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ORIGINAL FRENCH

REPORT

on the meeting of the Expert Group
held on September 15th and 16th 1970
in view of the establishment of an
International Institute for Sofware Engineering

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INTRODUCTION

As agreed upon, during the conference, held in Paris on July 9th 1970, some Institute Directors and Heads of Planning Departments concerned with the foundation of an International Institute for Software Engineering met at 3 p.m. on Tuesday September 15th 1970 at the Institut de Recherche d'Informatique et d'Automatique (IRIA), Domaine de Voluceau, 78-Rocquencourt, France, by request of Professor LAUDET, Director of the said Institute.

The meeting was attended by:

- German Federal Republic (G.F.R.)
  . M. GNATZ, Deputy of Professor BAUER
  (Technischen Hochshule Munchen Birlinghoven Munchen)

- France
  . Professor LAUDET, Director of IRIA
  . M. GRIFFITHS, Deputy of Professor BOLLIET (Grenoble University)
  . M. SIMIAN (Toulouse University)

- Great Britain
  . Dr. POOLE) (Culham Laboratory
  . Dr. MORTON) Abingdon - Berkshire)

- Greece
  . Dr. KONTOS - Greek Commission for Atomic Energy, Democritos, Athens.

- Italy
  . Dr. ANDRONICO) Deputies of Professor CAPRIZ (Istituto di Elaborazione
  . Dr. ONESTO) della Informazione - Pisa)

The meeting was also attended by:
Messrs PERONNE (Technical Adviser - Scientific Affairs Department French Foreign Office - Paris (France))
RENARD (Delegation for Informatics, Paris (France)
and BLAKE (Scientific Affairs Department - OTAN)

Secretary to the meeting: M. RODE, IRIA (France).

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The Agenda was as follows:

1°) Attempt at the definition of a future programme of work for the institutes taking part in the scheme.
2°) Attempt at the definition of the part of this programme to be reserved to the "Central nucleus".
3°) Attempt at a coordination of the work in process at these institutes.

I - OBJECT and INTEREST of the MEETING of the EXPERTS.

1.1. After welcoming the participants and thanking them for their presence, M. LAUDET invites M. PERONNE and M. RENARD to recall the object and interest of the meeting.

After having excused the absence of M. de BOISGELIN, who is at present in U.S.A., and welcomed the participants on behalf of the French Ministry for Foreign Affairs, M. PERONNE stresses how important it is, to his mind, that a contact should have been established as quickly as possible between the scientists interested in the scheme. To his eyes, the chances of the future Institute shall appear in the light of the meetings between the responsible scientists and the Institute shall first and essentially come to life through the scientists.

1.2. M. RENARD points out that he had not been present at the OTAN preleminary meeting on the scheme and recalls that the question at stake is the establishment of an International Institute for the industrialization of software. The discussions on this scheme at government level have particularly dealt with the two following points:

- the direction that can be given to research in this field, with reference to the scientific subjects proposed;
- the part of that research which can be centralized, the part which can be decentralized and the respective importance of these two parts.

Before the structure of the Institute can be given a definite form, it should be normal that a certain number of countries should have adopted a concrete line of action in this field, each country, for instance, financing an initial set of research-work, on which the participants in the scheme can be concerned. Hence, for M. RENARD the twofold interest of the present meeting:

- An attempt at defining the directions in which the teams of searchers can be set to work in this field;
- An attempt at defining how far this research can be:
  - decentralized;
  - or - centralized.

M. LAUDET then suggests an examination of the Agenda.

II - ATTEMPT at a DEFINITION of a FUTURE PROGRAMME of WORK for the INSTITUTES.

II.1. M. LAUDET points out that a very serious work has already been performed

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and wishes to have the opinion of the participants on two documents (°) which they have been sent before the meeting. As suggested by Dr. MORTON (Great Britain), he invites them to state what their laboratory can achieve in the programme contemplated.

II.1.1 - Dr. ANDRONICO and Dr. ONESTO (Italy) propose the following programme of work for the Pisa Institute:

. Work in progress: Study of portability for small computers:
SEL, a self extensible language has been developed with the general purpose of describing programmation systems independent from the calculator.

SEL has been experimented on the HP 2116/B calculator and has been operational since February 1970. Its present version is conversational; an optimized and extended version is at present being experimented on the same calculator.

An exchange of view follows on the subject with the Culham Laboratory (Great Britain).

. Future research: Portability and self-extension, theory (évaluation):
During the year 1971, the laboratory shall use an IBM 360/67 calculator. Studies are now being carried out to experiment SEL on a calculator of so great a power, not only about the portability problem but also about this other major problem in the field of software engineering i.e. the problem of auto-extension.

The laboratory is also interested, though in a less definite and more general way than with the SEL system, with theoretical research on a formal definition of machines and programmes unrelated to the computer. In the opinion of Dr. ANDRONICO and Dr. ONESTO, this type of research still belongs to the field of software engineering i.e. to the problem of evaluation.

II.1.2 - After having excused the absence of M. BOLLIET, at present in Rumania, M. GRIFFITHS then expounds the plans of the Grenoble University:

. Programme transfer.
A list of programmes is at present available written in a macroprocessor language for IBM 360 calculators. These programmes constitute an interpreter-analyzer for the ALGOL 60 language. The transfert of the programmes implies a precise definition of the necessary interface for these programmes to be incorporated in an exploitation system.

. Definition and evaluation of algorithms:
Fundamental algorithms for writing exploitation systems can be defined in a clear and precise way, e.g. by using the APL language. These algorithms

° 1) "Recommendations of the Expert Committee for the establishment of an International Institution".
2) " Suggestions for a programme of work".

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can offer to the persons defining such systems a possible choice for each point to be decided under decision. An eventual evaluation of the algorithms must render more scientific the process of a choice between the various possibilities.

II.1.3 - After having excused the absence of Professor BAUER, now unwell, M. GNATZ expounds the following plans of cooperation with the Munich Institute:

One of the major points in the programme of work of this Institute is the portability problem. A possible approach to this question may be achieved with the three following series of work performed at Munich:

. Low level programmation languages (PL 360, BCPL, Bliss and PS 440):
PS 440 is used at present for the writing of an operational system for TR 440.

The Munich Institute should like to cooperate in that field for the following points:

- study of a low-level programmation language unrelated to machine;
- possibility of writing the compiler of the low-level programmation language in its own language, this being a major requirement;
- study of adequate generators for compilers. Munich uses SMG which has been developed from the ideas of Glennic;
- study of the problem of storage allocation: static or dynamic allocation;
- introduction of an organization list in the low-level programmation languages:
  - -- study of the special tools for multiprogrammation and multiprocessing;
  - -- study of the procedure functions and co-routines and study of the principles of their classification;
  - -- insertion of macroprocessing sequences and coding sequences.

. The interfaces for a graphic communication system.
For Munich the problem is to produce a general graphic system which, on the one hand, can allow the use of all the languages available for graphic use and which, on the other hand, can be used for all the graphic peripherics.

There is thus a typical situation (UNCOL) inside a machine. The Munich Institute has a suggestion to solve the problem called "D II". This includes:

- a language to record the geometrical information and the information necessary to express the manner of producing the image (what paper, what nib and so forth are to be employed?);
- this low-level language can besides be used:
  - -- for an abstract translating machine, called interpreter;
  - -- to produce thanks to a series of parameters a special translating machine as well as the abstract machine.

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D II has not yet be solved but several efforts are being made to solve it at the Institute. It is hoped that the solution shall not be too costly on all c... and that is why it is thought that a good research subject shall be that of the efficacy of such a situation as UNCOL.

. Programmation.

The Munich Institute endeavours to find another approach to such situations as UNCOL.

The problem is to find out how to define special classes of machines (or languages), so that a special UNCOL situation could be defined and implemented within these classes ?

The tools to be used include:

- the notion of a virtual machine;
- the conception of several levels of machines;
- the structural processes (Randell);
- the axiomatic approaches (Hoare);
- and so forth .....

II.1.4 - Dr. KONTOSthen expounds the part of the programme which could be worked out by the "Democritos" Centre at Athens and which deals with the problem of "availability" rather than portability.

The techniques for generating programmes from smaller standard components are the major object of the research. The components used for the first stage shall refer to the extraction and management of the data and the treatment of visualization, with an effort to use as many common components as possible. Automatic means of linking and chaining the components shall be looked for to generate the programmes the basis adopted shall be a method for a natural training language described in its basic form in a document ° distributed by Dr. KONTOS to the participants. In the present development the method only employs a concentration of components. More complex forms of chaining shall be looked for as is necessarily the case for larger generators for the development of a practical system.

II.1.5 - Dr. POOLE and Dr. MORTON now expound the programme of possible cooperative work with the Culham Laboratory.

Dr. MORTON recalls the line of action adopted by the Culham Laboratory to establish a plan for software engineering, with the following chief objects:

a) the production of tools to contribute to the establishment of software;
b) on account of the investment in these tools and in the software of the system, the techniques for the writing of portable software.

Dr. POOLE describes the present position of the work and refers to a document distributed during the meeting and joined to the present report.

° "A question answering system using program generation" by J. KONTOS and G. PAPAKONSTANTINOU.

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II.1.6 - M. SIMIAN then mentions the work done by the research-team of the Toulouse University who are very much interested in the work done at the Culham Laboratory, and more especially so by the studies undertaken on the portable translators for algebric languages.

The Toulouse group having developed several language-translation programmes on various machines (in particular, three conversational interpreters of the APL language have been written on a CII 510 machine with 16 terminals, one on a CII 90 [illegible] with 4 terminals and one on a CII 10.070), they are ready to use the results achieved by the British team for the implantation of this language on other machines.

The existence of various tools to develop the portability of certain types of programmes makes it a necessity that there should be available on the most varied informatics materials and, in particular, on the materials from the associate centres.

The Toulouse University are ready to make an effort to implant these programmes, as far as possible, on the material at their disposal.

II.1.7 - As to M. BLAKE, he points out that OTAN have just published the report on the conference held at Rome, in October 1969, on "The Techniques of Software Engineering".

M. LAUDET thanks all the participants for the suggestion they have just made about a programme of work, which introduces Point 3 of the Agenda.

III - ATTEMPT at the COORDINATION of the WORK now being CARRIED OUT by these INSTITUTES.

III.1 M. RENARD stresses the original character of the planned institution, which is not to mean a mere extension of the research work financed in the national institutes, but the study of technical subjects which are co-dimensional with the institution itself and cannot easily be financed by each interested country taken separately. M. RENARD notes that the document on the "suggestions for work" includes a warning against certain lines of action.

Two general lines of work might be adopted as follows:

- attempt at a synthesis of the various types of work carried out, in order to define those which could be industrialized:
- within the range of studies or research which cannot be undertaken in the various countries taken separately, a plan might be set up for the study and implementation of a network of calculators; pooling the calculators of the various research-centres considered. This might be a means of experimenting portability and examining how the realizations of one centre could be employed in the other research-centres.

M. LAUDET suggests the regrouping of the suggestions for work made previously which show possibilities of a cooperation e.g. those of the Culham Laboratory

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and the Laboratories at Pisa, Grenoble and Toulouse.

Taking up one of M. BLAKE's suggestions, M. RENARD considers that the Institutes could, for instance, carry out the following work:

- a first topic might consist in an inventory of all the subjects and all the themes for intermediate languages facilitating the portability of software;

- a second topic might be the constitution of a library of parametrizable components (a library of sections of programmes ?);

- a third topic might be to study how far the centres could be connected: the problem of a network of calculators allowing an "in vivo" experiment of portability.

M. ANDRONICO thinks that, as to the network of calculators there already exists a scheme prepared by E.E.C. and that it is not advisable to have shcemes in duplicate. The inventory seems to be feasible, through an exchange of the working-plans. The problem amounts to a question of standardization and Section 1 and 2 are indeed connected.

Answering a question from M. GNATZ, M. RENARD gives the following precisions:

- the E.E.C. scheme for a network of calculators aim at a study of the operational constraints in the connection between the calculators;

- would it not be a better way of studying portability to try:
  - to experiment the transfer of programmes from one calculator to another;
  - to automatize this transfer when the calculators are interconnected.

The study of the "transparency" of some types of calculators in view of a definite utilization makes it possible to study the question of portability. In answer to Dr. POOLE, M. RENARD notes that if there do no exist national networks of communications, it is because this is too easily for one country. But a programme of research on the networks could be justified in the case of a European plan.

For Messrs POOLE and MORTON, these questions should indeed be examined in the following order: portability, library of programmes and network. But much work is to be done before examining the question of the network. The inventory could be coordinated by the Central institution, which should be responsible for the quality and level of the work as well as for drafting the final report on the subject, the work being naturally decentralized towards the Associate Institutes. As to the library of programmes, the problems of standardization subsist (languages, research on existing libraries).

M. LAUDET, approved by all the participants, thinks that if every delegate present states what his laboratory can do and how it can do it and, if all the participants are agreed on the programme proposed, an organization, endowed with a federating character, for instance, shall be able to start work very quickly,

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knowing that some definite partners are at work on definite studies. This is what makes it so important to make concrete suggestions during the present meeting.

Dr. POOLE states that the Culham Laboratory disposes of a method of software transfer for demonstration on a machine. He is personally ready, for instance, to go and verify this method in another laboratory, at Pisa, for instance.

After due discussion, the participants unanimously agree to try and pool the portability techniques.

III. 2. Concrete suggestions for co-operation by each country represented.

These suggestions differentiate, whenever possible, the immediate, the middle-term and the long-term possibilities.

III. 2.1 - The Pisa Laboratory suggests:

. in the immediate future, on their own premises, the trial of the method of software transfer developed by the Culham Laboratory and the transfer to Culham of the SEL extensible language developed at Pisa;

. within a year, a co-operation with Grenoble for the evaluation by mathematical methods of the efficacy of an algorithm.

III. 2.2. The Culham Laboratory suggests:

. in the immediate future:
- the transfer to other machines of the system implemented at Culham. In particular, the Laboratory is ready to supply the work and machine-time necessary to allow:
  -- Grenoble to establish their ALGOL interpreter on the Culham A/70 system;
  -- Pisa to establish on the Culham 4/70 system their auto-extensible system of programmation language.
- a study with Toulouse of the possibility of producing a portable APL interpreter.

Finally, the Culham Laboratory is interested in the work carried out at Munich (transfer of the priming bootstrap to another machine).

The total effort all this work would require from the Culham Laboratory can be reckoned at 4 men-months and the expenditure at £ 4, 000.

. within the next twelve months:

As the main lines of a possible co-operative work, the Culham Laboratory can offer:

- the development of a STAGE 3 macroprocessor more efficient than a STAGE 2;

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- the development of a software with generic components in a multiprocessor remote access system;

- the development of generic components for libraries and the software of the return of information.

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The meeting is adjourned at 7.30 p.m. and resumed on Wednesday September 16th at 10 p.m.

III.2.3 - On behalf of the Grenoble Laboratory, M. GRIFFITHS suggests the following co-operation work:

. within three months and after that time, transfer to the Culham ICL 4/70 systme of a set of programmes now written in a macro-language on IBM 360;

. within a year and for the years to come, definition, within APL for instance, of the fundamental algorithms of writing in operational systems and evaluation of the said algorithms.

III.2.4 - M. GNATZ states that the plans of the Munich Institute expounded above are all suggestions for an eventual co-operation.

This means the three following topics:

. low-level programmation languages;
. interfaces for a graphic communication system;
. programmation (UNCOL situation).

III.2.5 - Dr. KONTOS suggests the following concrete possibilities of a co-operation with the Democritos Centre at Athens:

. in the near future:
Management and treatment of data trying to use as many common components as possible. Development of the method.

. long-term:
3 possible objects:
- to have several hundreds of components;
- automatic storing and extraction of generated programmes;
- application of the developed techniques to the processing of a flying spot scanner out put.

III.3. After the statement of these concrete proposals for cooperation and by invitation of Professor ANDRONICO and Professor ONESTO, the experts unanimously decide to meet again for three working-days at the Istituto di Elaborazione della Informazione at Pisa, during the week from December 13th to December 20th 1970.

The Agenda for these three days shall include papers, followed by technical

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discussions, on the following subjects:

. 1) The notion of D II;
  2) Low level language.
     Rapporteur: Munich Institute (German Federal Republic)

. The transport of PL 1 conversational interpreter
     Rapporteur: IRIA (France)

. 1) The transfer of ALGOL 60 interpreters;
  2) Algorithms of exploitation systems written in APL (subject to agreement by Professor BOLLIET)
     Rapporteur: Grenoble University (France)

. The transfer of APL compilers
     Rapporteur: Toulouse University (France)

. Conception of abstract and portable machines
     Rapporteur: Culham Laboratory (Great Britain)

. Generators of programmes controlled by natural language.
     Rapporteur: Democritos (Greece)

. Self-extensible language in the problem of portability
     Rapporteur: Pisa (Italy)

III.4. M. LAUDET is satisfied with this pooling of knowledge, which can but be beneficial and helpful to the participants of the next general meeting of October 20th and 21st 1970.

M. POOLE stresses the importance for the future of the Institution of the following questions:

. control of software;
. diffusion of the results obtained.

IV - ATTEMPT at a DEFINITION of the SHARE of the PROGRAMME of WORK to be RESERVED to the "CENTRAL NUCLEUS".

IV.1. In the above outline of national co-operative work, how can, M. LAUDET asks, a central organization facilitate a coordination of these activities?

Dr. ONESTO and Dr. ANDRONICO suggest a reduced central nucleus, a limited committee stressing the federal character of the Institution.

The majority of the participants think the central board could at first be constituted by a committee of 4 or 5 specialists with the assistance of a secretariate, assuming the part played by the expert group now assembled, i.e.

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- define and precisely characterize the exchanges possible between the various laboratories;
- coordinate these exchanges;
- draft out and diffuse a report on the results of their work.

M. BLAKE remits to M. LAUDET a document recalling the five functional levels considered by the central coordination group at the Munich meeting of December 1969: information, administration, research planning, management of research and cooperation, central research plan.

All the participants are agreed to try and define the best way of organizing the work for a first period of three months. The first results of the common work obtained during this stage shall show, as pointed out by M. LAUDET, the necessity for the creation of our organization to federate the national experiments.

For M. MORTON, it is necessary to have a special research programme for the Central Institute which is to include specialists of a very high standard.

M. LAUDET, seconded by the participants, points out that although this question is to be dealt with by the general conference, it is important to help the conference by supplying the opinion of the experts on their estimation of a "feasible technical" institution.

M. MORTON considers that the financial participation of each country should include 80 per cent for the national activity and 20 percent for the Central Institution and for the national research. The Central Institution would attend to the coordination of the various research.

IV.2. With reference to the research programme of the Central Institution, Dr. MORTON thinks that the Director of this Central Institution should be free to choose within the general programme of research the type of research to be carried out. For Dr. POOLE, the Central Institution should deal with subjects which have not been studied by the National Institutes. Dr. MORTON considers:

- that there should be a certain flexibility in the research programme of the Central Institution;
- that, for the national Institutes, it should be more attractive that the research by the Central Institution should be within narrow limits of the national research with a coordination of all types of research by the Central Institution. An example can be given with the evaluation of software.

- that the research by the Central Institution should also include types of research which could not possibly be undertaken by a single country.

The expansion of the Central Institution shall quite naturally develop with the joining of new participating countries, that shall bring in their quota of financial participation.

For Dr. ONESTO the definition and structuration of the Central Institution should be the outcome of a progressive and empirical approach. It is difficult, for

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instance, to define a major plan, from the start.

IV.3. Dr. MORTON then puts the question of the relations between the Institution and the private sector as well as the problem of external contracts. All are agreed that this is a major question and wish that it should taken up by the general conference of October 1970.

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The meeting is adjourned at 12.30 and resumed at 3 p.m., M. GNATZ being absent, as he had been compelled to return to Munich.

V - Dr. MORTON recalls that this discussion between experts was founded on a document "Suggestions for a programme of work" which had been sent to the participants. He considers this document was, on the whole, a sound description of the work to be undertaken; yet, he suggests the following amendments to its wording:

- throughout the document, replace "Institute" by "Central Institute and Associate Institutes".

- Page 1 - Introduction: paragraph 2
  Replace "the research programme of the Institute for Informatics" by "the research programme of the Central Institute and the Associate Institutes for the engineering of software".

  Replace "In particular, it shall study the techniques for conservation" by "In particular it shall study the techniques and tools for conservation".

- Page 2 -
  - Paragraph 5:
    Replace "allowing an increase in the flexibility and possibility of adaptation of non-material elements"
    by "allowing an increase in the fiability, the flexibility and possibility of adaptation of non-material elements".

  - Paragraph 9 (2)
    Replace "The use of programme generators which engender ....."
    by "The use of programme generators and macroprocessors which engender .....".

M. LAUDET stresses the fact that the present meeting of experts has demonstrated the necessity, expressed by specialists, of an international organization dealing with the engineering of software.

Finally, at the request of M. LAUDET, Dr. POOLE reads a technical paper on Culham's plan for the engineering of software, specially describing the STAGE 2 portable macroprocessor, the MITEM portable text-reader and portable translaters for algebric languages.

The meeting is adjourned at 4.30 p.m..

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REPORT ON THE SOFTWARE ENGINEERING PROJECT

at Culham Laboratory, U.K.A.E.A.

September 1st, 1970

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Introduction

The main aim of the Software Engineering Project at Culham Laboratory, U.K.A.E.A. is the development of techniques for producing portable software. The project, which was started in 1969, was financed initially by the Ministry of Technology for a period of 2 years. It has already resulted in the production of a number of items of portable software and a brief description of each of these is given in this note.

The technique for achieving portability is based on the use of a powerful macro-processor to realise abstract machines on real ones. The macro-processor originally developed by Professor W.M. Waite of the University of Colorado is itself highly portable. To produce a unit of portable software, one first chooses a suitable abstract machine and then codes the problem in the language thus defined. The abstract machine may be one of those already developed during the course of the project or a completely new one designed specifically for the task in hand. The "compilation" of the program is then carried out by the macro-processor which accepts, as input, the program in the abstract language and a set of rules which define the relationship between the abstract machine and the target machine. To move the program to another machine one has merely to change these rules. Typically, for the machines designed so far, the amount of effort required to write a set of rules for a new machine is of the order of a few man-days.

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1. The Portable Macro-Processor - STAGE2

STAGE2 is a general purpose, language independent macro-processor which provides such facilities as parameter conversion, conditional expansion, iteration, etc. In addition to being the basic tool for achieving portability, it can also usefully be used as a pre-processor for user jobs written in any language. Since it makes use of a distributed macro-name, it allows the user to tailor macro-statements to his own requirements and avoids the rigidity so often associated with macro-processors.

The portability of STAGE2 has been demonstrated by transferring it to twenty different computers. The time required to effect a new implementation starting from the basic bootstrap is about one man-week. Estimates of the time required to program STAGE2 afresh on a new machine vary from six to twelve man-months. Thus, the return for the effort required to move the program is very high.

It is very difficult to compare the efficiency of the macro-processor with one which has been coded by hand since no such program is available. However, an examination of sections of the generated code suggest that a skilled programmer could perhaps improve the efficiency of the program by a factor of about 1.5.

STAGE2 was written for an abstract machine called FLUB (First Language Under Bootstrap). This is a very elementary machine, the design of which was constrained by its position in the bootstrap sequence. Such restrictions no longer apply to subsequent machines and the inclusion of many of the facilities of high level languages is possible.

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2. A Portable Text Editor - MITEM

First unit of portable software produced was a text editor called MITEM. This program is currently running on four machines and again only a few man weeks of effort are required to establish it on a new computer. It is designed to operate in both batch and interactive modes.

The MITEM project has also been used to study the techniques for the production of flexible software, i.e. software which can be tailored to meet the requirements of a wide variety users. There are in fact six versions of MITEM, each of which is generated from the one body of text. These range from MITEM1 , a very simple text editor, to MITEM6 which contains some of the pattern matching facilities of SNOBOL4. The more powerful the facilities, the larger the program and a system manager can therefore choose the version to be made available in the system on the basis of the amount of core he is prepared to allocate to it. The appropriate version may be generated merely by declaring a version number at the start of the text. As the facilities in each version are an exact subset of the higher numbered version, an installation can make more powerful versions available as the core increases without disturbing the user image.

The development of MITEM has also enabled a check to be made on the efficiency of code generated by this technique. On the KDF9, MITEM3 occupies 1600 words. The COTAN amender which has comparable facilities and which was hand coded in assembly language by an experienced programmer requires 1500 words.

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3. Portable Interpreters for Algebraic Languages

The third project being carried out at Culham is one to develop a range of portable interpreters for such algebraic languages as ALGOL, BASIC, etc. Each interpreter is composed of two parts. The first is the program which translates the high level language into a common intermediate code. The second program then interprets this code to execute the program. The former varies with the language while the latter is common for all languages. Since both programs are portable, then the whole interpreter can readily be moved from machine to machine.

In order to reduce the cost of producing the various translators, the syntax analysers for the various languages are generated by SID (Syntax Improving Device), a program developed by the Royal Radar Establishment. This has been modified to produce syntax analysers in a language which can be processed via STAGE2. The action steps which can effectively carry out the compilation are also written in this language.

As part of this project a systems programming language called ACTION has been developed. It is being used to produce a new supervisor for a MODULAR 1 computer. Since ACTION is processed via STAGE2, it will be possible to move much of this software to other machines.

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