developments, primarily in artificial intelligence and other aspects of computer science and microelectronics. I suspect every one is the audience has read at least one paper on this subject. Fig. 4 shows the objective of the Strategic Computing Program which is to develop a broad base using machine intelligence technology for the purposes of national security. The objectives are to redefine the technology base, to essentially depart from the domain of von Neumann machines into the area of non-von Neumann machines. DARPA intends to demonstrate this technology on a military level. The mere fact that DARPA is now trying to demonstrate technology indicates that they have departed from their basic research objective, and are now moving more in the direction of applica-

Fig. 4 PROGRAM STRUCTURE AND GOALS



tions and demonstration, which is more in common with Japanese procedures.

Fig. 5 STRATEGIC COMPUTING COST SUMMARY IN MILLIONS OF DOLLARS

	FY34	FY85	FY86	FY87*	FY88*
Total Military Applications	6	15	27	TBD	TBD
Total Technology Base	26	50	83	TBD	TBD
Total Infrastructure	16	27	36	TBD	TBD
Total Program Support	2	3	4	TBD	TBD
TOTAL	50	95	150	TBD	TBD

*Out-year funding levels to be determined by program progress.

Fig. 5 illustrates that large funds have at least initially been devoted to this program. This funding is on top of the ordinary amount of funding provided in the information processing programs in DARPA. The funding 4 and 5 years from now remains to be determined and will be dependent on how successful the current program is. However you measure this program, it is probably the largest single program in the competing fifth generation projects. The financing is crucial to redefining the technology base. This program just as the ESPRIT, Alvey and ICOT programs, are very long term and must be, if we're going to redefine technology. It is not possible to turn these programs on and off and I hope that the government officials in the audience either Japanese or other government officials will recognize that these programs have to be funded continuously from start to finish. In the West we have long admired the Japanese ability to finance an idea from the basic research all the way to production. And if the financing doesn't have that same ingredient, I'm afraid the program will have less chance at success.

Now, within the US community it's important to recognize that there are other sources of research support, even though the defense community tends to fund most of the work in computer science. There are some areas of funding that are not ordinarily reported as being fifth-generation related as shown in Fig. 6. This data is extracted from sources dated 1980-1982, because since 1982 this kind of data has been increasingly more fifficult to get or has become essentially no longer in the public domain. What I've indicated in the top paragraph are those areas that the Defence Department considers to be very much related to fifth generation technology, and these are things anywhere from secure operating systems through packet voice to distributed systems. And then you can see in the second and third paragraph other levels of funding, 30 million in the second paragraph, about 60 million in the third paragraph, of just some simple program areas that are very much related to fifth generation technology.

Fig. 6 OTHER DARPA PROGRAMS*

Information Sciences and Communications Milieu
- Secure Operating Systems, Robust Communications Networks, Packed Switching, Packet Voice, Satellite Communication, Machine Intelligence, Smart Sensors, Image Understanding, VLSI CAD, Distributed Processing

Computers and Communications Sciences
- Intelligent Systems ($16 Million)
- Advanced Digital Structures and Network Concepts ($18M)

Integrated Communications and Control Technology
- Distributed Information System ($16M)
- Advanced Communications and Control and Comm. Technology ($23M)
- Systems Cybernetics Technology ($25M)

*1980-1982 Sources

Fig. 7 illustrates a program, one which most American watchers should be familiar with, the so-called VHSIC Program, the Very High Speed Integrated Circuits. This is a 7-year program, 1980-1986, multi-hundred-million dollars, in rotography design architecture, computerized design,

Fig. 7 VERY HIGH SPEED INTEGRATED CIRCUITS PROGRAM
(VHSIC)
(1980-1986)

Integrated Circuits for 1985 + (Future Systems)

Design, Architecture, Software and Test Fabrication, Lithography, CAD and Production

IC Technology (Speed, Size, Weight, Power, Reliability, Tolerance)

Phase 0	Study Phase (Device Technology, Interconnect, Packaging Trade-offs, etc.) (1980-81)
Phase 1	Subsystem Technologies, High Resolution Lithography (1981-84) $168M
Phase 2	Production Capability (Lithography, Fabrication, Design, Architecture, Test) (1983-86) $75M
Phase 3	VHSIC Support (High Resolution Lithography, Increased Chip Utilization, Fault Tolerance, Advanced CAD (1980-86) $60M

and production. And the spending is somewhere around the order of about 100 million dollars in 1984. This has considerable industrial participation, and relates to all of the fifth generation research in the States, the same way the Gallium Arsenide work in the Super Computer Program in Japan relates to the ICOT work.

Fig. 8 OTHER US PROJECTS

MCNC	— $44 Million—Vertically Integrated VLSI Design Systems, Fast Prototyping, Fabrication Facilities
SRC	— $29 Million (1982-84)—Microstructures —System Components, CAD, CAM
MEIS	— $2 Million—Microelectronics, Architecture, Software Engineering
CIS	— $30 Million ($14M + Facility)—Knowledge based VLSI Design, Architectures, CAD Graphics

There are many other activities in the United States. Fig. 8 illustrates four nondefence programs. These are facilities or programs that have been started in the last few years. The Microelectronics Center of North Carolina, Semiconductor Research Corporation, and an organization in Minneapolis for research activity in microelectronics, and the Center for Integrated Systems, a very nice facility going up on the Stanford Campus. I haven't included the Software Engineering Institute funded by the Department of Defense, the MCC Corporation. And I can't even tell you about the research that is going on by AT&T and IBM. With that I'd like to close the discussion on the American programs, and introduce the first speaker.

The next speaker is Dr. Jean-Marrie Cadiou, Director of the ESPRIT initiative for the European Economic Community. And his talk is "ESPRIT and its Initiative for Information Technology in Europe." Thank you.

Dr. Cadiou: Thank you very much. First of all I would like to say that I am grateful to the conference organizers to have devoted a substantial portion of this opening date to international activities, especially to the European ones.

I'm going to talk about the ESPRIT program, which stands for European Strategic Program for R&D in Information Technology. ESPRIT is a program of the European Economic Community, abbreviated as EEC, and it might help if I give you a little bit of background information, so that you understand why ESPRIT was designed the way it was.

The EEC consists of the 10 countries and represents a huge market of 270 million people, and a total gross national product of 1.6 trillion dollars a year.

Next I'll list some of the key ingredients which Europe has and which are needed to be successful in the field of information technology. For example in the scientific area we have a strong tradition; in terms of numbers, we have produced more Nobel

Prizes in physics, chemistry, and field metals in mathematics than the United States since the creation of these distinctions. And that's even true if one looks at only the last 10 years. In the nuclear field, CERN, European Center for Nuclear Research, is a good example of a successful scientific European collaboration. And of course in our own field, as you know PASCAL, ADA and PROLOG were all invented in Europe. Not to mention the many Turing Awards that have been won by Europeans. By the way Turing was a European.

Turning to technology and industry, I'll just mention three examples, Space lab, ARIANE and Airbus, which show the capability of Europe to succeed in high technology fields, especially when a European collaboration is set up.

In the information technology field Europe is especially strong in telecommunications, where European industry is the world's No. 1 exporter. However, Europe has some handicaps and its worst handicap comes from inside: its fragmentation which has very deep-rooted historical origins, cultural, language fragmentation and market and industry fragmentation. And therefore any approach that does not address this problem of fragmentation will simply not succeed.

Our approach to the field of information technology has four main elements; Cross border Collaboration in R&D, transnational telecommunications policy, standards, and common trade policy. They are all aimed at reducing fragmentation and disparities and increasing the cohesiveness within Europe. I won't go into the various points on the strategy, but I'll say that it's vital for the European economy that it does succeed in the information technology field, because about two thirds of our economy depends on it for its competitiveness. And it's now perceived to be vital, not only by a few intellectuals and bureaucrats, but by the public at-large, which is very important.

So let me now get to three basic objectives of the ESPRIT program. The first point, which is the cross-boarder collaboration. in R&D, and that is basic to the ESPRIT program. Promoting cooperation in precompetitive R&D, is the first one. It's very important to start at the pre-competitive field and it's hoped that the side-effects of this increased cooperation across frontiers in Europe will be very important in reducing fragmentation by the process of people getting to know and appreciate each other.

The second objective is the technology objective: for European industry to be competitive in the 5 to 10 year time frame. And the third one is also important in reducing fragmentation and promoting inter-operability of systems. We believe that it is very important that we work on the technology base which is needed to accelerate the creation of international standards. I certainly don't mean standards in a protective way. That would be counter-productive in a world market. But it is very important for good and sound international competition to have standards that are internationally accepted.

Now, Fig. 9 summarized the main modalities and mechanisms of the ESPRIT program. It consists of projects which are of a pre-competitive nature, meaning upstream of product development. There the work needs to be done in the European community, and the conditions are that there must be at least two industrial partners belonging to at least two different

Fig. 9 ESPRIT MODALITIES + MECHANISMS

- Precompetitive R & D Projects
  - —Industrial
  - —Cooperative
  - —High risk
- 10 year framework—5 year 1st phase
- 1.5 billion Ecus—1st phase
- 50% Community—50% Participants
- Administered by ECC
- Operations Cycle
  - —Planning Process
  - —Call for Proposals
  - —Projects
  - —Evaluation
- Type A/Type B Projects
- Technology Transfer

countries within the common market. Of course, universities and research centers can contribute additionally to the industrial participants. Now, we have not taken the approach to create a new research center; instead we're doing it through distributed research, distributed contracts, and this is again suited to the European context, the fragmentation context, where having it in one unique center would, we feel, be a handicap towards technology transfer. The program is a 10-year program, but the first 5-year phase has been approved. It is a total program of 1.5 billion ECUs which is about 1.3 billion dollars. Incidentally our bottleneck is not so much the money as much as the number of qualified people. The funding is shared, 50% by the EC and 50% by the participants, where we feel that is the right balance to insure that the participants have some skin in the projects. It is administered by the EC together with two boards. One board with member states' representatives and an advisory board comprising personalities of all the relavant milieus, industry, university, users and so forth.

The way in which it operates is based on an annual cycle of operations within the five-year phase. And that derives from the fact that it's a program which is designed to achieve objectives and not a program which would be a waste of time and resources. So this cycle is sort of a sliding cycle with a planning process which is a 5-year sliding plan, very much along the lines of industrial planning. And this work plan is established and revised annually, because we feel it is very important to review the situation every year and to maintain flexibility in this area which is moving so fast.

The planning is not done centrally; it's done through groups and panels of experts, panels and workshops involving about 300 people, the best people we have in Europe. So it's a bottom-up process which is in itself very useful for getting people together and discussing what the issues are, but it's a bottom-up operation. It is not a program which is invented and directed by bureaucrats in Brussels. So the cycle starts from the planning; then there is the call for proposals, evaluation of the proposals and launching of the projects through contracts, and then evaluation of the results feeding back onto this planning process. The first cycle was started about a year ago with limited efforts, called pilot projects, to test the concept.

Fig. 10 ESPRIT: SPECIAL ACTION AREAS

- Advanced Microelectronics
- Software Technology
- Advanced Information Processing
- Office Systems
- Computer Integrated Manufacturing

Fig. 10 shows the five areas which ESPRIT concentrates on, with approximately equal funding for the first four areas, and about 50% funding for the last one. The first two areas are basic areas of microelectronics and software technology. The third area, advanced information processing, is the system architecture area, which perhaps has the most affinity with the Japanese Fifth Generation program. And the last two areas are generic applications, office systems and computer integrated manufacturing, which are basically there to provide feedback on the first three, and guide the progress of technology.

The software technology area, as you all know, is a very expensive area, and very difficult, where there is a lot of disparity, a lot of gaps, and the program really aims at reducing these gaps. The main disparity is across industry, and this causes all systems to be incompatible with each other. And another gap is the gap between the state of the art in research and the state of the art in industry, and the program is also aimed at closing that gap.

One of the projects which was started a year ago is called the portable common tool environment, involving most of the major computer manufacturers in Europe: Olivetti, Bull, Siemens, GEC, Nixdorf, ICL. The objective of this project is to provide a supporting structure to be a basis for tool development. It's an object management system approach based on UNIX, but there is also an ADA interface. We've completed a first prototype which was tested last month on UNIX and we've also validated a sample application on a configuration management system which was also tested last month.

The next area is the systems area, advanced information processing, aims to provide the architectures for tomorrow's applications. And there we must strike a balance between an evolutionary and a revolutionary approach. From a certain point of view there is a continuum between data bases, for example, and knowledge bases, so I think one has to take a very careful look at the aims. ESPRIT aims at the 5 to 10 year time frame, not further yet.

We started five projects last year; one of the projects is a very interesting one called Loki, which is a logic programming machine. And the interesting feature about it is that we started from a conventional data base, conventional software, conventional graphics package and built a logic programming machine on top of it. And that enabled us to move very rapidly and to be able to handle an aircraft design application relatively quickly.

New projects are about to launch this year, which involves companies such as Phillips, Nixdorf, Bull and others such as GEC, CSELT, the Italian Telecommunications Company and AEG. And the approach there is to try to indentify commonalities between object oriented machines, functional machines and logic oriented machines, and to try to determine a kernel and then move on to a so-called connection machine later on. The targets are to have a prototype for a logic programming machine by 1987, a parallel data flow machine the next year, and then a connection machine for the next year.

Next, I will talk about our status and plans as shown in Fig. 11. After the small-scale start of last year, we obtained a decision from the Council of the Community at the end of February, and we immediately issued a large number of information packages. Two months later we received 440 proposals which wanted 1.75 billion ECUs, whereas the first tranch only had available 200 billion ECUs. So this showed that there was a lot of interest in Europe to participate in this particular progam. We will this year support 110 projects, some large ones and a number of small ones, involving in total 550 companies, institutes and universities all over Europe. The 1985 cycle is already underway, and the new work plan is ready to be approved by the political authorities. So we are at the begining; we already have as I have said, a few projects that show some interesting results. We have established a platform for cooperation in Europe, there are already some side-effects which are apparent, such as Phillips/Siemens cooperation in microelectronics, the joint Bull/ICL/Siemens common laboratory in Munich, whose director Hervé Gallaire is here at the conference. A lot of standards work has been carried out which has been in one way or another influenced or made easier by the existence of the ESPRIT program. However of course we have just started, and the most difficult part is still ahead of us.

Chairman: Our next speaker is Mr. François Salle, Vice-President of Corporate Research and Technology of the Bull Group in Paris, and he is speaking for Professor Lions, the President of INRIA France.

Mr. Salle: First I woould like to convey to you the regrets of Professor Lions, President of INRIA who was scheduled to present a report on the French efforts in artificial intelligence, but who has not been able to join us since he has recently been appointed as the President of the CNES, the French National Space Agency. He has asked me to present the report to the conference on his behalf.

So, I would like to speak briefly to you, about how the research efforts are organized in France. Obviously I will mention the relationship with the ESPRIT project and other international projects. Historically, French research has been quite active in artificial intelligence. Just to mention a few names, you probably recall Pitrat who is active in studying games and natural languages, and also Gerard Huet who is known for his theory of problem solving; Jean-Claude Simon for his work in the domain of pattern recognition, Bernard Vauquois in automatic language translation, and Alain Colmerauer and his associates, in the domain of logic programming and more specifically for the development of PROLOG.

Before telling you about our current efforts, I would like to remind you how our research is organized in France. First there are a number of public laboratories. The most important organization is the CNRS, the National Scientific Research Center. The CNRS runs its own laboratories, I mean they have laboratories that are run completely under the sponsorship of CNRS. They include LRI in Paris Orsay, LIMSI also in Paris Orsay, LAS in Toulouse, and a number of associate laboratories. An associate loboratory is a laboratory within the framework of a university but with an important contribution of CNRS in terms of resources and tools. Just to give you an example there are associate laboratories from CNRS in Paris VI, VII, and VIII, and also in Orsay, Toulouse, Grenoble, Rennes, Nacy and Marseille.

In addition to CNRS there is an important laboratory for data processing and automatic processing, called INRIA. And finally the Ministry of Telecommunications runs the CNET laboratory, which is a very big laboratory complex for telecommunications, data processing and electronics.

Parallel to these public laboratories we have a number of large companies running their own laboratories. I might mention the Bull Group to which I belong, the CGE (Compagnie Générale d'Electricité) Group with its Marcoussis Laboratory and the Thompson Group. Various types of actions are used in France to coordinate research. The first two are under the sponsorship of CNRS. That does not mean that they are only applicable to CNRS laboratories.

The first type is ATP, Action Thématique Programmée. This is a form of coordination which creates liaison between researchers of various themes working in the same domain in various laboratories. The second one is GRECO, Groupe de Recherche Coordonnée. It follows the same plan as ATP, but accomplishes coordination as a single virtual entity, that means that all the themes working in the same GRECO are in fact working together. Then, more recently, since 1981, there has been in France the so-called Programme Mobilisateur pour la Filière Electronique, a name which is difficult to translate. I would just say it is an incentive program for the technology of information and electronics, that means: semiconductors, information processing, telecommunications and so on. This program is run at the interministry level. It is coordinated by the Ministry of Research, but with funding from other Ministries: the Ministry of Industry and the Ministry of Telecommunication. The two major tools of the Programme Mobilisateur pour la Filière Electronique are National Projects and PRC, Programme de Recherche Coordonnée. The first set of projects is oriented toward the transfer of technology to industry. That means that they are set up to facilitate the transformation of research results into industry. The Programme de Recherche Coordonnée is oriented toward research itself.

Now, I will come back to our subject, artificial intelligence and related topics. From 1980 to about 1983 all those subjects were coordinated at the research level by an ATP (Action Thématique Programmée). The Chairman was Hervé Gallaire who is here and now Director of the joint ICL/Siemens/Bull Research Center. During 1982, two efforts were started to figure out a more extensive program in this domain. The first group was initiated at the CNRS, and is a working group on artificial intelligence. The second group was initiated by INRIA named Club SICO for Systemes Informatiques de la Connaissance or computer systems for knowledge. And this club is made up of experts from research and industry. Finally these two groups have succeeded in joining their efforts and made a common report expressing the views of all the interested research parties in France and interested industries. This report was issued in the spring of 1983, and it recommended a set of actions in artificial intelligence and related areas, especially action for tools, for knowledge processing systems, man-machine interface and architecture. This report was submitted to the Programme Mobilisateur pour la Filière Electronique, and discussed in these various aspects. As a result, in the beginning of 1984 it was decided to launch three Programmes de Recherche Coordonnée (Coordinated Research Programs) in these domains. These three programs which will involve various teams acting in these domains in France, in CNRS, INRIA, CNET and industry laboratories will probably activate something like 200 researchers. The first of these programs, called basic tools and methods for artificial intelligence, is in fact, directly related to GRECO, the Groupe de Recherche Coordonnée, in advanced programming. The subject of this program is to develop and coordinate the research in fundamental methods, language for artificial intelligence programming, programming environments for artificial intelligence and machine architecture and systems for artificial intelligence. There will be about 13 different teams involved that is about 85 researchers. Obviously each of these teams will act with its own resources but special resources will be brought by the program for the investments and support facilities. Laboratories involved will be for example, Paris VI, Paris VII, Paris VIII, Marseille, CRIN in Nancy, LRI, LITP, INRIA and CNET.

The second coordinated research program will on man-machine communication, covering both written and spoken communication. It will cover both the vision and the speech by computers. Again this coordinated research program will be linked or is linked with an existing GRECO for which Mr. Haton is responsible. And in the same way as the first program, it will cover a number of topics on spoken communication, and graphic communication. It will involve about 10 laboratories active in this domain.

The third program has not yet started, but is under definition, and should be defined before the end of the year; it will cover more specifically the applications and algorithms for artificial intelligence. You could say it will be devoted to expert systems.

In parallel to these three coordinated research programs, there are a number of research projects run in three industrial groups active in electronics and information processing. The CGE Group is finishing the development of a LISP oriented processor, so-called MAIA Project. There is a research laboratory from Bull and from Thomson. Obviously these research projects are not disconnected; there are connections between those programs and some of the ESPRIT projects as described by Dr. Cadiou.

The last point I would like to mention on the European level is the ECRC, the European Computer Research Center, set up on the first of January 1984 by Bull/ICL/Siemens on a three party basis. As you know, this laboratory is located in Munich. It is run by Professor Gallaire, and this laboratory has 4 topics of activity now, Logic Programming, knowledge basis, man-machine interface and architecture. So that gives you some ideas of the way the research in this important domain is coordinated and encouraged in France.

Chairman: Thank you. Our next speaker will be Mr. Tsutomu Makino, the Director for the Electronics Policy Division, of MITI. His topic is "The Information Oriented Society and the Fifth Generation Computer Project".

Mr. Makino: Let me start with a quite general subject. As you may be aware, Japan, given its very few resources and large population, needs to greatly advance technologies for development of its technology oriented economy.

In addition, although Japan has been considered to be industry-centered, future priority should be placed on construction of a society where an active and comfortable life for each individual should receive more attention.

Holding a 10% share in the world economy in terms of GNP, the Japanese economy, according to government policy, should hopefully contribute much to the international community.

We believe that fulfillment of this task requires the presence of enhanced information capabilities in general society.

Now, I would talk to you about the background and significance of development of Fifth Generation Computer Systems. Our society is, and will be, increasingly information-oriented.

The 1980s and 1970s were also described as the information age. Yet, there is a significant difference between those years and the coming information era. While in the past industry and large corporations as well as large cities played central roles, every aspect of human life, both social and private, is anticipated to be involved in future ever-progressing information networks. At the same time, the requirements for computer application will develop to higher and more diversified levels. Computers have been used more for simple calculations in the past, but they will have to have more advanced functions supporting human decision-making activities in various fields.

Then, what sorts of functions will a computer have to be equipped with? For one thing, a computer must be something that can be handled by non-professionals, given the fact that it will spread more widely in society for more people. Naturally, future computers must be able to handle instructions in everyday words and graphics to become more accessible for end users. Furthermore, as I touched on earlier, a computer should be able to replace or support intelligent activities by inferring and arriving at a conclusion drawn from stored information. Another important factor will be that software should not be overburdened.

We have been talking about a software crisis in the past few years. In existing computers, software has been overburdened. And yet this software is nothing other than a product of human manual labor. It is really ironical that a computer requires, in a way, simple human labor. This is why we believe that Fifth Generation Computers should have architecture which is not overly dependent on software.

Current computers have many problems, as you may see from what I have mentioned. One ready example: they can hardly process such non-numerical data as sentences, voices or images, all friendly media to human beings. And there are more problems. Programs have become too massive and complicated. Because of the sequential processing format, the processing speed is too slow to be functionally intelligent. These problems give rise to the often-discussed needs for development of Fifth Generation Computers. We are thinking of the Fifth Generation Computers as something that will provide the technological basis for prosperous growth of a highly information-oriented society. Nevertheless, development of these high-performance computers entails high-technological risks and necessitates a technological breakthrough. This is why a national project for Fifth Generation Computer Systems was started in 1982 in response to the need for R&D on revolutionary new technologies.

In respect to the meaning of this development, the new computer systems will have a far-reaching effect on the realization of a blessed society in the 1990s. Improved welfare, solution to the problems of the aged and a medical consultation system will be all available by then. We will witness the solutions to the problems of the aged, remote areas or doctorless villages. Owing to the availability of robotics and CAD/CAM systems, productivity will rise in the factories and energy and resource-savings will be expedited.

In the office automation area, too, the present low level of productivity will be greatly enhanced.

These are some of the anticipated impacts.

Not only in such conventional human activities but also in unexplored fields new developments will constructively contribute to the progress of human society.

For example, automatic translation systems and other high-level translation technologies will facilitate understanding among peoples of different languages, enabling overall development of human society through mutual cultural understanding. Another contribution will be made specifically to Japan's technological development which has been often criticized for seeking after European technologies. Leaving this chasing-type practice behind, Japan will hopefully lead imaginative advanced technological development based on long-term perspectives. We hope that the Fifth Generation Computer will place Japan in a position where it can contribute to leading international research projects through technological development which does not necessarily bear fruit in the short term. Japan should be internationally committed to investment in advanced development projects as a world economic power.

Next, I would like to touch on the role of government in this project. You may ask why the government is actively involved in the Fifth Generation Computers in spite of the growth of Japanese private companies with the ability to invest in various R&D projects. First of all, there is a need for government lead in R&D which may not possibly proceed under the market-price mechanism or in very basic R&D. For instance, a project which may have a great impact on general society but require a long period before practical application, a project accompanied by large risks or financial burdens or a project requiring urgent action because of pressing needs from the society in general—all these are difficult for private companies to tackle. Therefore, such long-term or basic R&D greatly depends on the involvement of government. We are well aware of the frequent criticism that the Japanese government has given substantial assistance to technology development as well as application research by private companies, constituting a major cause for international unfair competition. There may have been such cases in the past. But the R&D by the government from now on should be focused on, as I have said many times, long-term, basic or fundamental projects.

For the reasons above, this Fifth Generation Computer Systems project should be the right one for government-led R&D activities. Certainly, utilizing a revolutionary technology based on a concept entirely different from that of existing computers, this project is too risky for voluntary action by private companies in terms of financial and personnel requirements. Thus we have reached the conclusion that it requires government initiatives in rallying domestic research resources.

I will only briefly speak about what specific results are expected from the R&D on Fifth Generation Computers. I will give a few examples here. Management diagnosis expert systems will computerize management decision-making. Design of buildings will be much simpler. The effectiveness will cover these industrial fields as well as in social applications. More personal attention will be given to students through educational systems with the curriculum individually programmed according to student ability. A new device like automated nursing systems will be possible by which seriously ill patients are kept under nighttime surveillance or sudden changes in a patient's conditions is readily addressed. Also automatic translation systems will bring about automated multi-national communication at a high level.

Let's now go to the problems to be addressed in the course of ICOT's R&D activities for the Fifth Generation Computer.

One of the problems is financial. As you know, financial reconstruction is today's mandate on the Japanese government. When efforts are made to curtail the national budget as much as possible, it is really difficult to have access to funds for the Fifth Generation Computer Systems project. We roughly estimate that 100 billion yen will be required for the ten-year project from 1982 to 1991. Whether it is 100 billion yen or less than that, the amount is still enormous. How will we get this kind of money? Of course it totally depends upon how we proceed in the negotiation with the financial authority. But it also depends upon how much support the Japanese people give to the understanding of the long-term significance of this project.

I am much impressed with such a large attendance at this conference. I feel we really have to do our best to be successful in negotiations with the financial authority in response to your enthusiasm.

The second problem concerns personal aspects of the development activity. Whatever amount of money we may have, we still have to solve the problem of how to recruit and organize capable people. To be frank with you, there are not many people in the country who can live up to the task of developing Fifth Generation Computers. Whatever number of these people we have, they are scattered among corporations and institutes working and playing important roles in their respective organizations. How to recruit these few available human resources and organize them efficiently is another challenging task. Currently, R&D work is being undertaken by fifty top researchers recruited from public organizations, NTT and some major computer manufacturing companies under ICOT serving as the core of the project. Our attention should be directed to how to recruit and increase personnel working for ICOT.

ICOT researchers are not alone in this task. They get advice from approximately 100 researchers working in different fields. Another problem here is how to consolidate and organize these ICOT researchers and the advisor group.

Let me briefly talk about international cooperation. We have no intention at all of limiting the ICOT program to within Japan. We believe that the research work should proceed openly through information exchanges with other countries and that the achievements and results should benefit the international community.

We have already seen exchanges of papers and meetings of specialists happening in this international context. This meeting is another example of these activities. We have tried and will continue to try to enhance this trend. In planning international cooperation, we would like to make it as effective as possible. Also we have to make sure that any international cooperation program should not change the nature of this long-term project aimed at the development of new computers ten years from now; it is not directed at short or medium-term results in three or four years. We would like to encourage international cooperation in the coming future with these things in mind.

Chairman: Thank you. Our next speaker is Mr. Brian Oakley, Director of the Alvey Program from the Department of Industry and Trade in the United Kingdom, and his topic is "The UK Alvey Program."

Mr. Oakley: It gives me great pleasure to be here in this thriving city and to learn about the progress being made by ICOT since what I think I can truely call the historic fifth generation announcement three years ago. If I sound unusually enthusiastic for an Englishman you must remember that I certainly would not be here without that conference because there would be no Alvey program and for that matter no Alvey director. You will appreciate the way that we admire the inspiration that you have given us by the Japanese program announcement.

The Alvey Program unashamedly copies features of the Japanese program in organizational approach, though not so directly in technical content. If to copy is to flatter, we are undoubtedly complementing the Japanese on their way of planning and executing national programs. The Alvey Program is a national cooperative research and development program in the enabling or underlying technologies of information technology. It's not directly enveloped by what has become known as the fifth generation subjects, those derivatives of artificial intelligence work, but it certainly includes those subjects. It's seen as a 5-year program with some of the AI parts of the program requiring more like 10 years than 5, or even more to come to maturity. It's a cost shared program between industry and government. I think the program differs from other national programs in that the public funds are derived from three government bodies, the Department of Trade and Industry, the Ministry of Defence and the Science and Engineering Research Council on behalf of the Department of Education and Science. The Research Council is the body that provides funds for academic research in the UK, including research in most of the information technology subjects. Well, I'm not sure what the tradition is in this country, but in the West, no one will be surprised to learn that a 50/50 cost shared program between industry and government means that of the 350 million pounds, that's roughly 100 billion yen, half means the government pays 200 million. I think you in Japan will recognize that it's difficult to get industry to work together, but that is nothing like getting three government departments to work together. Though I must say in practice this has gone very well in the Alvey Program.

The role of the Directorate is to pull the program together, to get it going. We are a mixed team, drawn from industry, from the sponsors and from the academic world. We have advisory committees for the various areas. We publish strategy

Fig. 12 UK: THE ALVEY PROGRAMME

THE ALVEY COMMITTEE April-August 1982
DECISION May 1983
L350 M over 5 years, L200 M from HMG.
FUNDED BY: DTI, MoD, SERC, (on behalf of DES) and Industry.
TOPICS:
1) Very large scale Integration (VLSI)
2) CAD for VLSI
3) Software Engineering
4) Intelligent Knowledge Based Systems (IKBS)
5) Man-Machine Interactions (MMI)
6) Networks

documents giving an indication of what we intend to do, and if you read them very carefully you will be able to read, between the lines, what we don't intend to do. We sometimes work from announcements of opportunity, when we say that we're interested in receiving proposals in particular areas. We work through consortia; we expect to have a whole group of firms and universities and research establishments working together on any particular project. And we like the consortia in a given field to join together into clubs for cooperation.

So far something like 50% of the program is committed. We have something like 100 projects underway. There are 60 full industrial projects, and about 40 "uncle" projects. Perhaps I should explain an "uncle" project. There is of course a certain amount of work in the program which is of such a long-term nature than in the UK it's unreasonable to find industry being prepared to put funds into work in the area. In such cases we ask the academic researchers to find a friend in industry, an "uncle" who will take an avuncular interest in the program and help to smooth the way, drawing our attention to it when the work has reached the point when they feel that industry should be taking a real interest in it.

Well, cooperation is going well. the average project contains something like 2 or 3 firms, 1 or 2 universities. There are something like 50 now in the project. There are about 35 universities, and there are a number of research establishments, the British equivalent of the NTT or ETL laboratories. We haven't established a central research laboratory; we have no ICOT. We intend to rely on good data communications between the dispersed research teams, including building wide-band links for pulling together the dispersed community. Perhaps I should just say that we in the UK are also of course fully involved in the ESPRIT Project, and I sit under the Chairmanship of Jean-Marie Cadiou in the Management Committee of ESPRIT. We try to harmonize the two programs though this tends to be a rather ad hoc process. The objectives of the two programs are in technical terms very similar, but of course they do have somewhat different industrial objectives.

Well, coming to the technical program, that's just a list of the universities primely involved in the program, Cambridge and Edinburgh. ICST is Imperial College. The work is pretty heavily concentrated in a limited number of universities.

Fig. 13 LARGE DEMONSTRATORS

Goal-Setting Projects
- Design-to-Product (C.I.M.)
- Mobile Information System
- Decision Making Aids—for Social Security Administration
- Speech Driven Word Processor

Fig. 14 THE ALVEY UNDERLYING TECHNOLOGIES

- VLSI
- Software Engineering
- Intelligent Knowledge Based Systems
- Man Machine Interactions
- Networks

We have a number of large demonstrators in the program as in Fig 13, 14. These are intended to pull the program together, to give the work a focus, a challenge to pull the enabling technology research work through. They're all difficult challenging targets which will certainly take us the 5 years of the program to bring through. One is a computer integrated manufacture project. Another one is a mobile information system or project. The third one is concerned with decision making aids for social security administration. And there is a speech driven word processor. All of these involve expert systems, all involve difficult software engineering targets; parallel architectures will undoubtedly be required to achieve at least three of the projects. And of course we expect that the integrated circuit work will be challenged to the limit in producing some of the equipment, for example for the mobile project.

I won't say very much about the VLSI because it's not really a fifth generation subject, I suppose, but of course it's absolutely crucial to the development of the fifth generation. There are relatively few firms in the VLSI fields in the UK, so I suppose it's been easy to put together a cooperative program. Of course the industry has hardly the distinction of the Japanese achievement, but we have particularly concentrated on the custom design part of the market. Ferranti with their ULA based on their relatively simple CDI process have had a remarkable success, which in turn has led to the success of the equipment manufacturers like Sinclair. Moreover the newcomer INMOS has become firmly established in their specialized part of the memory market. So our VLSI program has very few surprises, but I think in some way the consortia in this field have achieved what we were looking for in terms of sharing the research effort. As it happens the consortia, the firms, have particularly tapped the academic physics research community leading to some quite interesting work on advanced techniques for working at the shorter wavelengths, which of course one has to use below that of light, such as exma-lazer and bottle-optics.

The software part of the program is of course extremely important after the remarks which have been made about software this morning. I don't think I really have to emphasize the curcial challenge. We in the UK are especially interested in this for we have some inherent strengths both in industry and in the academic field. I must say I am interested in the architecture that Mr. Makino just referred to, that will eliminate the problem of software development. I must confess I'm not all that hopeful that I will see it in my time. So, we're making a determined national drive on software reliability in the belief that the application of formal methods of software verification will bring benefits in programmer productivity, as well as reducing the whole-life costs of software. (See Fig. 15)

Fig. 15 SOFTWARE ENGINEERING

Measurement/Reliability/Productivity
Production of Integrated Programming Support Environments

- First Generation
  - File-Based Tool Set
  - UNIX
- Second Generation
  - Databased-Based Tool Set
  - Distributed Operating System
  - Formal Specification Methods
- Third Generation
  - IKBS-Based Tool Set

The first integrated project support environment teams are making good progress and strong consortia are tackling former methods in reliability. You'll note that the third generation integrated projects support environment is seen as bringing about a convergence of the software engineering community and the knowledge based systems or AI community. I must say I shall believe it when I see it, but we have published a strategy for that part of the program as an earnest of our intention.

Concerning man-machine interface, as you see in Fig. 16, we have a number of consortia working in the pattern recognition field. This is a very difficult field, where I think that there is a very great deal of work remaining to be done. Our approach is embracing both the classical and the knowledge based system approach.

For speech we've put together a coherent programming embracing some 10 consortia; that means that we've got vertually everybody in the UK working in the speech field, in some part of this program. And it's a good example of where the club that brings together those 10 consortia will have a particularly important part to play.

Fig. 16 MAN-MACHINE INTERFACE
- •Speech Recognition
- •Pattern Analysis
- •Ergonomics
- •Better Displays
- •Link with Cognitive Sciences, Psychology, etc.

The human factor is part of the program, is interesting and very difficult, a multidisciplinary subject, which means that it is more than ever difficult to bring the teams together, since both hard and soft scientists involved. I don't know what it's like in Japan, but I think that in the UK, the human factors team is somewhat immature. We have still got to get a common sense of direction in this vital area.

Fig. 17 RESEARCH THEMES IN IKBS
- •Parallel Architectures
- •Declarative Languages
- •Intelligent Data Base Systems
- •Expert Systems
- •Intelligent Front Ends
- •Inference
- •Natural Language
- •Image Interpretation
- •Intelligent Computer-aided Instruction

Fig. 18 ARCHITECTURE WORK
- •On-going Projects
  DAP, GRID, CLIP, WISARD, Data Flow, ALICE, etc, etc.
- •Major Development Projects
  Alice/Date Flow Derivative
  Data Base Access
- •Simulation Facility
  Transputer, Tree Structure
- •Supervisory Architecture
  AWSAP
- •Language Work
  CTL, Parallel Prolog, etc.

Well, now turning to knowledge based systems, we call it IKBS; (See Fig. 17) we don't particularly like the term artificial intelligence in the UK; it may be artificial but it certainly isn't intelligence. The architcture part of the work is distributed throughout the whole Alvey Program. We do have coordinators to pull it together, and I thought I would just spend a couple of minutes enlarging on the architecture program. (See Fig. 18) We are lucky in the UK to have had considerable fermented work going on for some time. The ICL digital array processor, LaDat has been available for some years with further developments in progress. GEC has got its grid. And in the universities, I suppose the best known work is that of the dataflow machine team at Manchester University from which results are now available. And I find that the ALICE work at Imperial College is well-known here in Japan. We are at the moment putting together a program to develop ALICE, involving Imperial College and Manchester University, together with firms like ICL and Plessey. This machine is based on the parallel graph-reduction techniques of ALICE; incidentally ALICE stands for Application Language for Idealized Computing Engine. The ALICE developments have now got both virtual tree and shared distributive memory architecture features. The research model will make use of early versions of the Transputer. There is an absolute ferment of interest in architecture as I was saying, so in order to minimize the number we acutually have to build, we're proposing to build a national simulation facility, or do I mean emulation facility, which will also use the Transputer. Perhaps I should explain that the Transputer stems from the fertile brain of Ian Barron of Inmos, who I'm pleased to see is here; incidentally he's carrying some samples of complete Transputer in his pocket though I rather doubt he will hand them out. It's essentially a powerful 32-bit computer on a chip, capable of some 10 million instructions per second. But I believe that the crucial feature is that it embodies 4 ports capable of supporting bi-directional rings with a 1.5 mega-bite per second transfer rate. Thus, it's very suitable for the implementation of tree architectures. And I know there is interest in its use in that capacity here in Japan as well as in the UK. The language OCCAM stemming from the work of Prof. Tony Hoare at Oxford University is designed to make it easy to exploit the architecture of a number of loosely coupled Transputers or other processes connected by communication channels of the Transputer type.

We're also planning a program to tackle the interlinking of a family of equipments of the fifth generation era, essentially a supervisory architecture. This work has been planned by Tree and drawn from the seven leading IT system firms in the UK, and if the project goes ahead it will be opened up to the whole UK systems industry. For that project we may in fact establish an ICOT-like establishment.

Work is of course also going on at the language level, both to develop an improved PROLOG and to produce what we call a common compiler target language, CTL. This is essentially to buffer the language and application software work from the various architecture developments so that both can develop without being too interdependent. It enables software tools to be developed in parallel with hardware construction. It is of course a research tool, but we believe it may prove to increase the efficiency of the research effort. It can support traditional control flow concepts as well as reduction semantics.

Concerning expert systems, the work is flourishing in the UK now though I must say much of it is pretty elementary, but nonetheless very practical for that.

Natural language work is my own favorite. I think it is the most challenging part of the whole fifth generation field. In my view we have no real hope of making major progress in the natural language area without putting together a multi-disciplinary tram. We are beginning to increase the work in the field, though in the UK, the whole of this area is undoubtedly constrained by the lack of suitably qualified manpower. And we are taking steps largely through distance learning techniques, video techniques and so on to try and rapidly increase the community.

We are all involved in artificial intelligence developments. One thing is clear, though we can expect to see progress along the way, in many parts the road is going to be very rough, very hard going. With our different national programs, I sincerely hope that we have enough human intelligence to work together sensibly to make good progress along this stony road.

Chairman: Thank you Brian. Our last speaker is Professor Norbert Szyperski, he's the Chairman of the Board of Executives of GMD, which stands in German for the National Research Labs for Mathematics and Data Processing. Professor Szyperski is also Professor at the University of Cologne.

Prof. Szyperski: I would like to thank you for having the opportunity to talk and to discuss the subject of supporting research in the field of new computer architecture. For us in Germany, it was a similar situation to that of Great Britain. We had a lot of work going on in that field, but most of it was in the status of fragmentation. Due to the fact that our Japanese friends did such a wonderful marketing and public relations act with starting the project of the fifth generation, our authorities at home felt the same as Great Britain, and so they tried to establish a new program. And that helped us to come together, not only in the sense of organizing ourselves, but in the sense of getting new funds too. So the federal program to support the information technology, in the time frame of 1984 to 1988 consists of an amount of money, at least proposed, of 3 billion D marks for the fields of microelectronics, information processing and telecommunications. Well, that is in addition to the funds and the programs already well as possible. And that is in addition to the work done in the leading research labs mentioned at the European level. So we try to harmonize these two programs as like GMD, the Institute of Frauenhofer Gesellschaft and the Heinrich Herz Institute, in the field of telecommunications. Now out of this 3 billion D mark, you could pick out an amount of about 520 D mark devoted to new architectures, knowledge based systems, and CAD for hardware and software development. And that is combined with the program that goes into the educational field, for we would like to harmonize reserch and development on one side and educational aspects in schools, high-schools and universities, on the others, taking into account that the waves of experts are going by generations and no longer by age. Now if we look into the projects and organization I can say that we found what we call compound projects for that field too. These are joint projects in double sense. First, we are trying to bring together three groups: research people and experts from the fields of application, methods and methodology, and last but not least system architecture. And second, we are trying to combine industry, national research labs and research groups of the universities. Going into the application fields, we believe that under the horizon of new architecture we have to redefine the application areas before starting to define the tools. Then we have to discuss, and we have to try to develop, not later on but at the same time, the method in order to get a methodology for intelligent solutions, before trying to use a computer to solve problems. And in that field of new methods, the main topics are multilevel approaches, concurrent approaches and synchronized approaches.

That means, for example, in logic, you can no longer just think in terms of linear or line oriented logic systems, but you have to use net systems in order to understand the reasoning that is not only going on in proving theorems, but is going on and trying to design systems. The logic you need for engineering tasks is in one or the another different from the logic you are using for proving theorems or similar subjects. Now, within this framework, we are trying to find adequate computer and knowledge systems. Especially right now within the program we have numerical solutions for algebraic functions, with a special approach using multigrid machines. The second area is concerned with image and pattern processing machines and the third is knowledge-based systems.

Combining these three areas, we are working in the field of intelligent man-machine interfaces, speech-driven on a natural languages.

Now, going into the architecture, we are studying and prototyping, and you will find data type and object oriented machines, like the STARLET machine; the cooperative reduction machine for the development on the basis of the reduction scheme, fault-tolerant machines on the basis of multiprocessor systems. And last but not least, multiprocessor systems with various features of multilevel combinations.

On top of these developments, we are trying a machine design approach in order to describe and control virtual structures of machines, so that according to the given set of application problems, the materialization of given structure within a system depends on the conditions and requirements of the task and the application field.

Social implications is mentioned as the topic of our panel discussion. In Germany the human factor discussion is very important. So, let me present some aspects related to the social impact, the role of computer and communication in human society as far as we see it and the way we are trying to do our research in that area.

We have to start with a mission that we would like to promote further development of human beings and human society. Therefore, we have some rather tough conditions to accept. First, computer systems should play the role of a communicative knowledge agent. That means a communication system, a knowledge-based system should in any case be under human control which also apply to its components. That means we should have unlimited human responsibilities for computer actions. Therefore, we have to design, in the future more than in the past, open systems that are transparent in their computing and their communication transactions. We should have the chance to reconstruct the action, the procedures and the various status of the system back into the past. You could also say, we are working in a field that might be called security architecture and security engineering in order to find a way that we really can feel we would like to implement machines and systems of that new type in our organizations. Now considering the role of the human being, of course the first approach always is the question of employment. Of course we would have to say that at the micro level, less work will be done by human beings, but men will have to do more in order to look for new tasks for urgent problems we would like to solve. There's a very interesting aspect of a knowledge system: what are the changes in society and what are the changes in the working environmnt? So far we've studied problems coming up in the world of clerks, secretaries and of that type of people working with us. Now we are going into the field of professionals and managers. What might be the impact on these groups? We have to take into account that we ourselves will be influenced. What will be the future position of a researcher? Of a teacher? What are the changes? We can not assess the changes without experiments. So we are very much interested in pilot installations, and rapid prototyping of new systems, especially in the world of expert systems, as early as possible. The Federal Government spends about 100 million D mark a year on a program called humanization of working conditions using high-tec developments.

Going into the field of new media, for knowledge distribution, one has to ask, what's the balance of knowledge at the local level, knowledge provided by systems, combined information basis? What impact might that new balance of knowledge distribution have on individual? We are accustomed to material goods that we are dealing with on open markets; that means that we can take our money, go into a shop and buy what we like to, without registering, without becoming a member of a user club. Will we have the same open access to knowledge systems, to information in given systems? If you carry this forward to the world of programming, what does it mean when you can read, that is when it will be easier and easier to program regardless what type of language you are using? And combining conventional languages like we have it right now, on one side PASCAL, FORTRAN and ADA with PROLOG, technicians tell us that they will teach the computer to answer the question how to program, but the question what to program will be left to the human beings, man. Now, it is an interesting fact that we are developing conceptual notes while developing products, and systems in detail. We are not thinking in advance of a very large conceptual frame, we are doing detailed work, but it is by interaction that we mostly are doing it. Within our daily work, while solving less difficult problems, we're discussing and discovering new aspects so that we can answer what we would like to program.

The fifth generation program, ICOT and most of the CAD development was not invented, using CAD tools, but just using paper and discussion.

Let me come to the last point; we are discussing at home and are at least trying to solve legal problems. Of what type are the new parts of knwoledge systems realized in expert systems? What type of documentation will we have? Who will add what to our common knowledge? So far we can follow it up by reading literature, by inspecting the papers. But will we get this same open access to newly developed knowledge systems and information bases? The problem of property right and authorization of knowledge bases is an upcoming problem we have to look at.

And let me just make a final remark with respect to the impact a knowledge-based system may have on our own scientific community. The given understanding of scientific communities is that we accept the idea of publishing results in a regular form. How will knowledge-based systems be published, or will they be protected too early like industrial goods? What will happen to the transporter of knowledge flow? There's an ongoing discussion right now. What are the relations between the countries of the first, second, and third worlds? Will there be an impact on that by developing systems under the circumstances of new architecture? I'm very hopeful that we can find answers to all of these questions. It was very helpful for me to understand what Prof. Moto-oka said, that he would like to agree rather on scientific competition than on industrial competition. And I think it was very hopeful to hear Mr. Fuchi said that he would like to do is hypothesis testing. It is actually the real way and the given way within a scientific community to gain new experiences jointly. So it is interesting to see how we could try to achieve that. Well, turning to the topic you mentioned, I don't know if we would like to do it. That is a question for future international collaboration.

Let me just make two remarks, one about the conceptual side. I believe that we could prove some of our ideas not only by testing but by trying to apply them in an early stage to one or the other subset. We could share the fields of application we would like to work in. That might be related to regional aspects and cultural aspects as far as the cognitive style and the working of intelligent groups are concerned. Especially in the subject of logic tools, I personally believe that we have a lot to do. The given logic is not appropriate for the developments we are looking into.

The second area, engineering, if we really would like to test hypotheses, on a larger scale, we need international and multinational efforts. And it might be helpful to agree on a special tested installation so that we really can test different approaches in order to be able to compare results. Again an standardization of interfaces is something we should take into account not too late. And it is not only the interface between machines but it will become more and more the question of interfaces between computer languages and their compilers or interpreters. There is a lot of common interest I can see, and I hope that we can achieve some of these common goals. Thank you so much.

Chairman: Thank you Professor Szyperski. In this session there has been a wide-ranging discussion on the world-wide programs in intelligent computer systems. To me it's clear they're all artificial intelligence oriented, although Mr. Oakley may disagree with intelligence. They're all concerned with technology transfer. And they were certainly all started by governments primarily because of the high risks associated with research, associated with long-term definitions of a technology base. From my point of view, I see all of these programs suffering from the same bottlenecks: they don't have enough people, they don't have enough money, they don't have enough resources, there are not enough sequential inference machines to go around today, and it seems to me all of these programs could benefit from cooperation where each country that has certain strengths would exploit their strengths, and those countries that have weaknesses would avoid those areas. Now I would like to direct on question to the panel primarily to Mr. Makino and that is what do you consider are the prospects for international operation?

Mr. Makino: This large-scale undertaking will have such an impact on the next generation that international cooperation has to be there. As all countries have just begun full-scale research, we must identify and discuss what fields need international cooperation as well as at what stage and with what objectives their research activities are now going on in different countries. This should be the first necessary step. In this regard, exchanges of research papers and researchers themselves should be actively promoted for building up an international consensus and awareness on what sort of cooperation is necessary or possible. In this sense, this meeting is really useful.

Chairman: Thank you. One of the purposes of cooperation as I mentioned earlier is to reduce duplication of efforts and eliminate weaknesses, so I have a question for Jean-Marie Cadiou, who was managing a program across all of Western Europe, and that question is "Have you had any success in reducing the duplication of effort?"

Dr. Cadiou: I think that your question implies that duplication is bad, and I think it could be argued, in fact that some duplication is good. If one thinks in terms of competing approaches, particularly in this field where the technology is moving so fast, you are never sure which one is going to win and you always need to have several irons in the fire. However, there is a real problem, which is the fact that was emphasized by many speakers: about the bottleneck of scarce resources. Therefore there is the need to maximize the use of these resources as far as possible. And on this point, there is complete agreement between the national governments in Europe, EC officials and industry. We're all making our best efforts to achieve that so that the various programs reinforce each other. It's not easy but at least the will is there. Now the actual consultation is done on a continuous basis in a very pragmatic fashion, through an exchange of information about the various programs between the responsible parties. As was mentioned before by Mr. Brian Oakley for example, (he is on our Member States Advisory Board and we see each other very frequently), our people see each other very frequently, and we discuss issues as the need arises. Also the industrial participants play a great role there. They decide which are the collaborations and in what framework they're best done: at a national level, or perhaps it's best at the European level, because the natural partners are in another country for example. Or because the work has implications on standardization, it must be done at the European level. Also in many cases, the bulk of the national programs is actually downstream of ESPRIT, and there's a natural separation there. However, it is a difficult issue and we must make progress on it in the future in order as I said before, to insure the best use of the scarce resources, more than actually try to systematically avoid duplication.

Chairman: Let me just ask one more question since we're running out of time, and I'll direct this to Mr. Oakley. It relates to cooperation and in this particular case, just in the UK. What happens to the proprietary rights of all that research that's developed under the Alvey Program?

Mr. Oakley: Well, I think the situation is very similar in the UK, Alvey Program to that in the ESPRIT Program. In deciding what to do with the proprietary rights, one has to balance two opposing considerations. On the one hand one wants to spread the information coming out of the program as widely as possible around the community, and on the other hand one wants to maximize the chance of that work actually turning into something practical that can be used by the information technology user community. So one reaches a rather uneasy compromise. In fact what we tend to do is to say that the rights should belong to the firms which are actually doing the work. That of course doesn't mean that the universities and research establishments can't negotiate with the firms to get a share of the return. But we also say that in what I referred to as the clubs, in the community of wider workers, in the particular field, that information should be made freely available for the purposes of research, but not of course for the purposes of exploitation. By that means we try to get the information spread around but at the same time we try to give the firms the maximum incentives to actually create something from the work.

Chairman: Let me say thank you to the translators for what I think was a wonderful job. And thank you to the audience for your kind attention. Thank you.