occam™ user group · newsletter

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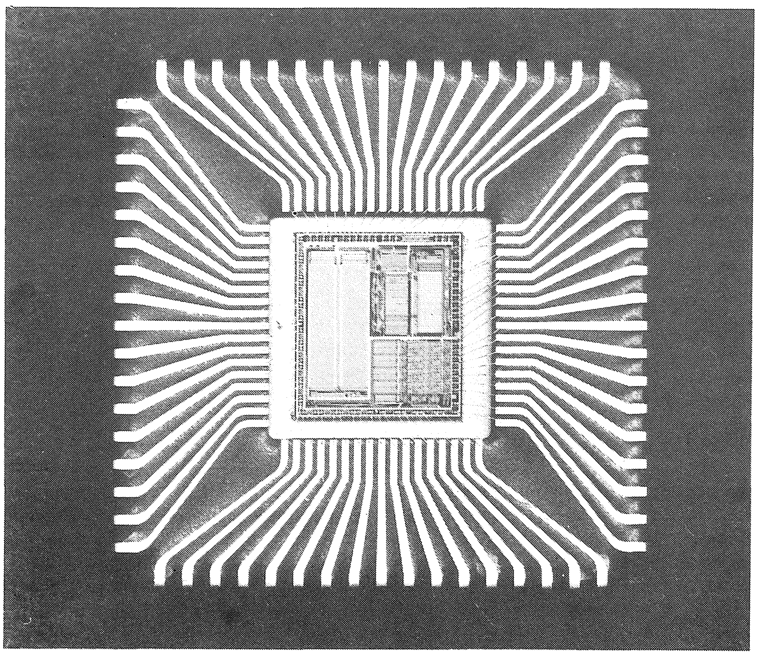
CONTENTS



Photograph of a 16-bit Transputer chip

EDITORS' NOTE

We hope this edition of the Newsletter will provide you with another hour's enjoyable reading! However, this is becoming increasingly difficult to achieve. We need contributions! They do not need to be long, they can cover any topic related to occam and/or the transputer, and it is possible that they could draw on material which you have already written for some other purpose. Please send contributions to the editor at the address on the back cover, preferably in machine readable form. We can accept any widely used format. (All discs will be returned).

Also welcome would be suggestions about sections we may include in future Newsletters. We have introduced one which we hope will receive regular updates - "New products which use transputers".

Again, thanks are due to Michael Poole of INMOS for coordinating his company's contributions to this newsletter.

Martin Bolton, Mike Barton   Editors

"LAUNCHED OCTOBER 1ST 1985"

"The beginning of a new era" by Chris Followell - Transputer Launch Manager

For INMOS, October 1st had a special significance. It represented the culmination of the years of work put in by the whole company: taking Iann Barron's original concept of a revolutionary microprocessor, designing it, manufacturing it and taking it to the market. It was also the culmination of a smaller project - the Launch program. October 1st was the day that INMOS launched the transputer onto the World Market.

On the 24th September, 3 large crates arrived at the office in Bristol and the first set of nearly complete demonstration equipment was loaded up and despatched to London, on its way to New York.

Three days later we heard that it had arrived. Almost simultaneously we heard via T.V. that Hurricane Gloria had also arrived in New York. We were facing not only gremlins but Nature as well.

The last day of September found our dedicated team standing in the cold at 9.00 am outside the Institute for Contemporary Arts in the Mall in central London. The second set of equipment arrived on time through the London traffic, all we needed now was the key - this duly arrived some 15 minutes later and the task of setting up began.

By mid afternoon the high resolution monitors were in place, the projection T.V. was aligned and the most powerful supercomputer to be built in Europe was lifted onto the stage by just two people.

And so October 1st dawned and the senior directors of INMOS stood up in front of over 150 European press representatives. They discussed the transputer concept and the occam language and then Peter Cavill, Director of Microcomputer Products, demonstrated 1,2,10 and 100 transputers executing various occam Programs.

By 3.30 pm the equipment and the presenters were hurrying to Heathrow. The demo kit was in transit to Japan but the presenters had to be in New York for a repeat performance the next morning.

Hurricane Gloria had now gone - and so had our custom designed crates. A few phone calls soon restored the crates however, and New York was back to normal with no adverse effects from the wind.

During the London presentation I was on the 23rd floor of Capitol Records in New York, busy converting the equipment to 110 volts. At 7.00 am on October 2nd we were busy moving it down the 23 floors and over to the Tavern-on-the-Green on Central Park. And it was here at 10.30 am that the Launch was repeated for the U.S. East Coast Press.

Both sets of equipment had performed flawlessly and so, despite the jet lag, had our team of presenters.

In the afternoon it was up up and away as we and the equipment left JFK en route for San Francisco.

On October 3rd we took a rest during the day until the equipment arrived in the evening when it was duly set up and found to be working. By now we were feeling confident having survived one hurricane, 5000 miles, jet lag and a considerable quantity of Long Island Iced Teas, which is probably why the TTL line drivers decided to blow during the presentation to the West Coast press on October 4th. However, a brief coffee break enabled us to resume the demonstrations with no omissions.

The first demonstration was designed to show the connection between occam and the transputer. On a single graphics screen a butterfly appeared. This was controlled by a single occam process running on a single transputer processor. A second butterfly (process) was then added running on the same processor demonstrating on chip concurrency. The transputer has links for process synchronisation, and a third butterfly (process) then appeared flying on a second graphics screen. It was running on a second transputer and it was flying in exact synchronism with the second process (butterfly) on the 1st transputer, a pair of occam channels (links) being used to maintain the synchronism. Of course, the links between transputers can also communicate data as well. A butterfly flying on a graphics screen is of course only data and the final part of this demonstration had a 4th butterfly appear on one graphics screen and then "fly" down a link and onto the second screen (transputer). This made the point so clearly that it elicited a round of applause from the audience on more than one occasion.

Naturally larger arrays of transputers can be used and the next demonstration that we used showed the difference in performance between one transputer and eight transputers connected in a pipeline. We chose the computationally intensive Ray Tracing algorithm, drawing an image of a number of spherical objects illuminated by three different coloured light sources. For each pixel on the graphics screen a light ray was traced through an imaginary pin hole and reflected off the spheres. At the intersection of each of the half million rays a number of floating point calculations were performed to generate realistic images that appeared on the screen. Two screens were used, one being driven by one transputer and the second by eight. It was clear from watching the screen that the eight were drawing 8 times faster than the single transputer.

Using sequential single precision floating point benchmarks one transputer can work roughly 15 times faster than the MC 68020. Thus our eight transputers could draw a number of balls about 120 times faster than the Motorola device. As the three balls took nearly 5 minutes to complete, then our competitors would be tied up for 10 hours on the same job.

Meanwhile, nature had not been silent. The London equipment had now arrived in Japan, and so had an earthquake - only 2 on the Richter scale - just enough to set the Hotel oscillating for 30 minutes and worry our P.R. lady.

We left San Francisco on Saturday morning to arrive, courtesy of JAL and the International Date Line, on a wet Sunday afternoon in Tokyo.

And so it was, on October 7th, that INMOS became the first major Western semiconductor company to launch a new microprocessor in Japan as well as the US and Europe.

50 Press men turned up for the first presentation and over 150 customers arrived on the second day to watch the butterflies and see what Europe's most powerful computer could do.

This machine was built by Meiko, a spin off company founded by some ex-INMOS design engineers. It comprised 100 16 bit prototype transputers connected up in 4 pipelines to perform a complex geometric transformation.

The task was to process the 50 Mbyte design database of the INMOS transputer and generate a 3 dimensional perspective view. The view would be seen by a very small observer standing some 300 micrometers above the chip's surface. The "computing surface" completed the task in roughly 4 1/2 minutes on one quarter of the total database. INMOS performs the same function, but in only 2 dimensions, on our VAX 11/780, to create the photo masks to produce the silicon. Until now this has taken roughly 20 hours on the 1 MIP VAX, compared to the 5 minutes on the 500 MIP super computer!

The demonstration then continued by processing a much smaller segment of the database, changing view every half second, giving the impression of flying through the layers of the device.

After 5 successful performances the team and the equipment returned to England for a brief rest. The same equipment was then loaded into the back of two estate cars and taken to the capitals of Europe, PARIS - Oct 21st, MUNICH - Oct 25th, MILAN - Oct 26th and ROME - Oct 28th.

October 1985 will be forever remembered as "Transputer Month".

THIRD TECHNICAL MEETING OF THE occam USER GROUP

Michael Poole, INMOS

The third technical meeting of the group was held at Rutherford College, University of Kent at Canterbury on 23rd and 24th September. As at the previous meeting we had visitors from all parts of Britain and from Germany and the USA. We also welcomed our first visitors from France and the Netherlands. About half the of 135 people who came were from universties, colleges and research establishments. The other half were from a wide variety of hardware and software companies.

The lecture programme was organised in three main sessions chaired by Peter Welch (our local host), Gordon Harp (our chairman), and Chris Nettleton. During the breaks INMOS staff demonstrated the OCCAM programming system running on Stride and IBM-PC computers, and including the loading of compiled code onto B001 transputer evaluation boards.

The opening address was by Ronan Sleep, of the Alvey Directorate. He enumerated the various facets of the Directorate's work and introduced us to some new acronyms and unpronounceable strings of initials. As the principal source of research funding Alvey holds a key position in Information Technology in Britain and it was valuable to get an inside view of the progress of the various funding activities. He closed by stating that occam and the transputer represent the greatest hope for the management of complexity in IT products.

Gordon Harp spoke of another major funding body, the European ESPRIT programme. He mentioned particularly an 85 man year project to develop a high performance multiprocessor machine executing at 500 Mflops on a network of 64 transputers. This project is a collaboration between universities research establishments and industry in Britain and France.

Several speakers were from groups who had already got hold of prototype silicon and were putting their designs to the test. A wide range of subjects were covered. Peter Cornwell of Texas Instruments is collaborating with Cranfield College on a project in computer aided manufacturing. They aim to be able to go straight from a hunk of metal and ideas in the designer's mind to a fully machined part in a few hours total elapsed time, and have already demonstrated a prototype using 68000s programmed in occam.

Simon Anthony of Smith Associates spoke of the encoding of fingerprints and scene of crime marks. It is expected that a device incoporating several transputers will be installed in every police station and will substantially reduce the time needed for these operations.

Gordon Manson of Sheffield University spoke of a transputer-based workstation that he is about to build. He is concerned about possible difficulties in mapping conventional ideas of the structure of operating system software onto the transputer.

Roger Peel of the University of Surrey introduced us to the world of computing in space with a saga of his attempts to escape from being locked in as the only programmer in his project who knows RCA 1802 assembly language. His solution is to rewrite the software in occam and to run a portakit interpreter in the satellite, interpreting code sent up into space as PIS code by a radio link! He hopes to see transputers in a future satellite.

Tony Hey of Southampton University spoke of some of the big problems of computational physics and the way transputer arrays will be used to master them. Some of these problems are such that it has been estimated that 10,000 years of VAX 11/780 time are required for their solution. A useful classification of these problems is based on the concepts of event parallelism, geometric parallelism and algorithmic parallelism. A fundamental problem in this field is the refusal of the majority of the physicists involved to think of writing programs in any language that is not a dialect of Fortran.

Bob Stallard of Loughborough University spoke of a wide variety of work based on or using his home grown occam compiler on VAX-Unix. Work is in progress on the design of vision aids for robot production machinery using arrays of transputers. They are facing some of the problems of occam program development with screen-based design aids.

Similar problems were mentioned by Peter Capon of Manchester University, who expressed particular concern that program development on a single shared processor tended to hide many of the potential problems in the behaviour of a truly parallel system. He raised several other shortcomings of the present range of occam software including the stopping of compilation at the first syntax error, the inadequate information at the occurrence of deadlock, and the potential problems of getting diagnostic information out of real transputer arrays. There are also language difficulties in considering the re-mapping of highly parallel systems onto a relatively small number of processors as hardware links will need to be made to support several occam channels and there will be a need for arrays of channels with some members "hard" and others "soft".

Professor Turner of the host University introduced his lazy functional language Miranda. This supports infinite sequences, set notation and other attractive ideas. It is claimed to be 10 times as concise as Pascal, but also to be 10 times slower in action. A transputer implementation taking advantage of the inherent parallelism of the approach might remove some of the speed objections to the language.

INMOS provided the two closing talks. Richard Taylor discussed some of the problems of writing a program copies of which could be loaded in an arbitrary array of transputers and which would then proceed to find out what network it was in before getting down to useful work. Ian Pearson gave a preview of the transputer launch programme which was to get going the following week. He was able to show some examples of the way hardware and software is being packaged and advertised. He brought along some copies of the transputer poster to give away and was able to provide information on pricing, availability, etc.

The second session had been concluded with a panel session in which David May (INMOS) and Bill Roscoe (Oxford Univ PRG) successfully defended a barrage of questions of the "Why didn't you ... " kind. They were joined on the panel by two representatives of a customer (Smith Associates) and the session was chaired by Brian Roberts of RSRE. Perhaps the most serious problem to be raised was the problem of how to retrain engineers who have become used to doing without parallelism. The chief of their problems seems to be to learn how to write programs which terminate cleanly rather than get to a deadlock. It was felt that support software could be more helpful to users in this area than it now is.

The OUG business session proved to be the usual non-event. Nobody seemed ready to grasp the nettle of taking steps to make the group more formal. In the absence of other initiatives the group's activities can only continue on the same pattern as at present. It was agreed to plan to hold the March 1986 meeting on March 24th and 25th at Manchester Polytechnic.

Advantage was taken of the two day format to have a conference dinner with guest speaker. For this we had invited the local Professor of Computer Science, Peter Brown, who gave us an entertaining account of the principles of software engineering project management applied to the process of design and production of an after dinner speech. We also took full advantage of the bar and other local facilites. Our thanks go to Peter Welch for being our man on the spot, and to Sue Tough for being my principal helper back at base.

SPECIAL INTEREST GROUPS

At the Canterbury meeting members were invited to suggest titles for Special Interest Groups within OUG and to sign up if interested in joining them. The groups listed below emerged and we should now like to invite members who were not present to add their names to the lists by contacting the person who has volunteered to lead the group, or the OUG Secretary, Michael Poole, at INMOS. Consolidated lists of members who have expressed an interest by mid-February will be circulated to everyone on them.

It will be up to each group to decide what to do to encourage sharing of their common interest.

Artificial Intelligence S Martin, Cambridge Consultants, Science Park,Milton Road, Cambridge, CB4 4DW.

Communications and Networking Ben Potter Esq., ICL, P O Box 8,Icknield Way, Letchworth, Hertfordshire, SG6 1ER.

Formal Techniques Bob Stallard, Loughborough University, Ashby Road, Loughborough, Leics, LE1T 3TU.

Graphics and Imaging Hugh Webber, MOD (PE), RSRE, St Andrews Road, Great Malvern, Worcs, WR14 3PS.

Hugh writes: I propose to hold an initial meetimg of this group at the Manchester OUG meeting at which the aims of the group can be set out. My first proposal is that we should have a round of informal lab visits, so that we can become acquainted with each others areas of interest, and RSRE is prepared to host the first one, shortly after the OUG meeting. Please contact me if you are interested in the visit, or if you have a major topic you think should be discussed at the first meeting. I can be contacted at the above address (Telephone Malvern (06845) 2733 Ext 2239, or on electronic mail, hcw@rsre (JANET users should be able to get through via ucl-cs).

Implementors John Ainscough, Dept of E&E Engineering , J Dalton Faculty of Technology, Manchester Polytechnic, Chester Street, Manchester.

Flexible Manufacture Peter Cornwell, Texas Instruments Ltd, MIS45, Manton Lane, Bedford.

Transputer networks Simon Turner, Plessey Electronic, Systems Research Ltd, Roke Manor, Romsey, Hants, SO5 OZN.

Operating Systems Gordon Manson, Computer Science Department, Sheffield University, Hicks Building, Hounsfield Road, Sheffield, S3.

Unix Peter Welch, Computing Laboratory, University of Kent, Canterbury, Kent, CP2 7NS.

Peter writes: 1. I should like to compile a list of all occam implementations available for particular UNIX systems on particular hosts. For each version, the following information would be useful: deviations from the occam "standard", implementation strategy, speed of compilation, size and speed of code (for some "standard" benchmarks), memory and disc requirements, any cross-compiled targets (particularly, multi-processor), tools and utilities, users' experiences, ...

2. UKC can distribute the INMOS OPS 2.0 (binary compiler plus folding editor sources) under licence. Because of demand, we make a small charge for postage and manual reproduction (you supply tape). Compiler targets for VAX code only and runs under 4.2BSD or System V.

3. I would like to find out demand for a complete Transputer Development System running under UNIX (e.g. Sun, VAX, ...).

In addition to these groups there has been a suggestion from a German member that a group of German-speaking members be established.

Such a group would:

- Put into communication the users of German language. - Exploit locality to reduce long-distance telephone calls or trips. - Avoid the language barrier (which everybody denies). - Exchange hardware and software experiences.

Anyone interested in forming such a group should talk either to Peter Eckelmann at the INMOS office at Eching or to Herr Stender at Brainware GmbH, Kirchgasse 24, D-6200 Wiesbaden, West Germany. (Telephone 06121 / 37 20 11).

PARALLEL PROCESSING FOR CONTROL SYSTEMS

D.I.Jones, University College of North Wales

1.Introduction

In this article some potential applications of occam in the control engineering area are outlined. The objective is to produce multiprocessor implementations of some numerical techniques common in control engineering for computer-aided design or real-time control of physical systems, in order that greater computational speeds can be achieved. For CAD work this would improve user interaction while, for real-time applications, it would enable shorter sampling periods to be realised.

The occam language is used to describe and program the parallel processes for three examples:

1. A parallel method for numerical integration.
2. A parallel line search as part of a typical numerical optimisation algorithm.
3. Multiprocessors for the inverse dynamics problem for a robot manipulator.

All the examples presented are very simple since the author, up to now, has been confined to the use of an occam evaluation kit running on the ACT Sirius, which makes development and execution very slow. However, this does not affect the principles involved and the structures presented are a good starting point for development to a more realistic scale.

2. Numerical Integration

Numerical integration of ordinary differential equations is a fundamantal component of the control designer's toolkit but represents a heavy computational demand. Many methods of speading the load over more than one processor have been described, but the one shown here is due to Miranker & Linaker [1]. Essentially it is an adaptation of the Adams Bashforth predictor corrector formula to parallel processing where, in the simplest second order case, one processor evaluates the predicted state and derivative while a second processor simultaneously evaluates the corrected state and derivative in a recursive fashion. However, the two procesors must communicate values to each other occasionally and tis coincides with the occam model of communicating sequential processes. The structure is shown in Fig. 1. In occam we have:

```
PAR
  Master( ) --pass forcing values to other processors; handle display
  Predictor( ) --compute predicted values; pass to Corrector
  Corrector( ) --compute corrected values; pass to Predictor & Master
```

where, for the Corector, the occam program is:

```
WHILE not.end.flag
  SEQ
    p.to.c?predicted.derivative
    ...calculate corrected state
    c.to.p!corrected.state
    c.to.m!corrected.state
    m.to.c?forcing.value
    ...calculate corrected derivative
```

The predictor structure is similar. This example has been programmed for linear differential equations on the OEK using home-grown floating point routines and works successfully through though the mantissa is restricted to 16 bits so that accuracy comparisons are not really relevant at this stage.

3. Gradient minimisation with a row of processors for the univariate line search

Optimisation by a 'hill climbing' method is a well known control engineering technique which is used in some on-line control applications and in parameter adjustment for CAD. An important ingredient of this method is a 'line-search' where an objective function is minimisedwith respect to a single scalar parameter, alpha, along a given set of directions in multi-dimensional space. Usually this involves evaluating the function at a number of trial points, in turn, for various values of alpha. The essense of this example is to investigate how all these evaluations of the objective function can be carried out in parallel by using occam to define a row of processes for this computation. It should be noted that, in some cases, evaluating the objective function is in itself a system simulation [2] so that computing, say, tenn trial points at once is a major benefit.

Fig. 2 shows the arrangement of the processes which all execute in parallel. In general each "Master" process in the row is interlinked to left and right, with process "Overseer" to control the flow of data into the chain. The outline action is as follows:

i)A value of alpha is passed from "Overseer" to "Master[1]" and propagated up the chain to "Endmaster", being doubled by each successive procesor.

ii) Each "Master[]" process computes a value of the objective function for the given value of alpha and passes it to the left down the chain to "Overseer".

iii) Process "Overseer" selects the minimum value of the objective function and the trial points associated with it become the values for the next iteration of the algorithm. It also communicates with the display.

The occam structure is:

```
DEF mcount=no.master.processes:
PAR
  Overseer( ) --select minimum value; control data flow
  PAR j=[0 FOR mcount-1]
    Master( ) --compute value of objective function
  Endmaster( ) --end of chain
```

This structure has been tested successfully on a quadratic function of two variables with steepest descent directions on the OEK.

4. Inverse dynamics for a robot manipulator

The computation of the inverse dynamics for a robot manipulator is receiving widespread interest at present. Basically the problem is to compute the torques required from each of the joint actuators in order that the robot wrist follow some specified path at a given velocity. This is not a simple calculation since the moment of inertia which each joint actuator must drive changes with robot orientation; furthermore each succeeding link exerts varying gravitational, centrifugal and Coriolis forces on the preceding link. The computation of the desired torque values must be performed within one sampling interval of the control system and this must be set so that the bandwidth is well above the torsional resonant frequency of the robot. For example, in [3] Hollerbach describes various computational schemes, on of which is the Newton-Euler formulation of inverse dynamics. It has been estimated that, for a six degree of freedom manipulator, computing the equations involved would take of the order of 10ms on a PDP 11/45; ideally a reduction to about 2ms using a cheaper processor is desirable.

The Newton-Euler formulation is essentially a set of recursive formulae which are evaluated for each of the robot's links in turn, beginning at the base. This immediately suggests that a processor could be dedicated to evaluating the equations for each individual link. Each processor would receive the computed values associated with the movement of the preceding link, e.g. angular velocity and acceleration, compute the corresponding values for its own link, then pass these to the next processor in pipeline fashion. This done, it is ready to begin another calculation thus increasing the throughput of the overall computation.

Fig. 3 gives an idea of how this might be structured. Each processor in the chain is connected to the robot measurement system and to the processors on either side. Data flow begins at the measurement system, passes up the "Link[]" chain to "Wrist" then back down the chain to "Control System" where the computed torque is used as the signal to the joint actuators. In occam:

```
DEF nlink=number.robot.links:
PAR
  measure.system( ) --pass measured variables to processor chain
  PAR j=[0 FOR nlink]
    link( )       --calculate Newton-Euler equations for joint j
  wrist( )        --measure external forces on robot wrist
```

A much simplified version of this program has been written on the OEK for a two-link planar manipulator. It should be noted, however, that the scheme shown above as not necessarily the best way of providing parallelism in a control system because, although the overall computational throughput is improved by the pipeline, there is still the same delay between the start of the sampling interval and the actuating signal being ready for use - a time delay which contributes to instability in a control system.

5. Some conclusions

Obviously, constraints on space have made the above descriptions quite brief, but if any one is interested in more detail then they are most welcome to contact the author. Copies of the Sirius OEK programs are available if anyone wished to have one. Our future plans at Bangor will be concerned with developing examples, such as those presented above, to a more realistic scale as well as expanding the range of multiprocessor applications e.g. field-oriented control of a.c. machines and flight control systems are likely candidates for investigation. Once the transputer is available we would like to attempt hardware implementations of some of these applications, in order to assess whether the desired improvement in computational times can be achieved in a reasonably cheap and efficient manner.

6. References

[1] Miranker, W.L, Liniger, W.M, "Parallel methods for the numerical integration of ordinary differential equations," Math. Comp., Vol. 21, 1967, pp 303-320.

[2] Jones, D.I, Finch,J.W, "Comparison of optimisation algorithms," Int. Jour. Control, Vol. 40, No. 4, Nov 1984, pp 747-761.

[3] Hollerbach, J.M, "A recursive Lagrangian formulation of manipulator dynamics," IEEE Trans., Vol. SMC-10, No. 11, 1980, pp 730-736.

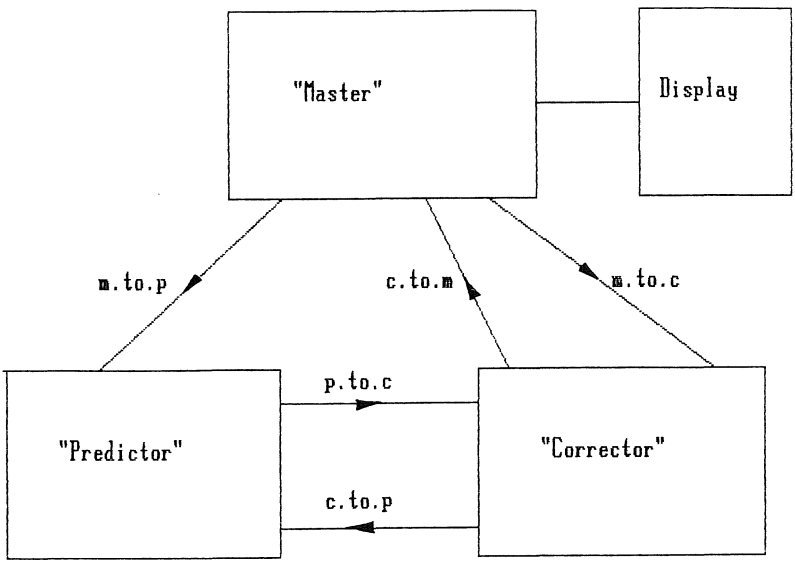


Fig.1 Structure for Numerical Integration

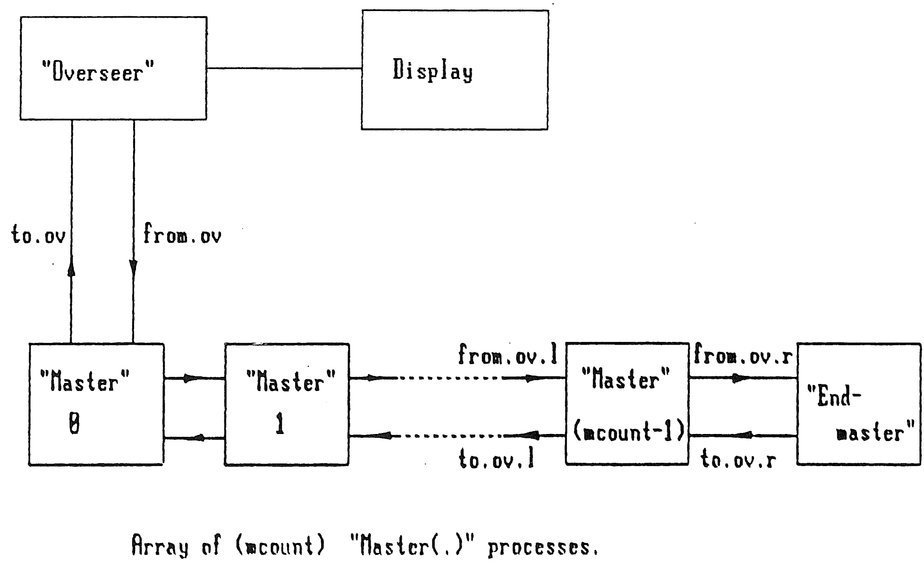


Fig.2 Structure for Parallel Line Search

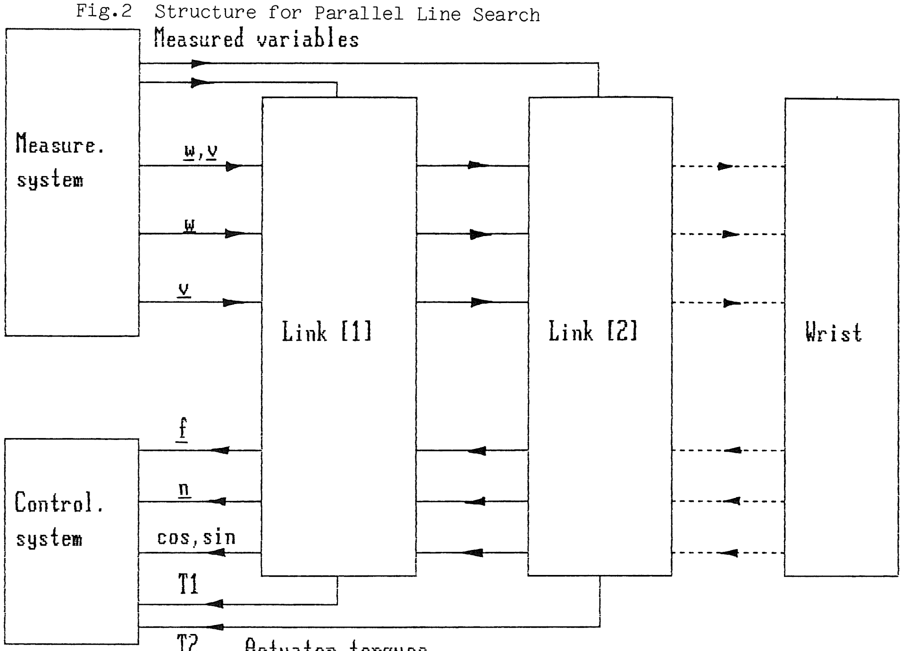


Fig.3 Structure for Robot Inverse Dynamics Calculation

BACK NUMBERS

Copies of Issues 1, 2 and 3 of the OCCAM User Group Newsletter are available while stocks last on application to the secretary at INMOS.

Issue 1 included 6 pages of bibliography on CSP, OCCAM and the transputer. Issue 2 included a complete list of members, and a bibliography update. Issue 3 included supplements to both the above. All three included a variety of articles of general interest to members of the group.

PRODUCTS FROM INMOS

Chris Followell - INMOS

Firstly - the transputer is available NOW! From October 1st 1985 - see Transputer Launch article - INMOS has been supplying the IMS T414a transputer, to its customers on a range of Evaluation Boards.

The products are:-

Evaluation Boards

IMS B001	Double Eurocard, IMS T414, 64 Kbyte RAM, 2 x RS232C ports	£2100
IMS B002-2	Double Eurocard, IMS T414, 2 Mbyte RAM, 2 x RS232C ports	£3300
IMS B004-1	IBM-PC add on card, IMS T414, 1 Mbyte RAM	£2900

Transputer Development Tools

IMS D100	INMOS Transputer Development System, Stride 440	£3000
IMS D600	Transputer Development Software, VAX-VMS	£3000
IMS D700	Transputer Development Software, IBM-PC	£3000

In addition we offer the IMS D701 which comprises the IMS D700 and IMS B004-1 at a combined price of £4400.

If you wish to develop occam programs only we still offer the IMS P600 occam programming system for VAX computers running under the VMS operating system. This is available for £1500.

Also available is the occam portakit. This package contains details of how to create your own interpretive version of occam for your own host computer. It is available from our distributors for £250.

Full details of these products and a free transputer poster please write to me at INMOS.

NEW PRODUCTS WHICH USE TRANSPUTERS

In this new section it is hoped to list commercial products which have recently been introduced and which use the transputer or occam. For inclusion in this listing, please send details of your product to the editor.

This time there is only one entry. The editor picked up a "Preliminary Data Sheet" at the INMOS stand at Wescon in November. This describes three VME/VMX32 boards, the MYRIAD 1000, 4000, and 8000, containing 1, 2, and 4 transputers, respectively. The MYRIAD 1000 contains 1 or 2 MB of memory and the 2000 4 X 256KB. Further details from:

Mycroft Machines,
4100 S.Parker Rd., Box 132,
Aurora, Colorado 80014.
Tel: (303)620-6201

AN OBSERVATION ABOUT SIMPLE REGULAR GRAPHS OF DEGREE 4 AND TRANSPUTER NETWORKS

Brian R. Stonebridge, Computer Science Department and Information Technology Research Centre, University of Bristol.

The IMS T424 transputer may be regarded as a node with four connectors emerging from it. Communication between adjacent transputers is made via these connnectors and although each is bidirectional, enabling transmission in both directions, it is convenient to regard each as a single link. If we construct a network of transputers which is fully connected then a single break in any of the links is sufficient to provide input and output for the system.

A network to model a transputer system in which no transputer is connected to itself is thus a simple (no multiple links), regular (having the same number of links at every node), graph of degree 4 (each node has four edges emerging from it); these therefore are what we consider. We ask the question: are there limitations to the number of nodes, n, of a graph satisfying these conditions? In fact, we prove that such graphs exist for all n greater than or equal to 5.

We call this "the theorem" and prove it by an inductive argument:

1. Construct a graph with four nodes at the corners of a planar square and a fifth node at its centre, making all possible planar connections.
2. Suppose the theorem holds for some graph of size n.
3. Choose any node and replace it by the five nodes of 1. then the theorem holds for the new graph of size (n+4).
4. The theorem holds for n=5, since there is just one way of satisfying the conditions, namely, to join each node to all the others. It may readily be shown to hold for n=6,7 and 8 - trivially, by adding nodes at 1,2 or 3 crossings of the planar graph for n=5 but symmetric graphs also exist. Hence the theorem holds for all n greater than or equal to 5.

An alternative proof has been suggested by G.R. Grimmett (pers. comm.):

1. Suppose the theorem holds for some graph of size n.
2. Take two edges which are not connected to the same node.
3. Replace the edges by the diagonals of the quadrilateral they describe after being deformed into a plane.
4. Place a node at the intersection of the diagonals and the theorem is true for (n+1).
5. The theorem holds for n=5, as shown above, and hence the theorem is true for all n greater than or equal to 5.

It should be noted that there is no difficulty should some of the four nodes involved be collinear, since links may be bent to make a crossing where it would not occur if straight lines were used.

This proof has the merit of simplicity but it rests upon the tacit assumption that it is possible to choose the two edges that are necessary to step 2.

The following proof that this choice is always possible is due to M.D. Gladstone (pers. comm.):

If the graph has at least 5 nodes each of degree 4, then the total number of edges will be 2n, which is at least 10, (since each node lies on 4 "half-edges"). If, now, we take any edge x, then there will be exactly 3 other edges meeting it at each end. Hence, subtracting known edges, there will be at least 10-3-3-1 = 3 edges not meeting x. Thus we may choose one of these as the edge which does not meet x.

The inclusion of this makes the proof longer than the original proof, which requires only a single arbitrary node at each step and is more clearly sound.

The manner of construction of the graphs in the proofs shows that there are, in general, many graphs which satisfy the conditions. It is desirable to discriminate amongst them in some sensible way and one way which seems most attractive is to minimize the maximum distance between any two nodes of the graph. In this way the maximum time of communication between any two transputers in the network is minimized.

Various metrics could be used but the general principle may be shown using uniform unit distances between adjacent nodes. We can define the distance, d(i,j), between two nodes as the length of the shortest path between them. The graph required then minimizes over all the possible graphs with n nodes, say N graphs, the maximum distance between any two nodes of each graph. That is, we may define the graph by

$$\min_{N} (\text{diameter}) = \min_{N} \left(\max_{i,j} \left(d(i,j) \right) \right).$$

It should be added, that diameter may be defined in other ways; for instance, it could be the length of the minimum spanning path for the graph, which for our graph would usually be an uninteresting path length of (n-1).

The task of finding the conformation of the n nodes which minimizes the diameter defined above appears to be non-trivial. Indeed, no polynomial-time algorithm is known to the author; however, it should be possible to improve upon the obvious method of exhaustive searching with back-tracking.

Probably the theorem is "well known" and is a particular case of a more general graph-theoretic result. However, this seems an appropriate time to draw attention to it and the wealth of results of graph theory that may be applicable to processor networks.

OCCAM USER GROUP

FOURTH TECHNICAL MEETING

The fourth technical meeting will be held at Manchester Polytechnic on Monday and Tuesday, 24th and 25th March 1986. The activities of the meeting will be spread over two whole days to allow plenty of time for interaction between members. Accommodation in student study-bedrooms will be available.

The meeting is being organised by the Polytechnic and all inquiries should be made to the address below. A registration form with further details either accompanies this newsletter or may be obtained from the Polytechnic.

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PROGRAM EXCHANGE

A message from Hugh Webber

The catalogue of programs available to User Group members is still very small. I am sure that there are enough of you now writing programs that would be of interest and benefit to other members that could be shared, so why not make a name for yourself. As occam is still young even short routines, which may seem trivial and obvious to you, could be of use to others only just starting up. I look forward to being inundated with items that can be listed in the next newsletter.

For address and other information, see inside back cover.

FINGERPRINT RECOGNITION

Some details of the development by Smith Associates

The automatic recognition of fingerprints has been the subject of extensive research and development in UK, USA and Japan for about 20 years. One of the most promising approahes is that developed by the Scintific Research and Development Branch of the UK Home Office.

A system based on this work was installed in New Scotland Yard in the early 1980s. It has proved that the technique is sufficiently effective to be of value, but that much faster computing equipment would be needed before automatic fingerprint recognition (AFR) could be widely used.

There are two stages to AFR use:

1. Encoding
2. Matching

Encoding is the process of onverting a video signal representing the print into a compact digital format. Matching is the process of searching a database of encoded prints of convicted criminals to find those prints which might match the print of interest.

Smith Associates is developing transputer-based equipment for both of these stages. Design studies have been completed of both, a demonstrator model of the encoder is now functioning and a demonstrator model of the matcher is under development.

Initial measurements of the processing speed of the encoder have confirmed the prediction of the design study, that it would be possible to encode a typical fingerprint in about 3 seconds using an array of 16 transputers. The system in New Scotland Yard takes about 35 seconds using a minicomputer and FPS AP120B vector processor.

It is predicted that the matcher will carry out about 250 comparisons per second using an array of 100 transputers. This may be compared with the New Scotland Yard system, which uses two minicomputers and four FPS AP120B vector processors to achieve less than 20 comparisons per second.

A useful consequence of this approach to high speed processing is that the algoritm may be changed by alterations to the software only. Smith Associates is conducting a research programme into improvements to the algorithm, and any resulting developments will be incorporated in the demonstrator models. Both the US and Japanese systems employ hardwired logic to achieve high speed processing, and hence are unable to exploit such research as easily.

ELECTRONIC GRAPEVINE

A message from Geraint Jones

You are invited to join an electronic mailing list which I hope will help support discussion of occam. There is a JANET (UK academic network) mailbox at Oxford through which such material will be automatically distributed to subscribers. I hope we can gather a wide representation of theoreticians, implementors, and users.

This mechanism offers you the opportunity rapidly to distribute short papers, programming problems, or even occam-related gossip, to a number of the sort of people who might be interested in them. Enquiries about the practicality of some course, or about what people are actually doing could usefully be distributed this way, as might short programs, or information about longer ones.

In the first instance, try making contact through the mail list manager's mailbox

occam-request@UK.AC.OXFORD.PRG

In case you have trouble getting to me by electronic mail, try post or 'phone to

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OCCAM INTERESTS IN JAPAN

Derek J Paddon, Computer Science Department/Information Technology Research Centre, University of Bristol.

I have recently returned from a year's sabbatical leave in Japan, where I was able to observe, at first hand, the Japanese interests in occam and the transputer.

The Japanese have a long standing respect for British ideas, in fact, many Japanese words describing inventiveness and originality use compounds of their writing character for English (英). But a typical Japanese engineer would know very little, or nothing, about British products, British companies or even British company names. This is also true of those working in the computing industry. The major exception to this comment the knowledge displayed by the Japanese about occam, the transputer and INMOS. One indicator of this interest in occam was shown by the very early "sell out" of the first printing of the Japanese translation of the occam programming manual when it was released in 1984.

The many advantages of occam as a specification of concurrency were grasped early in the establishment of the Fifth Generation Institute (ICOT). Rikio Onai, a senior researcher at ICOT, introduced occam to Japan in 1982. His recent return to NTT Musashino Research Laboratories has not dampened his interest. He is presently engaged in writing a book on occam and its applications.

There are numerous projects in hand at the present time in Japan involving occam and more recently the transputer. Many major companies have ongoing projects. Some projects use occam as a specification language for concurrent systems, while many other projects use occam and the transputer as the basis for multiprocessor systems. One of the more interesting projects is being undertaken by one of Japan's major robotics manufacturers. This research group have been using occam for a number of years and are now evaluating the transputer as a decenralised control mechanism for robotic motion.

Many researchers in Japanese universities are active in work involving occam and the transputer, including Keio University, my base during my visit to Japan. Projects range over reduction computers, Monte Carlo simulation computers, finite element machines, CAD and image processing computers, general multiprocessors and a number of theoretical studies.

In Japan, an occam users group will be formed in the near future, which will help draw together their interested scientists and engineers, as has happened in the U.K. I am looking forward with anticipation to the stronger ties that should develop between European and Japanese scientists and engineers. I am sure many of us will enjoy and benefit from contact with the Japanese occam users community.

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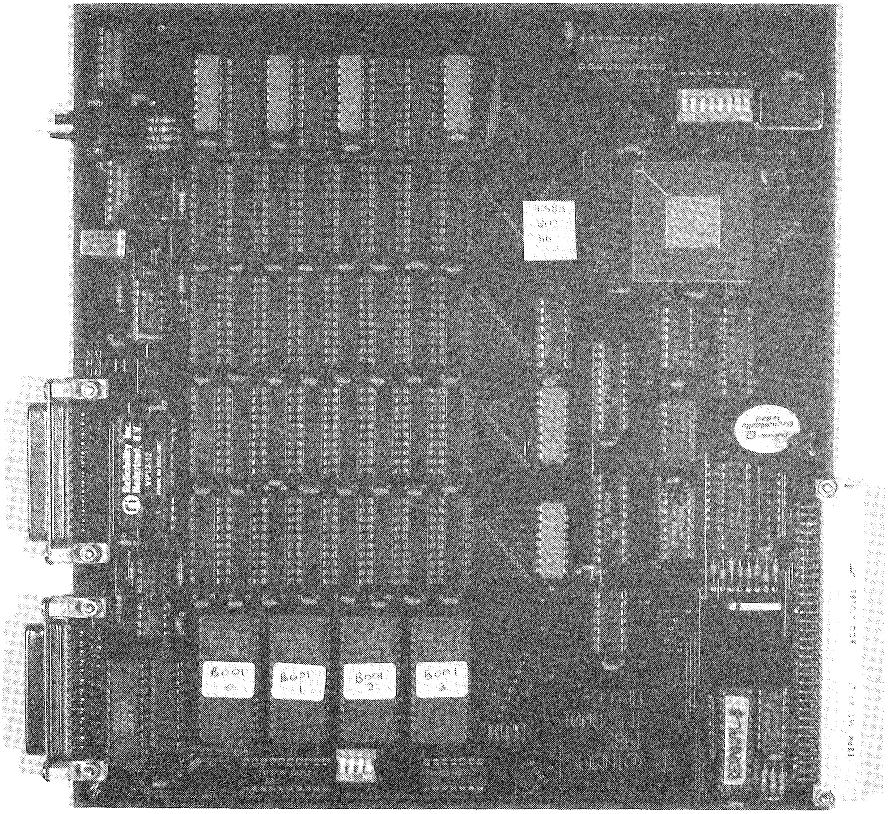
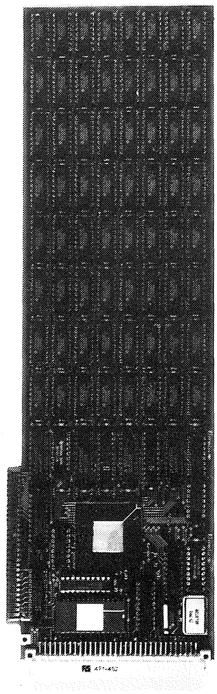
Dr Ali Yaghi, Computer Science Dept, Univ of Manchester, Oxford Road, MANCHESTER, M13 9PL.
H Zedan Esq., Teesside Polytechnic, Computer Science Dept, Middlesborough, Cleveland, TS1 3BA.



<u>IMS BØØ1 Transputer Evaluation Board</u> (see p14)



IMS BØØ4 Transputer Evaluation Board for IBM-PC (see p14)

Program Exchange

The User Group does not provide a library but maintains a catalogue and, via the newsletter, allows members to publicise programs that they are willing to make available.

Contributors :- Please send a one page description to the coordinator of what your program does, its form (source/compiled etc), its hardware/operating system dependence, the exchange medium (type, format etc) and the name and address of the provider. It is advised that appropriate disclaimers be included.

Requestors :- Please make your request to the provider and not to the User Group. The User Group can itself provide no support for such programs nor can it accept any responsibility for problems that might arise due to their use.

Program exchange coordinator:

Mr Hugh Webber,
RSRE, St Andrews Road,
GREAT MALVERN,
Worcs,
WR14 3PS

Tel: Ø6845 2733 (x2239)

(electronic mail hcw@rsre)
(eg via JANET ucl-cs)

see also page 17 in this newsletter.

User Group Committee

In addition to the newsletter editor, program exchange coordinator and secretary, the following are members of the informal committee and would be willing to answer any queries about the group's activities.

Mr Gordon Harp, (Chairman)
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The User Group is an informal organisation run by its own members. Its primary concern is the occam programming language, developed by INMOS Ltd. By virtue of its special relevance to occam, the INMOS transputer hardware is also included in the Group's area of interest.

The main aim of the User Group is to act as a forum for the interchange of information among existing and potential users of these products and as a channel for communication with INMOS. These aims will be met by organising meetings, issuing a newsletter, and supporting the exchange of programs between members.

Membership is free upon submission of an enrolment form, included with all INMOS software products or available from the User Group Secretary at INMOS. The Group is dependent upon its own members to contribute to meetings, to provide material for the newsletter and to make their occam programs available to other members.

Occam User Group Newsletter

This is the main vehicle for communication between members and is sent out free of charge. It is issued approximately twice yearly in June and December. Members are encouraged to submit short descriptions of their interest in and intended uses of occam. Text may be retyped, but diagrams should be suitable for reproduction. Please submit articles, letters, comments, enquiries on any occam or transputer-related subjects to the Editor:

Dr Martin Bolton,
Department of Electrical and Electronic Engineering,
University of Bristol,
Queens Building, University Walk,
BRISTOL BS8 1TR. Telephone: 0272 303030 (x 3301)

Technical Meetings

These are held aproximately twice yearly in September and March. Apart from any necessary business they will include informal presentations by members and by INMOS. If you are prepared to give a presentation or act as host to a future meeting, please inform the User Group Secretary:

Dr Michael Poole,
Software Support,
INMOS Limited,
PO BOX 424,
BRISTOL BS99 7DD. Telephone: 0272 290861

continued inside