

Using the ILLIAC IV from the UK via ARPANET - a recent experience

July 1974 - November 1976

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April 1977

## S U M M A R Y

An account is given of the use of a network to develop research programs in fluid dynamics. The use of the Illiac IV at Ames Research Centre provided the main reason for carrying out work via the ARPANET; this large array processor offered the opportunity to gain experience of one of the most powerful computers currently available.

A number of secondary features emerged during the course of this experiment including the use of a "local" computer to simulate Illiac IV, and the effect of the time difference between UK and San Francisco.

Some important deficiencies in current practice were identified, and it is shown that the characteristics of users of a network need to be carefully assessed by host computer organisations.

## 1. OBJECTIVES

Following discussions between the Atlas Computer Laboratory (now absorbed into the Rutherford Laboratory) and Professor F Walkden of Salford University, in 1974, it was agreed that experience of using the ARPA Network for developing and running computer programs on the Illiac IV at Ames Research Centre would be useful. The choice of the Illiac IV, as host, was dictated by two considerations:

- (a) the need to gain experience of an array processor for the large computations of fluid dynamics with which Professor F Walkden was concerned;
- (b) the personal contacts which had been established with the Computational Fluid Dynamics department at Ames Research Centre where fluid flow problems dominated the use of the Illiac IV.

It was expected that the experience of using a network combined with the advantage of using powerful computing facilities could give some indications of the factors to be considered in the use of networks in the future. The features of this particular exercise do reflect the likely reasons for wanting to access a network, ie to use facilities of a special kind without the possibility of extensive contact with the host computer and its services, except via the network itself.

The distance of the host computer, located near San Francisco, from the UK meant that the time delay of 8 - 9 hours brought this work to Illiac IV during the night shift. Thus the use from the UK would occur at a time of low demand from local users and would not be competing for generally scarce prime time resources. The possible future advantages of this type of connection have, however, to be weighed against the fact that support staff are absent at these times.

The experiment started with no experience either of using the ARPANET, or, of using the ILLIAC IV, but the group at Salford had developed programs via a remote terminal link to the Rutherford Laboratory IBM 360/195. The learning process was carried through almost entirely by indirect contact with the host and valuable experience of information gathering under these conditions was obtained. Questions

of importance were raised for users as well as for the system designers of the future host computers and communications networks. A special feature of the experiment was the use of the SRC Rutherford Laboratory's 360/195 computer, as a test bed for the programs developed for Illiac IV. A FORTRAN based compiler CFD was mounted on the 360/195 which could either produce an object code for Illiac IV or prepare programs that could be run in serial fashion on the 360/195 to simulate the 64 simultaneous parallel processing elements of the Illiac system.

## 2. THE APPROVAL PROCESS

Before work could start, various levels of approval had to be obtained:

- (a) approval to use the network
- (b) approval to use the host computer Illiac IV

Access to the ARPANET is organised through the unit directed by Professor Kirstein at University College, London. The unit is responsible for all UK access to the ARPANET. Approval was requested and, when this was granted in July 1974, members of Professor Walkden's staff were introduced to the ARPANET command language and protocols. This part of the approval process was relatively straightforward and the introduction course was much appreciated and proved of great value.

In the meantime, approval to use the Illiac IV was being sought, but this ran into difficulties because of the dual management of the Illiac IV in which both ARPA and NASA were involved. Bringing our request to a successful conclusion took time. Eventually a mutually agreeable arrangement was set up in which the Computational Fluid Dynamics Group at Ames Research Centre was able to access Professor Walkden's suite of programs on the Rutherford Laboratory's 360/195, so that comparative studies could be carried out on common problems. No question of charging arose with this arrangement, although it is clear that in making the arrangement ARPA required to see some benefit to the USA. Because this was research work, free use of the ARPANET from the UK under the present scheme was allowed. We are grateful to all the participating organisations, to ARPA, to NASA and to the staff at the Ames Research Centre for allowing this experiment to be set up, and for the early opportunity to find out just what working on a network involves for the larger user of resources.

### 3. EARLY USE OF THE NETWORK

The use of the network described in this section covers the period between July 1974 and September 1975.

A two-day course held at University College, London in July 1974 provided an introduction to the ARPA Network. The course proved to be of great benefit and sufficient documentation was provided to enable early use of the network to commence from Salford.

The first three months were used to gain experience of the network and accounted for 13 hours terminal connect time. In the absence of the necessary permission to use the Illiac IV computer, a familiarisation programme was undertaken using two other host computing systems: USC-ISI (University of Southern California, Information Sciences Institute) and PARC-MAXC (Xerox Corporation, Palo Alto Research Centre, California). The user accounts at both these sites are free of charge, but are restricted. Access to the USC-ISI account, which is available to all UK network users, is only allowed before 1300 hours GMT each day. The PARC-MAXC account is available to all network users but the host system restricts the user to particular classes of work such as listing documentation files and running programs with a short time limit. Despite the restrictions, some use was made of each of these accounts.

Many host computing systems on the network use the same operating system (TENEX) so that most of the experience with the network facilities used at this time was beneficial to the future use of ILLIAC IV. The facilities supported by TENEX and used during this period included sending and examining network mail, transferring files, text editing and running small FORTRAN programs.

Extensive use was made of the network mail facility, which provides the only practical method of communication between users at the various host sites. Messages are in the form of files which are distributed to user-accounts at the host sites. Use was also made of the network file transfer facility and after early difficulties some files were transferred between the IBM 360/195 and USC-ISI. Files were created and modified using text editors which enabled small programs to be run using the FORTRAN subsystem. No remote job entry facilities were available, however, so that users had to remain on-line throughout the duration of job processing. This restriction together with the lack of a suitable account meant that no realistic computational work was carried out at this time.

During this initial use of the network the method of access to the London TIP, the UK node of the network, was via a GPO dial-up line operating at a speed of 300/300 baud. This method was found to be satisfactory and few problems regarding the reliability of the network were encountered.

The use of the network during the remainder of the period to September 1975 was confined to periodic checks of system changes and examination of network mail. During this time documentation for the Illiac IV computing system was obtained and this enabled some insight into this particular system to be obtained prior to permission being granted to use the computer and before the CFD translators referred to in Section 1 were available for use on the IBM 360/195.

#### 4. CFD TRANSLATORS

The CFD language is a high-level vector orientated language based on conventional FORTRAN, for use on the Illiac IV computer. The availability of vector variables, each of which has 64 elements, is a feature of the CFD language which is not available in conventional FORTRAN. A full description of CFD is given in Reference (1).

A CFD compiler is not mounted on the Illiac IV computing system so that

it is not possible to run programs written in CFD directly on the Illiac IV. Instead, two translators are used in conjunction with a serial computer:

- (i) to produce FORTRAN serial code, from CFD programs, for testing and de-bugging on a serial computer such as the IBM 360/195
- (ii) to produce ASK (Illiac IV assembler language) code for input to the Illiac IV computer.

In August 1975 the CFD translators were installed on the IBM 360/195 at the Rutherford Laboratory. However, before the translators could be used in a realistic manner, additional routines were required to simulate the input and output of data in CFD programs.

The originators of the translators (NASA-AMES) absolved themselves of any responsibility for the maintenance of the translators. The lack of any documentation and information from NASA-AMES has made the task of locating and correcting errors in the translators difficult. The implementation of the translators on the IBM 360/195, the writing and development of the input/output routines and the continued support of the translators as compilers have been undertaken by staff at the Rutherford Laboratory, in particular by Mr D Parker.

Despite these difficulties it has been possible to make full use of the vector capability of the CFD language (with the exception of some non-FORTRAN features, which have not proved restrictive), including the method of input and output of data, and to test programs on the IBM 360/195 without any reference to the Illiac IV or to the ARPA Network.

When CFD programs have been de-bugged and fully tested in serial mode, ASK versions of the programs are obtained. The ASK program is made available in the form of an ELECTRIC file and this file is then accessed, via the ARPA network, from the Illiac IV computing system. Both uses of the translators require the submission of HASP jobs to the IBM 360/195.

## 5. USE OF ILLIAC IV

The use of Illiac IV described in sections 5.1 - 5.4 covers the period between October 1975 and November 1976.

### 5.1 Illiac IV System

The Illiac IV computer is located at the Institute of Advanced Computation (IAC), NASA-AMES Research Centre, Moffett Field, California, USA. The main components of the IAC system, which are shown in Figure 1, are (i) the Illiac IV processor, (ii) the central file system, (iii) file storage devices, and (iv) the B6700 computer.

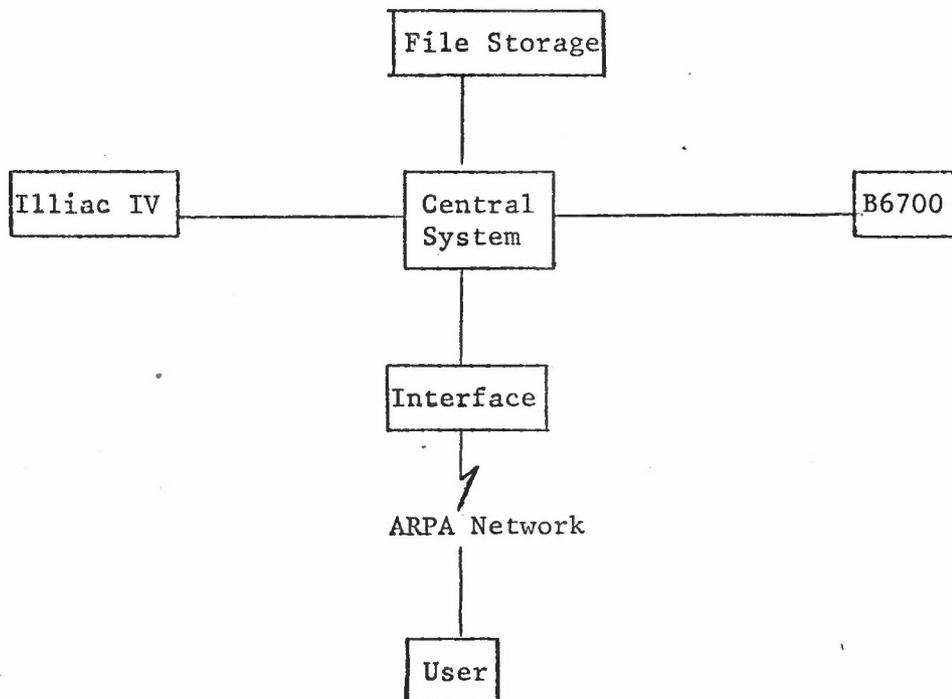


Figure 1 - Main Components of the IAC System

The functions performed by these resources may be briefly summarised by the following (a full description is given in Reference (2)):

- (i) The Illiac IV processor is the major data processing resource in the system and is dedicated to the execution of user programs.

- (ii) The central system provides the user-system control language interface and attends to overall system scheduling, resource management, central file system management and performs operating system functions for the Illiac IV. The central system consists of processors, memory and devices which interface with Illiac IV. The main processor in the central system is a PDP10 computer running under the TENEX operating system.
- (iii) The file storage is provided by a hierarchy of storage devices ranging from central memory to a mass storage laser memory device.
- (iv) The Burroughs B6700 computer provides the user with ILLiac IV utility services including the ASK assembler.

The TENEX operating system at IAC differs in several instances to the ones previously used at other host computing sites. Most of the differences between the facilities, such as text editing and message sending, are of a minor nature and have presented no difficulties. The method of submitting programs to be run on Illiac IV is, however, quite different.

## 5.2 Job Submission Procedure

Fifteen stages in running a computing job on Illiac IV may be distinguished; four of these stages have been described above and refer to work preparatory to the use of ARPANET and the Illiac IV. Two computing systems in two centres have to be used together with the ARPA Network and because of the special features of the IAC system up to fifteen different files may be created.

The files created, both by the system and the user, are designated by an asterisk\* followed by the file number. The POF in step 12 is the last of fifteen files which may be created in the course of running one complete job on the Illiac IV computer.

The fifteen job stages are:

1. Write program in CFD language.
2. Use CFD translator to produce FORTRAN code for a serial computer (IBM 360/195).

3. Use serial computer to test and de-bug CFD program.
4. Use CFD translator to produce ASK source code<sup>\*1</sup>.
5. Transfer ASK source code file to Illiac IV.
6. Create a primary input file (PIF)<sup>\*2</sup> specifying a B6700 computer job.
7. Submit PIF from stage 6 to B6700 computer for execution to produce:
  - (i) an REL file<sup>\*3</sup> re-locatable binary file
  - (ii) an ERR file<sup>\*4</sup> error file
  - (iii) an LST file<sup>\*5</sup> (optional) assembler listing file
  - (iv) an POF file<sup>\*6</sup> monitor file

all from the ASK code file.
8. Use LINKED sub-system interactively to convert the REL file to an absolute address Illiac IV save file (ISV)<sup>\*8</sup> - this requires creation of a LINK file<sup>\*7</sup>.
9. Create a FORMAT<sup>\*9</sup> file to specify 'named' disc areas in the program, eg areas for input and output of data and results respectively.
10. Use the MAP sub-system interactively to produce MAP file<sup>\*10</sup> containing Illiac IV disc memory (I4DM) allocation tables. The MAP file is created from the FORMAT file established in stage 9.
11. Create a PIF<sup>\*11</sup> to determine an Illiac IV job. This file contains the following information:
  - (i) ALLOC - a statement allocating named physical space on the disc on the basis of information contained in the MAP file (see 10).
  - (ii) MOVE - a statement which moves the data file<sup>\*12</sup> (if required) onto the part of the I4DM specified in the disc area statement for input.
  - (iii) RUN - a statement which moves the ISV file to I4. core and initiates execution of the job on I4. A dump (DMP) file<sup>\*13</sup> may be specified.

- (iv) MOVE - a statement which moves results from the part of the I4 DM specified for storage of output into a results file<sup>\*14</sup> which the user can access via the central system.
- (v) DALLOC - a statement which deallocates (ie releases) named disc space.
- (vi) LOGOUT

12. Submit PIF of step 11 to Illiac IV computer for execution of the job described by the file. Specify a POF<sup>\*15</sup> (primary output file) corresponding to the PIF.
13. Examine output in the RESULTS and DUMP files. This is done using the sub-system I4MAT for DUMP files and the DATA sub-system for RESULTS files.
14. Transfer files to the IBM 360/195 computer at the Rutherford Laboratory.
15. Obtain printer listings of relevant files.

Some of the sub-systems may be used both interactively and in batch mode and consequently some variations in the job submission procedure are possible. For example, by using LINKED (step 8) in batch mode the two PIF's referred to in steps 7 and 11 may be combined and submitted as one job which is performed in turn on the B6700 and Illiac IV.

The job submission procedure described here is quite complicated by any standards, however, the documentation in reference (2) was found to be extremely useful in the early stages.

### 5.3 Summary of Experience

Stages 1 to 4 of the job submission procedure, which are performed on the IBM 360/195 computer, independently of the Network, have been discussed in Section 4. In Sections 5.3.1 - 5.3.6 some points relating to the use of stages 5 to 15 are presented.

### 5.3.1 Transferring files to IAC

Until February 1976 it was not possible for users to initiate file transfers. Instead the transferring of files was carried out by staff at IAC acting on user requests. These requests, which included information such as file name and IBM 360/195 account details, were sent via the network mail facility which meant that several days elapsed between the initial request and the completion of the file transfer. The introduction of the file transfer facility at I A C in February 1976 has enabled transfers to be initiated by the user and performed in a much shorter overall time but some difficulties have been experienced.

The difficulties, which have arisen, are due to the way in which the file transfer facility is implemented on the 360/195. A user request performed at IAC to transfer a file between the 360/195 and IAC must pass via the network to a PDP9 computer at the London TIP. The PDP9 computer, which controls all activities between the 360/195 and the network, submits two batch jobs to the 360/195 in order to initiate the transfer of a file to IAC (one batch job to transfer a file from IAC). Despite the high priority of these 360/195 jobs (P13) delay in their initiation occurs, particularly at times when the 360/195 is heavily loaded or in the event of a system failure. The transmission of a file only takes place when the two batch jobs have been successfully completed.

Once the transfer of a file has been requested from IAC it is not possible to detect whether or not a transfer has been successfully initiated or to assess the progress of the transfer, information is only provided when the file has been successfully transferred. This means that the terminal is unnecessarily tied up for long periods of time waiting for the completion of a transfer which may not be taking place. On several occasions the transfers have been abandoned to reveal either that the transfer has not been initiated or that additional waiting time would have resulted in the whole file being transferred instead of part of it. In order to overcome these problems it has been found beneficial to transfer files when the 360/195 has been lightly loaded and to split larger files into units of 10,000 bytes.

### 5.3.2 File space allocation at IAC

An allocation of 100 TENEX pages is provided at IAC for use by UK network users. When a batch job is processed by either the B6700 or Illiac IV computers sufficient space has to exist in the users' account to accommodate the files created by the various sub-systems described in stages 6 to 13 of Section 5.2. If the space is not available at a time when a new file is required then the processing of the job is halted until sufficient space is made available by the user. The effect of the present allocation has been (i) to increase the time taken to carry out the testing of simple programs at IAC since it has not been possible to submit a job until the previous one had been completed and (ii) to prevent jobs which produce a realistic amount of output data from being successfully completed.

The IAC user account is the responsibility of staff at University College, London. An application was made in March 1976 for an increase in the allocation and this was subsequently forwarded to IAC. The outcome of the exercise was that the allocation remained at 100 pages since no additional file space was available at this time. The present position is, however, more hopeful. A complete re-evaluation of file space allocations is now underway at IAC and an estimate of our future requirements together with a planned statement of future use of Illiac IV has recently been forwarded to IAC.

### 5.3.3 Job turnaround

An obvious advantage in accessing a computing system outside the UK is the difference in local times. In the case of IAC, the 8 hour time difference between GMT and PST allows access to under utilized facilities during the normal working day. The running of jobs on the B6700 computer has benefited from this since little queuing time has been experienced. The Illiac IV jobs, however, have never started before 1600 hrs GMT and generally not before 2000 hrs. The result of this is that while several B6700 jobs have been run in a day, the effective turnaround of a complete job has been at best one per day.

#### 5.3.4 User support

In the course of running jobs at IAC certain technical difficulties have been encountered. These problems are forwarded to user support staff at IAC through the network mail facility which necessarily incurs some delay before replies are received. The delay has been kept to a minimum, usually 1-2 days, when answers to questions of a general nature have been required. Longer delays, however, have been experienced before questions of a more fundamental nature have been answered, particularly during the early use of IAC.

#### 5.3.5 Output retrieval

Two basic methods of output retrieval are available, one is directly from IAC and the other, via the file transfer facility, from the IBM360/195. The choice of method used depends on the type and size of file under consideration.

When programs are run at IAC two types of files are produced which are of particular importance, output data files and assembler listings which enable program execution errors to be detected. The data files generated at IAC have been sufficiently small to be both listed and transferred without difficulty.

The assembler listing files consist of lines containing approximately 130 characters and are not well suited for listing on a terminal. It has not been possible to transfer these files from IAC to the IBM 360/195 because the current implementation of the file transfer facility does not allow files containing lines with more than 80 characters to be transferred. This has caused some inconvenience when locating execution errors in programs run at IAC.

The transferring of files from IAC to the IBM 360/195 has recently become a more desirable feature of our work. A PDP 11/40 computer at Salford enables line printer listings of files on the 360/195 to be obtained locally rather than at Rutherford. This means that copies of files produced at IAC can be obtained in a much shorter overall time. In the near future it is intended to access the IBM 360/195 computer via the Daresbury node and SRC network. This link, which will operate at a

much higher speed than the present one of 75/1200 baud, will enable results produced at IAC to be both processed and examined locally using the PDP 11/40 computer.

#### 5.3.6 Experience at a terminal

Both computing systems, which are used to run programs on the Illiac IV computer, have been accessed from a Tektronix 4010 terminal. The IBM 360/195, when used independently of the network, has been accessed via a GPO S3-leased line and IAC, via the London TIP, using a dial-up line, both lines have operated at a speed of 75/1200 baud.

The IBM 360/195 has of course been much easier to access than IAC and the response time, in general, has been faster. No problems have been experienced accessing the London TIP but there have been occasional difficulties in establishing subsequent connections to IAC which have been due to:

- (i) line trouble between London and the rest of the network
- (ii) the connections being broken by the IAC system
- (iii) IAC being disconnected from the network.

The response time when using IAC has been generally good but deteriorates when local users access the system after 1600 hrs GMT. Some breaks in connections have occurred but these are often automatically restored to allow work to resume with a minimal loss of information.

The secondary role of the IBM 360/195 has alleviated the need for cards or magnetic tapes to transfer programs from one computing site to another. The problems experienced when using the network file transfer facility, referred to in Section 5.3.1, have, however, meant long periods of time spent at a terminal waiting for files to be transferred.

Once jobs have been submitted to the B6700 and Illiac IV batch queues it is possible to determine their status. The files produced when the job is being processed are immediately accessible from the user account and no difficulties have been experienced in obtaining listings of most of these from the terminal.

#### 5.4 Statistics of Use

An average weekly connect time of 210 minutes has been used to access the Illiac IV computing system over a period of 14 months. During this time 83 jobs have been submitted at IAC and 71 files have been transferred. In Table 1 a breakdown of these figures is given.

Table 1 - Statistics of Use

Period	Connect Time (mins)	Number of Jobs	No. of files Transferred
October 75 - December 75	2215	8	2
January 76 - March 76	4555	23	23
April 76 - June 76	2825	20	15
July 76 - September 76	1415	8	12
October 76 - November 76 (2 months)	1830	24	19

Table 2 illustrates the type of terminal activity currently being undertaken in order to run jobs on the Illiac IV computer.

Table 2 - User Activity 18-30 November 1976

DATE	18.11			19.11	24.11	25.11	26.11				29.11	30.11
	1	2	3	4	5	6	7	8	9	10	11	12
<u>IBM 360/195</u>												
CFD to ASK JOB	X							X				
File listing	X							X				
<u>IAC</u>												
Send mail						X						
Examine mail				X	X							
File transfer		X						X				
File Editing		X						X	X	X	X	
File listing:-												
ERR file			X							XX		
POF file				X						XXX		X
RESULTS file				X								X
SUBMIT B6700 JOB		X							X	XX		
LINKED		X								X		
MAP											X	
SUBMIT I4 JOB		X									X	
Time per session (minutes)	12	70	4	44	1	5	10	26	11	23	10	12

The activity described in Table 2 (denoted by crosses X) took place between 18-30 November 1976 and consisted of 12 terminal sessions. Two programs were run on the Illiac IV computer during this period and in both cases CFD programs had been de-bugged and tested at an earlier stage using the CFD translators, in serial mode, on the IBM 360/195 computer.

The ASK version of the first program took approximately 13 minutes to transfer (session 2) and a combined B6700 and Illiac IV job was submitted during the same session. The output from these jobs was examined in sessions 3 and 4.

The transfer of the second ASK file (session 8) took some 10 minutes. Errors in some of the files meant that three B6700 jobs (sessions 9, 10) were required before the program was finally submitted to Illiac IV (session 11). In session 12 the output from this job was listed.

## 6. EARLY RESULTS

In order to assess the performance of Illiac IV some small scale tests of simple computational procedures have been carried out. Two problems have been considered:

- (i) the product of two 64 x 64 matrices
- (ii) a relaxation scheme for Laplace's equation.

The matrix problem had been previously carried out by Professor Hockney's group at Reading University. Three calculations were considered using different programming techniques and the computing times obtained in each case were similar to those previously obtained by Reading. The Laplace problem was selected for study because it is the simplest problem which exhibits all the features of more complicated problems of interest in fluid dynamics.

Both problems were also run on the IBM 360/195 and the results obtained showed that the Illiac IV was four times faster than the IBM 360/195 for the calculations considered. A full description of the work carried out at this time is given in reference (3).

The consideration of these problems has, in addition to providing performance measurements, also suggested programming strategies for more complicated problems associated with supersonic flow calculations.

## 7. CURRENT WORK

A three-dimensional supersonic flow calculation program is currently

being tested using the CFD translators on the IBM 360/195. The program is similar to a FORTRAN program currently being used on the IBM 360/195 but the CFD version is restricted to a particular size of mesh. The times taken by the two programs will be compared so that the performance of Illiac IV may be assessed for this type of problem.

The CFD program is much more complicated than anything hitherto considered and uses several features of the CFD language which are not clearly presented in the CFD Reference Manual (1). These features are currently being investigated on the Illiac IV computer using small test programs.

## 8. CONCLUDING REMARKS

A period of two and a half years has elapsed since the ARPA network was first accessed. During this time the Illiac IV computer has been used to carry out small scale testing of simple programs with a view to predicting run times for the calculation of solutions of partial differential equations characteristic of fluid flow field problems.

Early use of the network revealed that the facilities which were generally available to users, were not suitable for realistic computational work for two reasons:

(i) the restrictive nature of the user-accounts available

(ii) the limitations of the method of running programs.

The method of running programs on Illiac IV has depended on the use of CFD translators on the IBM 360/195 computer at the Rutherford Laboratory. Difficulties, which were encountered during early use of the translators, were due mainly to lack of support and information from the originators of the translators. The use of the Illiac IV has depended critically on the easy access to, and, faster response of, the IBM 360/195 when used independently of the network to test and de-bug CFD programs and subsequently to convert them to forms suitable for running on Illiac IV.

The transferring of prepared programs from the 360/195 to IAC, which has been carried out using the network file transfer facility, has been

one feature of the work which has been less than satisfactory. It has not been possible to transfer programs easily as a matter of routine. The lack of information supplied to the user regarding the initiation and progress of a transfer has resulted in large amounts of time being spent waiting for the completion of transfers which have not been successfully initiated.

Several factors have contributed to the length of time taken to run programs at IAC once they have been transferred. These may be summarised as follows:

- (i) the method of submitting jobs to be run on Illiac IV is a complicated one, being difficult to learn, and far from easy to use in practice
- (ii) an inadequate amount of file space has prevented a job from being submitted before a previous one has been completed
- (iii) it has only been possible to obtain at best a one per day job turnround using Illiac IV
- (iv) delays in receiving answers to questions of a fundamental nature from the user-support service particularly during the early stages of use.

A 3-D supersonic flow program is currently being tested on the 360/195 using the CFD translators. The size of the ASK version of this program is much larger than anything hitherto considered and is not atypical of the size of files required for the type of problem considered suitable for Illiac IV.

The transferring of this program to IAC will be a time consuming process since, time will have to be spent splitting the program into small units, in addition to time spent carrying out the transfer. The need for an alternative method of transferring files from the 360/195 is obvious, particularly one which alleviates user-terminal participation when the transfer is in progress. One such method could be to transfer the file as a batch job which would allow the terminal to be used for other purposes.

The size of the ASK version of the 3-D program is approximately double the size of the file space allocation which has been in operation at IAC throughout the period of use. Additional file space therefore has been requested from IAC. This request has coincided with a re-evaluation of file space allocations currently being carried out at IAC so that the problems previously encountered in this area may not arise. The need for adequate file space on a computer such as Illiac IV which has been specifically designed for large computational problems is obvious, particularly as the method of running jobs creates several additional files, all of which have to be accommodated in the users' account. In general the use of special facilities such as Illiac IV will come from the relatively small group of users who have large problems to handle.

Output data files produced from programs so far run at IAC have been small enough to be both listed and transferred without difficulty. There is no essential difference between transferring a file from IAC to the 360/195 and carrying out the reverse process. Consequently the problems, which have been encountered with program files, will also arise when large amounts of output data are required to be transferred from IAC to the 360/195. It will not be possible therefore to transfer large amounts of output data from IAC with the present network file transfer facilities and alternative strategies such as transferring selective parts of the data will have to be employed. Since it is uncertain which parts of the data will be required the need to store results at IAC for longer periods of time will be required, this of course will require additional file space in the user account at IAC. In any case the movement of large output files may be pre-cluded because communication changes make this movement of data uneconomic.

The advantages offered by the differences in local times between the UK and California have been offset by:

- (i) the limited processing of the Illiac IV batch queue
- (ii) the method employed to communicate with the user-support service at IAC.

A 24-hour batch service is desirable if full advantage is to be made of access to under-utilized facilities during the normal working day. It is acknowledged that during early use of Illiac IV there was a shortage

of user-support staff at IAC which accounted for long delays in answering questions arising out of the use of Illiac IV. If the network message sending system is to be an effective method of providing user-support facilities then provision has to be made for user support to be adequately staffed by people who have a detailed knowledge of the system.

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