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VOLUME 1 - ISSUE 1

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THE UNIX USERS PRODUCT GUIDE

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Axe & Bottle Court
70 Newcomen Street
London, SE1 1YT
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David Reay, Dip. Inst. M

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Typeset and Printed by the Pindar Group of Companies, Scarborough, North Yorkshire

Price: £35.00 (including postage & packing)

Acknowledgements
The Editor and Publisher would like to express their thanks to the following Organisations:-
AT & T UNIX Europe Ltd.
Dundee College of Technology
Transtec GmbH of Tuebingen
Hammond Software (UK) Ltd.

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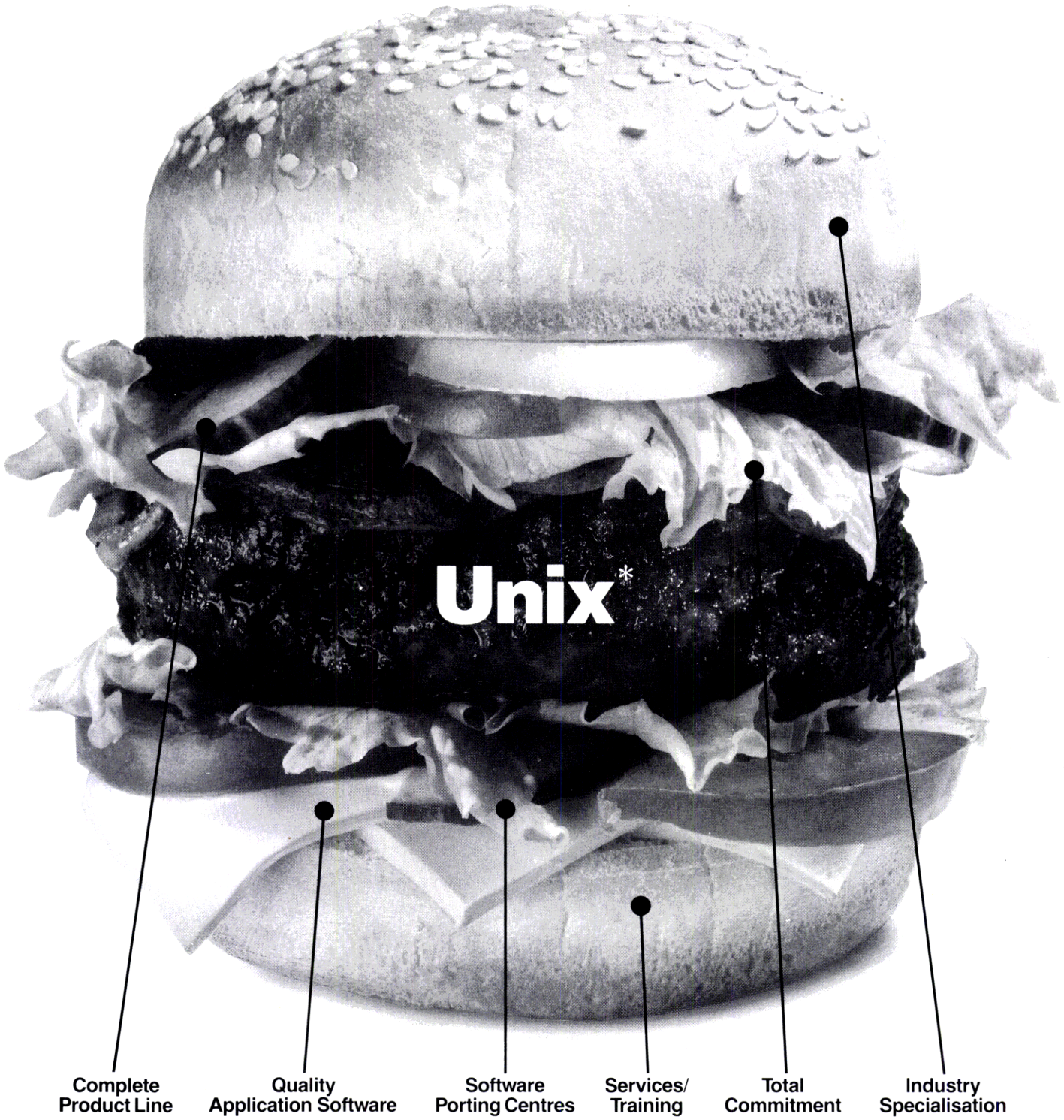

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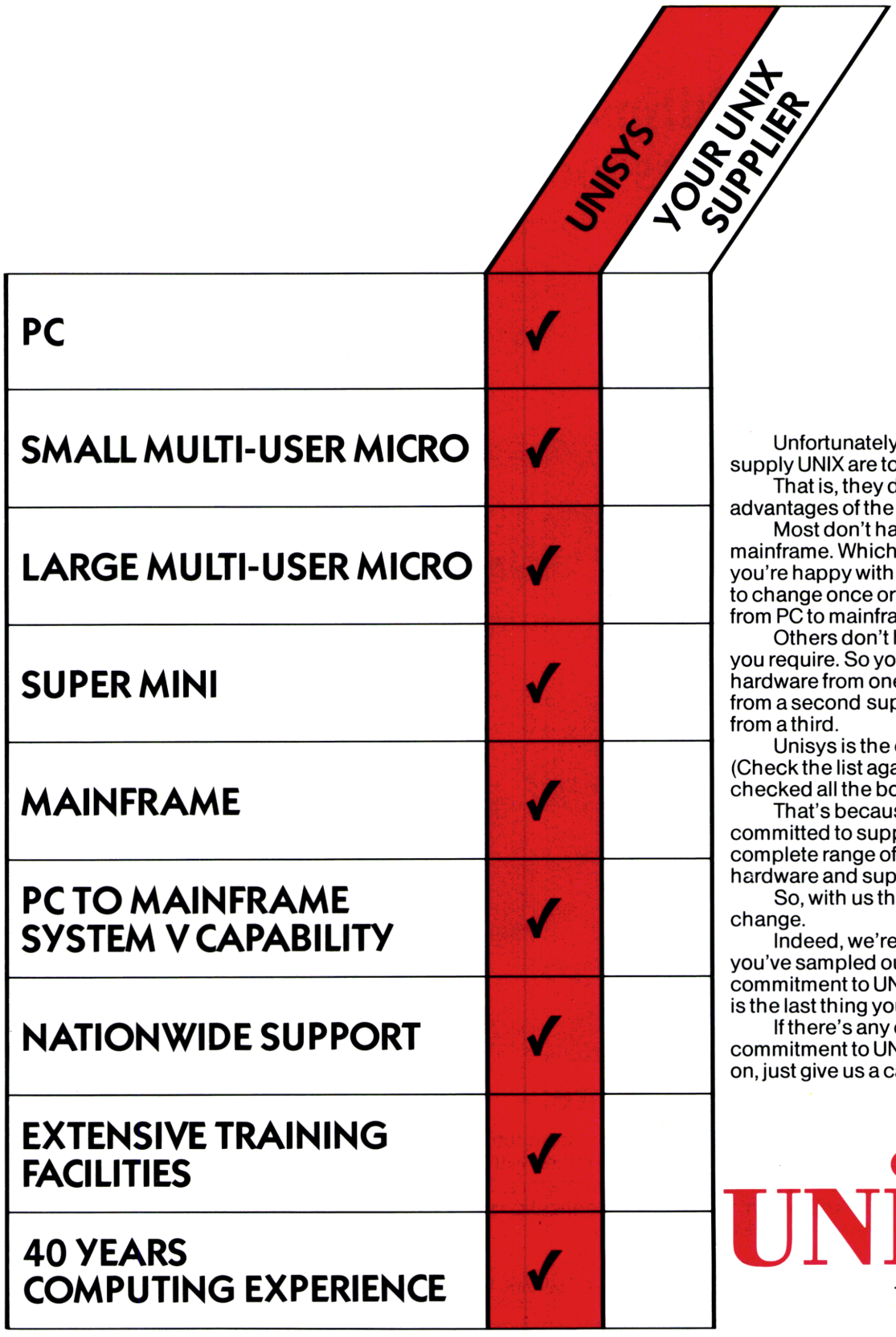

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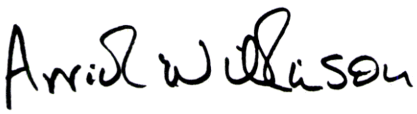
INTRODUCTION

CGP grows as a result of perceived needs; we tend to discover a problem which someone is experiencing, and which we think we may be able to help them with, and develop a solution which is hopefully of interest to a number of people. As some of you will be aware, your editor works as Director of Computer Services at Dundee College of Technology. He used to work in an exclusively DEC environment, but now finds himself responsible for purchasing DEC, IBM and, more recently, UNIX equipment. He uses the DEC/DIGITAL Users Product Guide to help with selecting equipment for the DEC Computers, but became aware of the lack of a similar product for UNIX very quickly. His story of the three major workstations offered is told in this issue, and doubtless future issues will continue his experience.

Another topic we shall be tracking closely over the next few issues is the development of work carried out by the X/OPEN group of manufacturers – BULL / ERICSSON / ICL / NIXDORF / OLIVETTI / PHILIPS / SIEMENS / AT&T / DEC / HEWLETT-PACKARD / UNISYS – which has already published portability guidelines. Their work on the C language, on FORTRAN and PASCAL, on COBOL, ISAM, SQL and its calling from C and COBOL, on 8 bit international code and on disc and tape source code interchange formats could well be seen in a few years to have been the spur leading to the 'legitimisation' of UNIX. The POSIX and X/OPEN work combining to produce a standard with the backing of ISO, IEEE and a large number of manufacturers can only be good for users in the long term.

The set of articles in this issue has been designed to include, we hope, articles of interest to all sorts of UNIX users; end users, managers, gurus and people with all sizes of UNIX systems; workstations, multi-user systems and super-computers. We have articles on pageprinters – that keystone of modern electronic printing, on databases for UNIX – covering techniques rather than products – on the new generation of multiple-processor based UNIX systems, on real time UNIX, migration to UNIX and on training. Specially featured is an article on IBM's UNIX for the 6150 AIX.

Many of the articles in this issue are contributed by manufacturers, rather than users. This seems to reflect a peculiarity of the UNIX marketplace; the major user group is dominated by manufacturers, and users seem harder to contact. As a User Product Guide, we aim to provide information for users and recognise and value the contribution made by manufacturers, but if you think you would like to write for us, or if you think you know a topic we should cover and would like to suggest it to us, then please write. We listen to you.



Arrick D. Wilkinson
Editor, UUPG

Publishers Note

The Parameters for the UNIX Users Guide Volume 1 Issue 1 were based on:

a) Observations of our editor Arrick Wilkinson during the period spent evaluating UNIX based systems for the engineering department of Dundee College of Technology, Scotland.

b) Objective comments from key suppliers.

c) The declared needs of UNIX Users and potential users already registered on our database.

In compiling Issue 2 of Volume 1 to be distributed this November to a predominantly European user base we intend to extend the following sections:

i) Hardware Section – *Additional tables to cover Multiprocessor systems.*
– Expansion of Workstation and Single user systems' supplier categories.

ii) Software Section – *Expansion of Compilers, and System tools;*
Financial services and Graphics categories.

iii) Services Section – *Consultancy, Finance and Maintenance Services.*
Greater range of information designed to cover UNIX based service providers.

SUPPLIERS PLEASE NOTE: Listings of course are free. To apply for your questionnaire and ensure your inclusion in the next issue please contact the production manager Bob Charlton, at the publishers:

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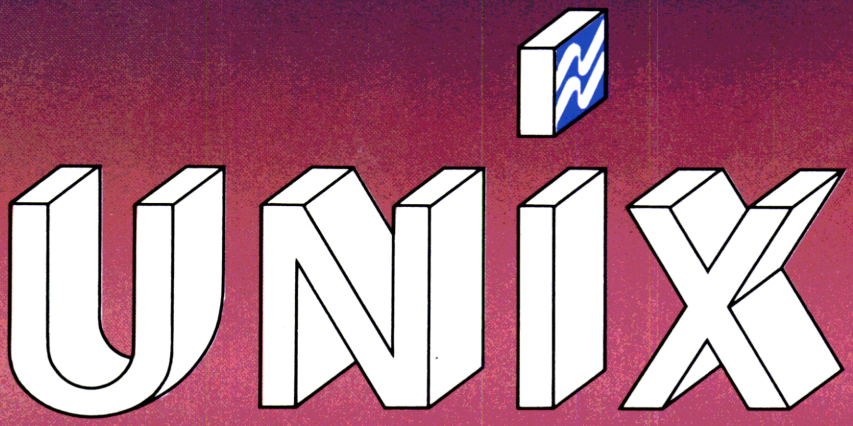

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The publication is constructed to make the sourcing of product information by you, the reader, as simple as possible. Local distributors who can serve your needs within Europe are specified alongside primary US and other suppliers (see MSI for description below). It is never easy trying to manipulate relatively large amounts of information into an absolutely fool-proof set of look-up tables so, if you have recommendations or criticisms please pass them on. In the meantime, a synopsis is provided of source information on each of the 600 products listed in the guide. Firstly: The editorial features – considered to be key articles (see pages 11 to 17) preface the tabular sections. Secondly: The Master Suppliers Index (MSI) provides the key index to Company Contact Information in the guide as in the following example:-

MASSCOMP EUROPE B.V.	– Company name
Hogeweg 25 3814 CC Amersfoort The Netherlands	– Address
H.A. Steenman	– Primary UNIX contact
Vice President, General Manager Europe	– Position held in company
(+31) 33 755455 Telex 40157	– Telephone/Telex numbers
1981 $75M	– Year formed/Last year's turnover
Real-time (UNIX) computers and workstations for technical/scientific applications.	– Brief description of company's primary UNIX specific activity
Hardware/Multi-user Systems Hardware/Workstation Systems Hardware/Single-user Systems Software/CAD/CAM/CAE Software/Compilers/Languages Software/Communications/Networking Software/Database Management	– Sections for which company has returned tabular information
159	– Circle Number reference for Product response card located immediately following the MSI.

Tabular Sections

Immediately following the MSI are the tables for the Hardware, Software and Services sections of the guide. These list, from suppliers questionnaires, some 600 UNIX specific products available (or becoming available) on a Pan-European basis from the 150 or so independent listed companies. These sections each have their own comprehensive title pages which specify content – both editorial and tabular. Editorial comprises the specially commissioned articles discussed within the editor's introduction identified on the "Contents page" (see page 3) and expanded for each section title page. For Hardware see page 33, Software page 59 and Services page 107.

Reader Response

Our reader response facility is available by replying to the circle numbers indicated on each advertisement and the corresponding circle numbers which appear against each company reference within the Master Suppliers Index. The response cards are located between pages 32 and 33 following the MSI.

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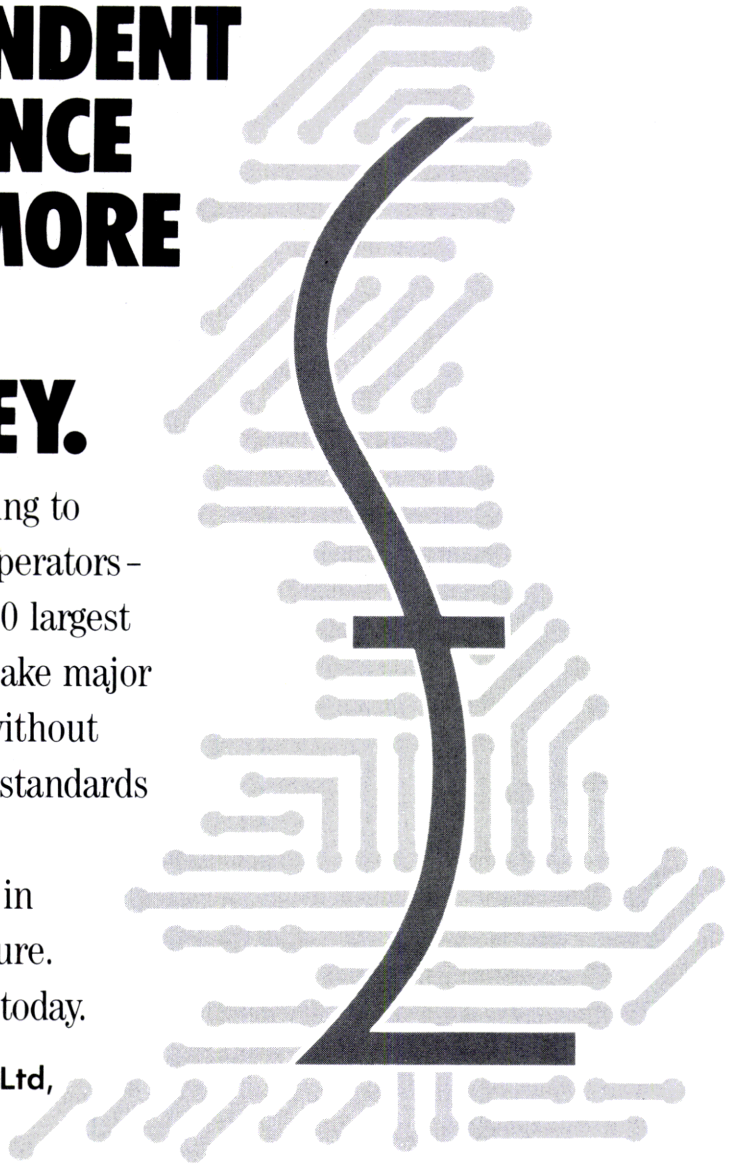

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AIX – The Future for UNIX?

IBM introduced several standards with the Systems -360 in the 1960's to the PC in the 1980's. With the introduction of the PC/RT (6150 to its friends) came a new standard operating systems – AIX. Will AIX become a standard, with multiple software vendors providing products? Or will it become "just another UNIX implementation?" Dr. Neil Thomson, Peter Donelly and Arrick Wilkinson discuss.

Throughout the short history of computing IBM has consistently set de facto standards. The most noteworthy is the 360/370 mainframe standard established in the mid-1960's and still going strong. Other important areas within which IBM has virtually imposed its standards on the industry include networking with SNA and the Token Ring, personal computing and relational databases with, for example, SQL. However, IBM has been having a difficult time recently; profits have been down, market share in PCs and mainframes have been down and the media has been suggesting that IBM has lost its drive, its direction and its skill at manipulating the industry.

AIX – the acronym stands for Advanced Interactive eXecutive – came out during this depression. Is it another attempt to impose a standard? Is it, less deviously, simply a high quality version of UNIX – one that attempts to bring the operating system into the 1980's? Whatever the truth, IBM has not made a half-hearted attempt at porting UNIX. More effort appears to have been expended, both in porting UNIX and in setting up development and support facilities, than for any comparable commercial UNIX development.

Unlike XENIX, IBM's previous low-end UNIX, AIX is not just a 'UNIX like' operating system. It is pure A.T.&T. System V, with major enhancements layered upon it. So significant, indeed, are these enhancements – virtual terminals, full-screen 'windowing' editor, PC/AT DOS user interface, file management, security and overall ease of use – that AIX could come to challenge System V as *the basic UNIX* standard. There are over a million lines of new code in AIX to implement these capabilities. More, these features make UNIX user-friendly and impresive enough to potentially convert a lot of UNIX sceptics, and to make AIX a system with a great appeal to software providers.

The Hardware

IBM originally devised the 6150/6151 in January 1986. It was uprated in February 1987. The architecture announced in 1986 was significant in that there really were two 'hardware' announcements; the 6150 processor – the ROMP – and a Virtual Machine Interface (VMI). IBM itself calls the 6150 a "new synthesis of computer concepts". In its development, it called upon the internal expertise gained in building such diverse parts of their product range as the System/38, the PC/AT, various SNA based networking products and the VM operating system.

The task of managing physical devices is transferred from the UNIX kernel to an underlying level of software called the Virtual Resource Manager (VRM). AIX itself contains a number of 'generic device drivers' which understand the basic capabilities and functionality of different *types* of hardware, without needing to know the details of how they work.

This in turn has led to the provision of a simple table-driven configuration facility with which the user may add new devices. The user only needs to know the characteristics of the device, not the internals of AIX. In the simplest case, all the user needs to know is the type of peripheral and the adapter port to which it is connected. The VRM solution to device support provides other advantages over standard UNIX, including real-time support, simplified and dynamic device installation, improved virtual memory support and memory mapped files.

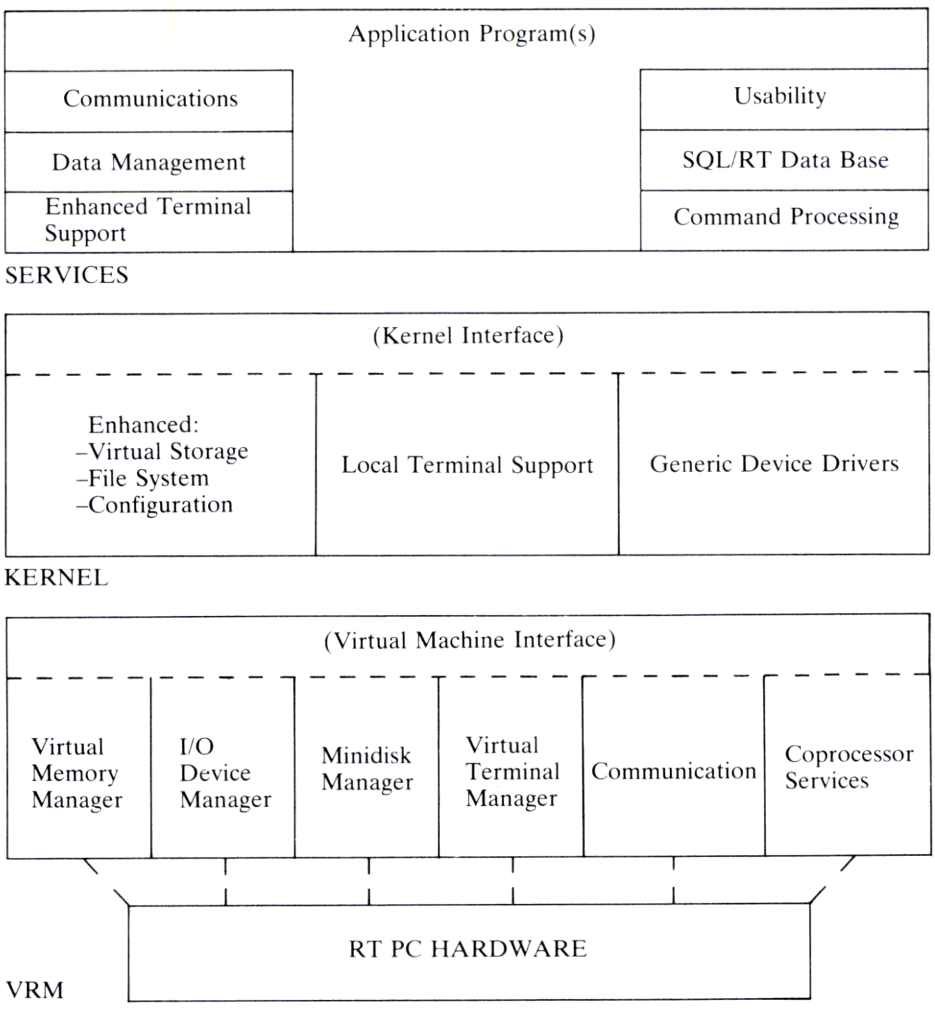


Figure 1. Overall Structure of AIX Operating System

The Co-processor capability

In a way, it seems unfair on the 6150 that it should be labelled as a PC at all. It justifies its PC tag by having an inbuilt capability to run PC DOS programme. This is accomplished by having a slot for a co-processor designed into the architecture, and by implementing a PC-DOS software component in the user interface. The effect of this is to allow PC/AT programs to run at 80% efficiency without interfering with the 6150's normal operation, yet allowing the PC to access all the devices of the system and share consoles, etc.

Virtual Terminals

One of the great advantages of a multi-tasking operating system is that it allows the user to carry out more than one activity at a time; the most common means of providing this is a window management system, like those provided by SUN, APOLLO, Hewlett-Packard or DEC. IBM has followed this trend by announcing AIX support for X-Windows, the MIT-developed system which is fast becoming a standard itself.

Despite their immediate appeal, it can be argued that these 'messy desk' window managers have a number of inherent disadvantages, not least their impact on system performance, and their reliance on a large and space-consuming display for effective use. AIX supports an alternative solution using virtual terminals. In IBM AIX terminology this virtual terminal is a counterpart of the real IBM 6150 display-keyboard-mouse combination. It consists of a supervisor, a Keyboard Device Driver, a Sound Device Driver, a Display Device Driver and multiple virtual terminals.

Memory-mapped files

Virtual memory management systems often suffer from a very simple problem. No sooner has an application read data from disk into a memory buffer, than the operating system decides to swap the data back out to disk. Even more infuriating is to laboriously read an entire program into memory only to have the operating system promptly swap it back out to another part of the disk. This syndrome leads to poor performance, and frequently explains the rapid deterioration of response under load which is typical of so many Unix systems.

Through the VRM, AIX supports a facility to map disk files to virtual memory. Once mapped, all physical device I/O operations on the file are performed by the memory management component of the programs. Internally, AIX uses memory mapping to manage executable programs. When an application makes use of this facility, it can reference a file using Load and Store instructions. The virtual memory paging system automatically takes care of the physical I/O. In other words, the application simply accesses the file as if it were part of its data space, regardless of the fact that the data physically resides on disk. The result of this is a significant performance increase, particularly for large programs.

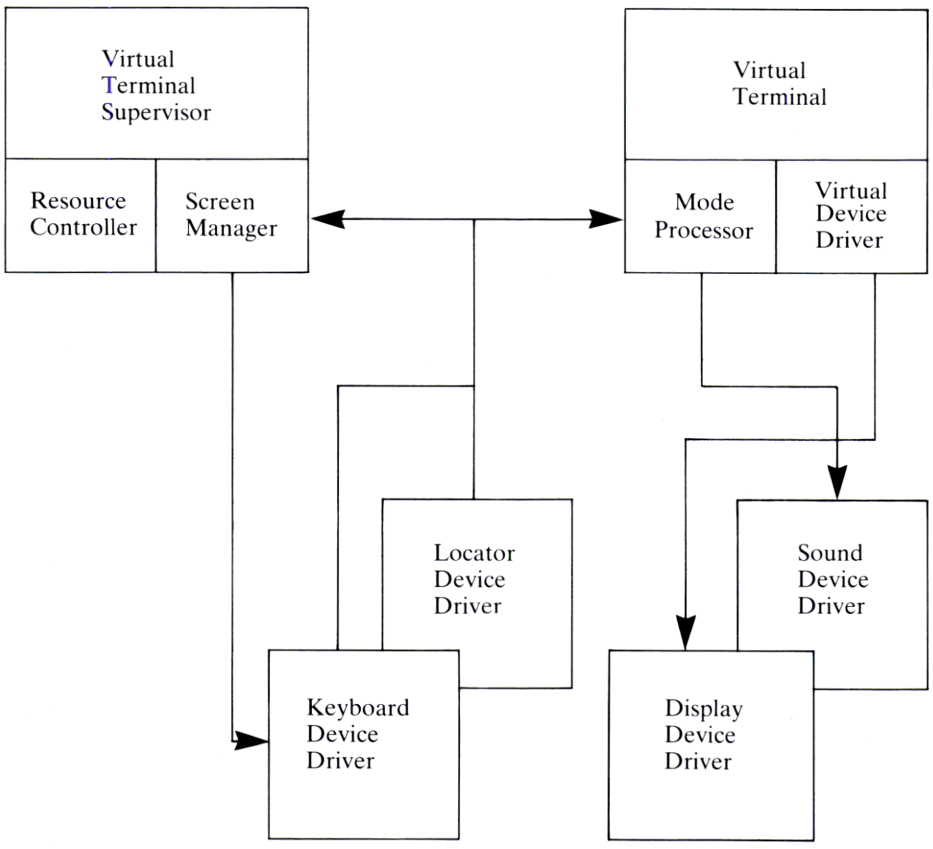


Figure 2 The IBM 6150 Virtual Terminal Driver

Extended File Management

Standard UNIX provides only basic byte- and string-oriented file manipulation functions. In principle, this is sufficient as a basis even for sophisticated applications. In practice, however, it means that every software vendor requiring (say) an indexed record-oriented file structure, has to implement it from first principles, leading to a multitude of different and incompatible file structures from different vendors. AIX provides its own standard set of extended file-handling facilities packed as 'Data Management Services' (DMS). DMS provides both a record-level indexed sequential access method, and a higher-level field access method. Record-access allows data structures of fixed or variable length, and is the traditional file access method for languages such as Cobol, Fortran and PL/1. It also lends itself very well to applications written in C. Field-access permits an application to view a file as a 'table' where the rows are records, and the columns are fields. AIX also implements file- and record- level locking extensions in either advisory or enforced form, providing facilities for either co-operating or non-co-operating processes.

Conclusions

Perhaps the true significance of AIX to the UNIX community is that it offers the chance to alter the nature of the operating system from guru's toolkit through developer's workbench to user's system.

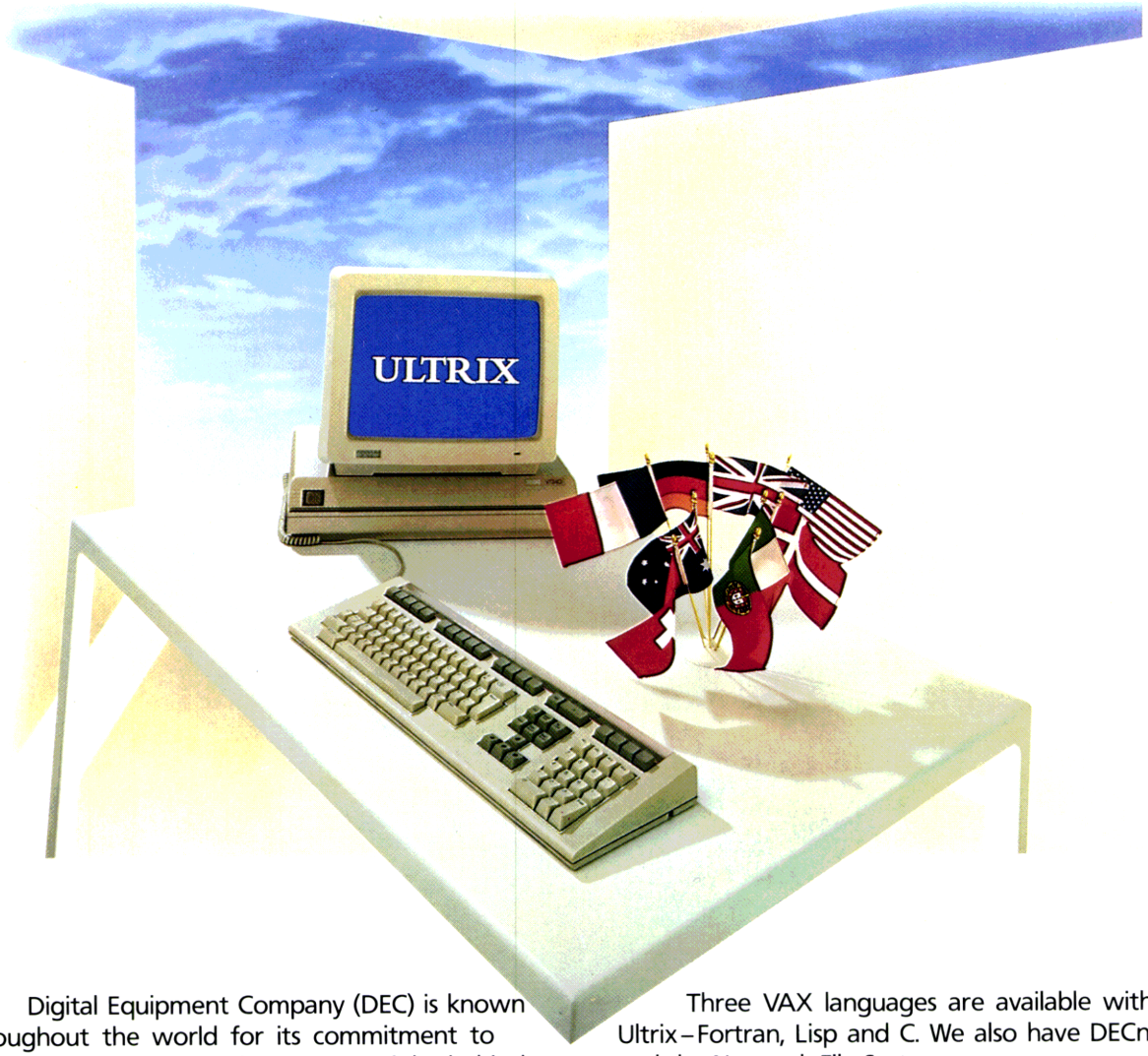
IBM's Attitude to UNIX

IBM's attitude towards UNIX remained somewhat ambiguous even following the announcement of the RT PC in January 1986. In February 1987, the signals became clear and positive when the upgraded 6150 was announced. Included in the announcement was the fact that IBM was moving its entire UNIX team to Austin, Texas – where the 6150 development team is located. IBM also upgraded its standards-making activity and became an active participant in the POSIX process. IBM also stated that "AIX" – note *not the RT PC or 6150* – "is the vehicle with which IBM plan to provide high quality software support to customers wanting a UNIX solution". This should imply that AIX is a long term runner. AIX positions IBM at the sophisticated end of the UNIX market ready to take advantage of the operating system commercially.

AIX – Beyond UNIX

As far as IBM is concerned, there may be a wider significance to AIX – and one that is of interest to existing UNIX users. At the time of the February 1987 announcements, IBM said that its UNIX offerings were "designed, in many cases, to co-exist with and complement other IBM operating system environments". This suggests that there may be more to AIX than first meets the eye. Indeed, when the 6150 was first launched, IBM published a set of papers

Partners in Standards: Posix is emerging as the new standard for Unix* based systems. What support is this getting from DEC?



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written by members of the development team. These papers gave an insight into the development of the 6150 and particularly into the development of the VRM and VMI and their use as a migration tool. The machine which AIX sees has nothing to do with the hardware that is actually being used. This opens up all sorts of possibilities for UNIX software developers. If IBM can plug the 6150 hardware into the back of the VRM and VMI, with AIX as the front end, it might well consider plugging in other elements of its product range in the 6150's place. Now there's a future.

Postscript

On 2nd April 1987, IBM announced it's new PC – the Personal System/2. Included in the plans they announced was a new version of AIX for the high end of the PS/2. The new AIX will be upwardly compatible with the 6150 version and will support PC DOS 3.3 as a task. Further details will be announced in the fourth quarter of 1987. (Ed.)

Dr. Neil Thomson

Peter Donnelly is General Manager of Dyadic Systems, the authors of Dyalog APL, the first implementation of the APL programming language for UNIX systems. As a result of porting Dyalog APL to over 30 different UNIX systems, Dyadic has built up a considerable background of UNIX knowledge. By developing a 'vendor-logo' version of Dyalog APL for the IBM 6150, Dyadic has also acquired a special expertise in the 6150 and its operating system, AIX.

Dr. Neil Thomson is Managing Director of Thomson Computers. He was instrumental in the development of Sea-Change, the well known application generator for end users and C programmers. Thomson Computers is a leading software house providing software tools for the UNIX community.

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Circle No. 297

UNIX Networking Standards – NFS

Networking in the eighties requires, above all, transparency and user friendliness. Thus UNIX apparently has a major conflict, because absolutely anyone will tell you that "Networking cannot just be grafted on to a product. It requires a major re-design and re-coding of any piece of software, particularly an operating system". So has UNIX coped? Arrick Wilkinson discusses.

Those of you old enough to remember the days when UNIX was a system which ran only on PDP-7s and PDP-11s, will remember also that networking was a research topic; to be sure, there was soon a method for connecting systems together to ensure that every UNIX system in the world could, if it wished, join into the first and biggest bulletin board in the world. However, the technology of WANs, X.25, LANs, Token Rings and Ethernets postdates the conception of the basic UNIX command language and kernel.

Networking in the eighties requires, above all, transparency and user friendliness. Thus UNIX apparently has a major conflict, because absolutely anyone will tell you that "Networking cannot just be grafted on to a product. It requires a major re-design and re-coding of any piece of software, particularly an operating system". So has UNIX coped? What solutions are available? How do they differ? This article aims to answer at least in part, these questions.

The Basics

The basic ideas of an ideal network are simple: to connect machines by combining all or some of the file systems into one single, conceptually straightforward file system – as viewed by any user. No new commands should have to be learned, no remote systems need to be mastered, yet file sharing across the entire extent of the network becomes as simple as accessing a file on a dedicated machine; similarly, if an application only resides in one location, the user should be able to run it as if it were located on the locak workstation. There are two basic philosophies in use in UNIX networking. The first is the logically simple concept of "root-extension". This extends the local hierarchical file structure by one level; instead of the root being the top, there is a new "network" level in the file hierarchy, so that referring to a file on another system is as simple as referring to a brother node on the same system. This is the concept behind the Newcastle Connection. The alternative logic is to 'mount' a remote file system or part thereof. This is exactly analogous to the UNIX system for 'linking' files. This system is the one used by NFS, and also by the new RFS developed by AT&T.

Sun Microsystems NFS

SUN's Network File System is a facility specifically designed for sharing files in a heterogeneous environment of machines, operating systems and networks. That is to say, it is not confined to SUNhardware, nor to UNIX, nor to any particular carrier medium. NFS was designed to overcome the deadlock introduced by workstations; team working, as practiced on mainframes had run out of processor power, and the interference between members of the team reduced productivity; team working, as practiced on workstations lost much of the benefit of software engineering tools, since only one person could be modifying a

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source code module at any time, there being no network-wide source control system. The primitive alternatives were file copying, which led to obvious re-synchronisation problems, or remote logins, which looped back to the mainframe problem again.

A distributed file system solves these issues; from a user viewpoint, the local system provides all of the files; from the system viewpoint, some of the files *will be local*whilst the remainder will be provided by a remote server, on demand.

Like the Newcastle Connection, NFS is implemented as an extension to UNIX. NFS, however, really is a synthesis of components – RPC, XDR and NFS proper, each with its own protocol specification. NFS has the potential for at least five different types of transparency.

1. **FILESYSTEM TYPE**
   A particular system could have more than one file system implemented, with a different interface. NFS can be used to disguise this difference from a user or an application.
2. **FILESYSTEM LOCATION**
   There is no distinction between NFS access to local or remote file systems.
3. **OPERATING SYSTEM TYPE**
   RPC is implemented in a way which allows it to be implemented on almost any operating system – UNIX in any flavour, VMS, MVS, MS-DOS etc.
4. **MACHINE TYPE**
   XDR handles the problem of data representation differences between different machine types and their implementations of floating point data, strings, arrays etc.
5. **NETWORK TYPE**
   RPC and XDR can be implemented for a variety of different protocols or networks – X.25, Ethernet, Cambridge Ring, Token Ring, Apollo Domain etc.

NFS

NFS provides, as was mentioned above, the ability to mount a file tree remotely. The process has two parts, representing the caller and the called, more usually called the *client* and the *server*. Security has not been neglected; it is necessary specifically to declare the parts of the file system which can be made available to clients. This is handled by the (local) file / etc / exports which contains the definitions of the various parts of the file system which are available through NFS. The same file can optionally contain a name which will restrict usage of the file specification to a particular user or group of users. NFS has also been designed with the frailty of networking in mind. Despite everything, networks are still less reliable as a whole than are the individual components; NFS was designed so that the server part of NFS is 'stateless' – which SUN defines as meaning that the server does not have to 'remember', from one transaction to the next, *anything* about its clients, transactions or files. This adds complexity to the system, but it does provide robustness in the event of the failure of the client – when the process will fail also, and be subject to any recovery processes on reboot, failure of the server – when the client will detect the problem on its next attempt to access and (hopefully) the application can fail gracefully or re-try until successful, or failure of the network – when the scenario is as if the server had failed.

ABBREVIATIONS

Abb.	Expansion	Description
IP	Internet Protocol	– A specification made available by SUN as a standard for UNIX networking
RPC	Remote Procedure Call	– That part of NFS which provides the mechanism whereby a caller process can have another process execute a procedure call.
LA	Two/Three Letter Abbreviation	– Just checking whether you are reading carefully
TCP	Transmission Control Protocol	– A reliable flow-controlled two-way protocol.
UDP	Universal Datagram Protocol	– A simple unreliable connectionless protocol.
XDR	External Data Representation	– That part of NFS which provides a standard way of communicating various data types between possibly incompatible systems.

XDR

XDR is SUN's contribution to defeating the second law of thermodynamics – that is to attempting to reverse the entropy which has been increasing since there was only one computer. Consider the SUN and the VAX – two leading systems for UNIX users, and the way they represent numbers:

SUN		VAX	
Hex	Decimal	Hex	Decimal
00000000	0	00000000	0
00000001	1	00010000	16777216
00000002	2	00020000	33554432
00000003	3	00030000	50331648
.	.	.	.
00010000	16777216	00000001	1

That is to say the order of bytes is not the same. A similar problem exists with the order of characters in a string, and a much worse one with floating point numbers. XDR specifies a series of filters which convert between the internal and external forms of data items. The routines are direction independent; that is to say that a program calls the same routine regardless of whether it is reading from or writing to an external file. A mechanism is also provided for passing data without fondling – opaque data in NFS terminology.

RPC

The RPC section of the SUN NFS manual introduces some beautiful new jargon word combinations: the writer was particularly intrigued by the section headed "Binding and Rendezvous Independence". The explanation for this is quoted directly, perhaps in the hope that the Plan English Society might get involved. "The act of binding a client to a service is *not* part of the remote procedure call specification. This important and necessary function is left up to some higher level software. (The software may use RPC itself). Implementors should think of the RPC protocol as the Jump-subroutine instruction of a network".

More relevantly, RPC is transport service independent. RPC is also a level at which authentication (security) services are provided. At present there are only two types of authentication, NONE and UNIX, the latter of which provides the user identifier, group identifier and group for use by the remote server.

Summary

SUN have been active in promoting NFS to end-users and other computer vendors; it is unclear whether this is altruism or self-interest, but certainly NFS is now available on quite a number of systems, UNIX based and otherwise. The sophistication of NFS does not approach that of DECnet or SNA, but is tailored to meet the needs of a large proportion of UNIX communities. It is not unfair, perhaps, to compare NFS to a RISC hardware architecture, optimised for a particular set of requirements. The deficiencies of NFS are in the areas of remote command execution, of providing access to devices rather than files remotely, and of providing file locking or append access to files. Its strengths lie in the ease of implementation on any sort of file system, its UNIX independence and its extension of the IEE work on floating point representation into a standard for all sorts of data.

Abbreviations and References

To assist the reader, we append a list of the TLAs used in the article, along with a brief definition of each. We would also refer readers to two articles on related topics from one of our sister publications, the DEC/DIGITAL USERS PRODUCT GUIDE, and to the SUN Network Documentation.

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MASTER SUPPLIERS INDEX

Have you read 'How to use this guide'? (Page 9)

- The following Master Suppliers Index (MSI) provides source information of those companies represented in the Hardware, Software and/or Services sections which follow the MSI.

- The following information is provided:
  a) Key location address(es) and contact numbers
  b) Prime UNIX contact
  c) Company formation date and the previous year's annual turnover details
  d) A brief description of each company's activity
  e) Reference sections represented in which Company has products.
  Please refer to the following example:-

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H.A. Steenman	– Primary UNIX contact
Vice President, General Manager Europe	– Position held in company
(+31) 33 755455 Telex 40157	– Telephone/Telex numbers
1981 $75M	– Year formed/Last year's turnover
Real-time (UNIX) computers and workstations for technical/scientific applications.	– Brief description of company's primary UNIX specific activity
Hardware/Multi-user Systems Hardware/Workstation Systems Hardware/Single-user Systems Software/CAD/CAM/CAE Software/Compilers/Languages Software/Communications/ Networking Software/Database Management	– Sections for which company has returned tabular information.
159	– Circle Number reference for Product response card located immediately following the MSI.

- Each main section carries its own index page. This will refer you to the particular page number for each product type within each section (for example, 'Workstations' within the Hardware section). The Hardware Product Index is on page 33, Software Product Index page 59, and Services page 107.

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Sussex BN4 1ER
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Marketing Executive
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Software/Other Software
Services/Maintenance
Services/Training
001

ACCESS TECHNOLOGY
66-68 Chapel Street
Marlow
Buckinghamshire
SL7 1DE
UK
(0628) 890345 Telex 848138 ATL
1980 15M Sterling
Paul Basson
Managing Director
Developers and suppliers of integrated, multi-user spreadsheet.
Software/Financial Planning
002

ACE MICROSYSTEMS LTD
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Kew Bridge
Brentford
Middlesex TW8 0EJ
UK
(01) 847 4673 Telex 929460
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John Irwin
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Independent, British company, specialising in software design and development for mini and micro computers.
Software/Word Processing
003

ADVANCED SOFTWARE APPLICATIONS
Suite 4 Brookland House
46 Kneesworth Street
Royston
Hertfordshire SG8 5AQ
UK
(0763) 47712
1983 150K + Sterling
J.P. Smith
Director
Software product development organisation, specialising in advanced solutions for the engineering industries.
Software/CAD/CAM/CAE
004

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23 Eyot Gardens
Hammersmith
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UK
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Software/Office Automation
005

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432 Dewsbury Road
Leeds
Yorkshire LS11 7DF
UK
(0532) 704499
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R Foster
Managing Director
Systems house.
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Software/Accounting
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007

ANDOR SYSTEMS (UK) LTD
The Genesis Centre
Birchwood
Warrington
West Midlands WA3 7BH
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(0925) 828181 Telex 628417 PIXEL G
1.2M Sterling
Jan Klin
Systems integration and distribution of UNIX systems, via value-added resellers.
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008

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David Elsy
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Computer manufacturer.
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Software/Software Maintenance
009

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UK
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1971 2M Sterling
Martin Griffiths
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Systems integrator and UNISYS distributor.
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Software/Word Processing
011

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New Jersey 07054
USA
201 316 0866
1986 250K US Dollars
Chris Arndt
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Markets UNIX and XENIX software for software development environments.
Software/Systems Tools
012

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N Meaden
Market Communications Manager
Wholly owned subsidiary of AT&T. The company is AT&T's software representative in Europe and Scandinavia, reponsible for promoting, licensing and supporting UNIX System V and related software.
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B Wadsworth
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Software house/development company.
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BLEASDALE COMPUTER SYSTEMS PLC
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UK
(04555) 56841
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Chairman
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UNIX systems house developing and marketing own UNIX products.
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Software/Accounting
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017

BRAINSTORM COMPUTER SOLUTIONS
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V Vasiliou
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UNIX software development, UNIX systems house and DEC OEM.
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BRAZIER SYSTEMS & CONSULTANTS
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Trust Industrial Estate
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Marketing/Projects Director
Independent third-party maintenance company.
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(0420) 84313
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Nicola Nobes
General Manager
Computer systems house.
Software/Manufacturing
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CONVERGENT TECHNOLOGIES (UK) LTD
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Supplier of desktop business computer and microcomputer systems.
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6236 Eschborn 1
West Germany
6196 481606 Telex 4072760
1974 80M US Dollars
Werner Salmen
Technical Manager
Hardware/Multi-user Systems
Hardware/Workstation Systems
038

DANSK DATA ELEKTRONIK (DDE)
199, Herlev Hovedgade
DK-2730 Herlev
Denmark
(02) 845011
1975 153M Dkk
Fleming Torp Petersen
International Marketing Manager
DDE is a Danish public co. manufacturing the advanced UNIX multi-CPU Supermax minicomputer incorporating up to 8 68020 processors.

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Senior Sales Executive
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Software/Applications Generators
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25431 Cabot Road, Suite 110
Laguna Hills
California 92653
USA
(714) 837 3744
1979
Kevin E Roberts
Marketing Director
Design, development, marketing and service of SMC software system.
Software/Manufacturing
040

DIGICOMP AG
Zurcherstr 6
Zurich-Schlieren 8952
Switzerland
01/730 7655 Telex 27742
1978 2.5 M Swiss Francs
Willi G Vollenweider
President
Independent computer training institute.
Software/Office Automation
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041

DIGITAL EQUIPMENT CORPORATION
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Chris Mellor
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Manufacturer and vendor of fully-compatible and networked computer systems, incuding peripherals and software.
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9594182 Telex 210323
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A Kambourakis
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617 460 0500
1983 4.7M US Dollars
John Brewer
Marketing Communications Manager
Manufacturer of UNIX based multiprocessing, parallel processing computers and terminal servers.
Hardware/Multi-user Systems
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EXCELAN
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UK
(0628) 34281 Telex 847591
1984 22M US Dollars
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Manufacturer of local area network technology.
Software/Other Software
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- Office Automation
- Data Communications
- CAD/CAM
- PC Connections
- Process Control
- UNIX Utilities

Please contact us directly for further information

dde

SUPERMAX

SUPERMAX THE GREAT DANE – MADE TO OUTGROW THE OTHERS.

Dansk Data Elektronik A/S, Herlev Hovedgade 199, DK-2730 Herlev, Denmark. Tlf.: Int. +45 2 84 50 11. Tlx.: 35 258 dde dk

ProMotion/DK

Circle No. 294

GEC COMPUTERS
Elstree Way
Borehamwood
Hertfordshire
WD6 1RY
UK
(01) 953 2030 Telex 22777
1968 Sterling
Graham Hawkes
Marketing Manager - Computer Products Div.
Designers, manufacturers and suppliers of computers, computer systems and associated products for commercial, industrial, defence, education, communications, academic, scientific and numerous other applications.
Hardware/Multi-user Systems
Hardware/Workstation Systems
051

GEC SOFTWARE LTD
132 Long Acre
London WC2E 9AH
UK
(01) 240 7171 Telex 21403 GEC LA G
1984 3M Sterling
Irene Dawson
Head of Sales
Develops and markets software tools to help bring in projects on time, to budget and to specification.
Software/Applications Generators
Software/Communications/Networking
Software/Operating Systems/Enhancements
Software/Other Software
Services/Consultancy
052

GOLDCREST COMPUTER SERVICES LTD
10 Tower Crescent
Neath Hill Centre
Milton Keynes
MK14 6JY
UK
(0908) 676198
1976 Sterling
Charles Hartnett
Director
Software/systems house.
Software/Accounting
Software/Manufacturing
Services/Other
053

GOULD ELECTRONICS LTD
Computer Systems
Copthall House
Grove Road, Sutton
Surrey SM1 1BY
UK
(01) 643 8020 Telex 947707
Sterling
Philip Martin
Marketing Manager
Supplier of high-performance industrial and scientific computer systems for commercial, engineering and scientific applications.
Hardware/Multi-user Systems
Software/Compilers/Languages
Software/Information Management
Software/Operating Systems/Enhancements
055

HARD FEATURES LTD
25, St.Francis Road
London SE22 8DE
UK
(01) 274 6407
1980 800k Sterling
Arthur Thugg
Managing Director
Turnkey systems for monitoring of criminal records and specialists in communications hardware.
Software/Communications/Networking
056

HARRIS SYSTEMS LTD
Eskdale Road
Winnersh
Wokingham
Berkshire RG11 5TR
UK
(0734) 698787 Telex 848174
Sterling
Robin Moore
Software Support Manager
Multinational communications company.
Hardware/Multi-user Systems
Software/CAD/CAM/CAE
Software/Office Automation
057

HEWLETT-PACKARD SA
European Headquarters
150 Route du Nant-d'Avril
Geneva
CH-1217 Meyrin
Switzerland
022 838111 Telex 419019
1929 7.1B US Dollars
I. van Sabben
PR Representative
International manufacturer of measurement and computational products and systems used in industry, business, engineering, science, medicine and education.
Hardware/Multi-user Systems
Hardware/Workstation Systems
Software/CAD/CAM/CAE
058

HONEYWELL INFORMATION SYSTEMS LTD
Maxted Road
Hemel Hempstead
HP2 7DZ
UK
(0442) 42291 Telex 82413
1936 160M Sterling
Peter Harry
Product Manager - UNIX Products
Full support of own and third-party hardware and software. Supplier of turnkey solutions to government, industrial and commercial organisations.
Hardware/Multi-user Systems
Services/Other
059

IBM (UK) LTD
P.O.Box 118, Normandy House
Alencon Link
Basingstoke
Hampshire RG21 1EJ
UK
(0256) 56144 Telex 858043
1950 Sterling
Jane Singleton
Information Officer
Develops, manufactures and markets information processing equipment and related services and products.
Hardware/Multi-user Systems
Hardware/Personal Systems
Hardware/Workstation Systems
Software/Accounting
Software/Applications Generators
Software/CAD/CAM/CAE
Software/Compilers/Languages
Software/Communications/Networking
Software/Database Management
Software/Graphics
Software/Mathematical/Statistical
Software/Office Automation
Software/Word Processing
060

ICS COMPUTING LIMITED
Queens Road
Belfast
BT3 9DT
Northern Ireland
(0232) 54166 Telex 74365
1967 Sterling
David Laird
Managing Director
Offers services ranging from on-line bureau to the development of specialised software for turnkey in-house installations.
Software/Information Management
061

INTASOFT LIMITED
60 Portland Street
Exeter
Devon EX1 2EQ
UK
(0392) 217670
1986 Sterling
M Lamb
Director
Software development, consultancy and on-site training.
Software/Applications Generators
Services/Training
062

INTEGRATED SOLUTIONS
NBI House
462 London Road
Isleworth
Middlesex TW7 4EP
UK
(01) 568 8899
1975 300M US Dollars
Steve Gills
European Technical Support Manager
Manufacturer of high-performance UNIX systems and workstations.
Hardware/Multi-user Systems
Software/Office Automation
063

INTEL SCIENTIFIC COMPUTERS LTD
Pipers Way
Swindon
SN3 1RJ
UK
(0793) 696578 Telex 444447/8
1970 1.4B US Dollars
David Moody
European Sales & Support Manager
Manufactures a range of massively parallel supercomputers. Intel is a manufacturer of computer systems and semiconductors.
Hardware/Multi-user Systems
064

JAROGATE LTD
Unit 2, HQ3
Hook Rise South
Surbiton
Surrey KT6 7LD
UK
(01) 391 4433 Telex 8950311
1978 3M Sterling
Robin Tracey
Managing Director

Manufacturer of Sprite 286/386 business computers.
Hardware/Multi-user Systems
065

JSB COMPUTER SYSTEMS LTD
Cheshire House
Castle Street
Macclesfield
Cheshire SK11 6AF
UK
(0625) 33618
1981 1.5 M Sterling
Chris Wilson
Marketing Manager
UNIX systems software house.
Software/Other Software
067

KALAMAZOO BUSINESS SYSTEMS
4-Front Computer Services
Old Court
31 Bunbury Road, Northfield
Birmingham B31 2DR
UK
(021) 477 4111
47 M Sterling
Dave Walker
Product Support Manager
Systems development, utilities, applications, support and training for the UNIX and PICK communities.
Software/Accounting
Software/Applications Generators
Services/Training
068

KDG COMPUTER SYSTEMS LTD
Axe & Bottle Court
70 Newcomen Street
London SE1 1YT
UK
(01) 403 5060
1986 1 M Sterling
N M C Brackenbury
Managing Director
Supplier of UNIX based computer systems to business and technical users. Also offer both hardware and software maintenance.
Hardware/Multi-user Systems
Software/Compilers/Languages
Software/Communications/Networking
069

KODE LIMITED
Station Road
Calne
Wiltshire
SN11 0JR
UK
(0249) 813771 Telex 449335
1962 6 M Sterling
Liz Laing
PR Assistant
Systems and peripherals distributor.
Hardware/Multi-user Systems
Hardware/Workstation Systems
Services/Consultancy
070

LANGUAGE PROCESSORS, INC
400-1 Totten Pond Road
Waltham
MA 02154
USA
(617) 890 1155 Telex 951671
1980 US Dollars
John Hurd
Vice President, Marketing
Offers a family of high-performance compilers and related software development tools for UNIX/XENIX based systems.
Software/Compilers/Languages
Software/Systems Tools
071

LATICORP, INC
185 Berry Street
Suite 6200
San Francisco
CA 94107
USA
(415) 543 1199 Telex 988522
1984 US Dollars
Linda Ware
Marketing Co-ordinator
Develops, sells and supports an integrated range of office automation software applications for computers running UNIX and MS DOS.
Software/Database Management
Software/Graphics
Software/Word Processing
Services/Maintenance
073

LEXON BV
Rupel 24
1186 LC Amstelveen
Nederland
(020) 474473
1985
L J Oostryk
Director
Software house.
Services/Consultancy
074

LOGITEK PLC
Logitek House
Bradley Lane
Standish
Gt Manchester WN6 0XQ
UK
(0257) 426644 Telex 677354
1979 Sterling
Karen Harris
Marketing Services Manager
Computer product distributor. One of the world's leading suppliers of Altos multi-user systems.
Hardware/Multi-user Systems
Services/Maintenance
075

MARI ADVANCED SYSTEMS LTD
Unit 20
Newburn Haugh Industrial Est.
Newburn, Tyne & Wear
NE15 8SG
UK
(091) 264 4588 Telex 537038 MARI G
1986 540k Sterling
M C Dawson
Technical Services Manager
Hardware/Multi-user Systems
Software/Communications/Networking
Software/Database Management
Software/Manufacturing
Software/Office Automation
Software/Word Processing
Services/Consultancy
076

MD/8
35 Upland Road
South Croydon
Surrey CR2 6RE
UK
(01) 688 5794
1987 Sterling
D E Forbes
Partner
Hardware and software systems house. Commercial projects, VME bus support and compiler development.
Hardware/Multi-user Systems
Software/Accounting
Services/Consultancy
077

MEGADATA CORPORATION
35 Orville Drive
Bohemia
NY 11716
USA
(516) 589 6800 Telex 144659
1966 12 M US Dollars
Dick Adams
Marketing Manager
Manufacturer of UNIX computers, intelligent display terminals, communications controllers and multiplexors, all based on the 68xxx microcomputer family.
Hardware/Multi-user Systems
079

MICROPROCESSOR DEVELOPMENTS LTD
3 Canfield Place
London NW6 3BT
UK
(01) 328 2277 Telex 945978 MPD UK
1981 Sterling
Mark Crowther
Marketing Assistant
British based software house, authors and distributors of Sculptor 4GL and related products.
Software/Applications Generators
080

MICROTEC RESEARCH
Frances Road
Basingstoke
Hampshire RG21 3DA
UK
(0256) 57551 Telex 858893
1974 Sterling
Hugh Griffiths
Director
Software House (cross development software for microprocessors).
Software/Compilers/Languages
Services/Training
081

MIMER INFORMATION SYSTEMS AB
P.O. Box 1713
S-751 47 Uppsala
Sweden
+46 18 18 50 00 Telex 8195006 mpc
1984 100M Swedish Kr
Sven G. Johansson
President
Swedish company which develops, manufactures, sells and supports the MIMER DBMS and 4GL tools.
Software/Database Management
082

MIPS COMPUTER SYSTEMS
Mountbatten House
Victoria Street
Windsor
Berks SL4 1HE
UK
(0753) 857181 Telex 849011 mntbtn g
1984
Jamie Muir
Managing Director and Company Secretary
International value added reseller and OEM supplier of RISC based chips, boards and systems to the computer industry.
Hardware/Multi-user Systems
Software/Compilers/Languages
Software/Communications/Networking
083

MORTICE KERN SYSTEMS INC.
43 Bridgeport Road East
Waterloo
Ontario
N2J 2J4
Canada
+1 519 884 2251
1983 500k+ US dollars
Ruth Songhurst
Vice President, Business Services
UNIX software development house.
Hardware/Multi-user Systems
Software/Systems Tools
085

MOTOROLA COMPUTER SYSTEMS
27 Market Street
Maidenhead
Berkshire
SL6 8AE
UK
(0628) 39121
1982
Software/Operating Systems/Enhancements
086

NAG LTD
Mayfield House
256 Banbury Road
Oxford
OX2 7OE
(0865) 511245 Telex 83354
1976
Susan Ing
Sales Executive
Mathematical and statistical software for use in engineering and scientific environments.
Software/Scientific/Technical
087

NATIONAL SEMICONDUCTOR GMBH
Industriestrasse 10
D-8080 Fuerstenfeldbruck
West Germany
+49 8141 103 325 Telex 527 649 nsc d
1959 1.5 bn US Dollars
Nicholas J Maddicks
Product Marketing Manager
Designs, builds and sells the integrated computer module (ICM) to the OEM market.
Hardware/Multi-user Systems
Hardware/Workstation Systems
088

NCR LTD
206 Marylebone Road
London
NW1 6LY
UK
(01) 725 8479 Telex 263931
1884 173.2M Sterling
Steve Cooper
Tower Product Manager
Develops, manufactures, markets, installs and services business information processing systems for worldwide markets.
Hardware/Multi-user Systems
Software/Information Management
091

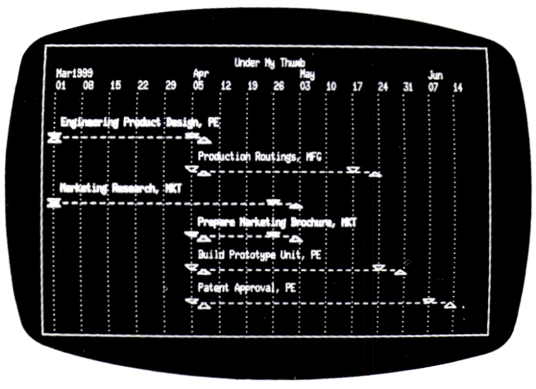
NEW TECHNOLOGY ASSOCIATES INC
314 S.E. Riverside Drive
Evansville
Indiana 47713
USA
+1 812 422 4525
1984
Steven A. Eberhart
President
Computer services company specialises in multi-user systems for industrial and business applications.
Software/Office Automation
092

NIXDORF COMPUTER LIMITED
125-135 Staines Road
Hounslow
Middlesex
TW3 3JB
UK
(01) 570 1888 Telex 934030
1952 3.153M Deutschmarks
Paula Schmidt
Marketing Communications Department
Supplier of computer solutions.
Hardware/Multi-user Systems
Hardware/Workstation Systems
Software/Database Management
093

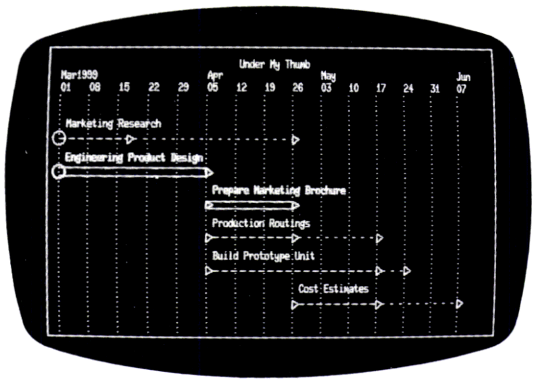
Prothos™
Project Management Software

Prothos is a full project management system which provides today's manager with the tools for planning, tracking and controlling all aspects of a project. More than just a schedule tracking and control system, **Prothos** also has utilities for controlling direct costs and labor resources.

Prothos features PERT/CPM and Gantt charts, Budget Forecast graphs, Performance to Budget and Summary reports. All charts can be displayed on both graphics and non-graphics devices.



The **Prothos** reporting function provides a detailed analysis of actual performance versus the original project plan for all work to date, as well as, planned activities for the remainder of the project duration.



Prothos is a user oriented, menu-driven package that is available for many of the popular mini and microcomputer systems running UNIX or UNIX-like operating systems. It features on-line help, data validation, and formatted data entry/update screens.

Graphics Drivers

Our commercial software packages produce output which can be displayed by the standard UNIX plot filters and are system independent. For those systems without the necessary graphics drivers, we also provide graphics filters for the Hewlett Packard pen plotters, Genicom 3310 and DEC LA100 dot matrix printers, DEC VT240/ VT241 graphics terminals.

NEW Technology Associates, Inc.
P.O. Box 9227 • Evansville, IN 47710 • USA
(812) 422-4525

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Circle No. 283

NORSK DATA LTD
Benham Velence
Newbury
Berkshire
RG16 8LU
UK
(0635) 35544 Telex 849819 NORSKD G
1967 2.6B p N.Krone
Geoff Butcher
Marketing Manager (UK)
Manufacturer of 16 bit mini and 32 bit supermini computers.
Hardware/Multi-user Systems
094

OASYS (A DIVISION OF XEL INC)
60 Aberdeen Avenue
Cambridge
Massachusetts
MA 02138
USA
+1 617 491 4180
1982
Mr Paul Ray
VP - Sales
Markets wide range of software and hardware development tools. Enhancement, integration and maintenance across range.
Hardware/Personal Systems
Software/Compilers/Languages
Software/Systems Tools
095

OFFICESMITHS INC
331 Cooper Street
Ottawa
Ontario K2P 0G5
Canada
(613) 235 6749
1981
Colin Hawkins
Manager International Sales
Develops and distributes software products for document based applications in large organisations
Software/Database Management
097

OLYMPUS SOFTWARE, INC.
1733 South 1100 East
Salt Lake City
UT 84105
USA
+1 801 487 4534 Telex 1784455
1981
Cary Petterborg
Product Manager
Computer software developer.
Software/Office Automation
098

ORACLE CORPORATION UK LTD
Thames Link House
1 Church Road
Richmond, Surrey
TW9 2QE
UK
(01) 948 6911 Telex 923842
1983 7.6M Sterling
Mike Evans
Sales & Marketing Director
Supplier of relational database systems and 4th generation software development tools.
Software/Applications Generators
Software/Database Management
099

PA CONSULTING GROUP
Computer Aided Engineering
Cambridge Laboratory
Melbourn, Royston
SG8 6DP
UK
(0763) 61222 Telex 81561
1943 110M Sterling
Dr A.W. Bishop
Business Director - Software
International management and technology consultancy.
Software/Database Management
Software/Other Software
100

PENNINE COMPUTER COMPANY LIMITED
Office Park 41
Dean Clough
Halifax
West Yorks HX3 5AX
UK
(0422) 41719 Telex 51469 dcop g
1981 1M Sterling
Jeff Turner
Support Director
Services/Training
101

PH INTERNATIONAL
34 Rue de Miromesnil
Paris 75008
France
(+1) 42 65 7901 Telex 281141 F PHC
1984 5M Francs
Georges Benzimra
Responsable Commercial
Involved in Software distribution, consultancy and computer services.
Software/Communications/Networking
Services/Consultancy
103

PHILIPS EXPORT BV
Building HKA
Eindhoven
5600 MD
Nederland
+31 40 784321 Telex 35000 PHTC-NL
Guilders
Hardware/Multi-user Systems
Software/Communications/Networking
Software/Operating Systems/Enhancements
104

PRIMAGRAPHICS LTD
Melbourn Scence Park
Melbourn, Royston
Hertfordshire
SG8 6EJ
UK
(0762) 62041
1982
Chris Childs
General Manager
Manufacturer of graphics display systems, VME boards, terminals and workstations.
Hardware/Workstation Systems
105

PRIOR KNOWLEDGE SYSTEMS LTD
1-5 The Horsefair
Romsey
Hampshire
SO51 8EZ
UK
(0794) 515522 Telex 47125 PKS G
1986
Martin Prior
Managing Director
Manufacturer of UNIX based multi-user computer systems.
Hardware/Multi-user Systems
106

PRODUCTIVITY PRODUCTS INTERNATIONAL
27 Glen Road
Sandy Hook
CT 06482
USA
+1 203 426 1875 Telex 506127
1983
Stacey A. Wildenberg
Supervisor, Sales Support
Develops and markets an object-orientated software engineering environment and tools for C programmers.
Software/Compilers/Languages
107

PRO-LAB PLC
Mount Pleasant House
Huntingdon Road
Cambridge
CB3 0BL
UK
(0223) 323151 Telex 81181
1985 5M Sterling
Bruce Levitt
Distribution Manager
Responsible for the marketing, support and development of the PRO-IV 4GL application generator.
Software/Applications Generators
109

PYRAMID TECHNOLOGY LIMITED
St. James House
Knoll Road
Camberley
Surrey GU15 3SY
UK
(0276) 63474 Telex 59056
1982 45M US dollars
David Thornley
Regional Director - Northern Europe
Manufacturer of proprietary supermini computers for UNIX based applications.
Hardware/Multi-user Systems
110

QUADRATRON A.G.
Rathaus
CH-9001 St. Gallen
Switzerland
+41 171 20 85 50 Telex 71550
1984
Marco Palatini
Marketing Manager
Computer software.
Software/Office Automation
111

REAL TIME SYSTEMS LIMITED
P.O. Box 70
Viking House
Nelson Street
Douglas, Isle of Man
UK
(0624) 26021 Telex 946240 cweasy g
1979 1M Sterling
Dr. Malcolm O. Norris
Marketing Manager
Systems software house, supplying a wide range of portable software, incuding C compilers and assemblers.
Software/Compilers/Languages

Software/Operating Systems/Enhancements
Software/Systems Tools
Services/Training
112

REDWOOD INTERNATIONAL LIMITED
Chaucer House
4-6 Upper Marlborough Road
St.Albans
Herts AL1 3UR
UK
(0727) 40601 Telex 266999 rdwood g
1981 3M Sterling
Les Ferrington
Sales Director
UNIX software design and marketing.
Software/Office Automation
113

RELATIONAL TECHNOLOGY *
Anchor House
15-19 Britten Street
London
SW3 3TY
UK
(01) 351 7722 Telex 947086
1980
Susan Plastow
Marketing Executive
Developer and distributor of the INGRES relational database management and application development system for mainframe, mini and micro computers.
Software/Database Management
115

RHODNIUS S.A. - EUROPE
69 rue du Rhone
CH-1207 Geneva
Switzerland
+41 22 35 40 70 Telex 27024 mrns
1985 2.4M US Dollars
Georges Rezwiakoff
President
Develops, markets and supports a line of software tools.
Software/Database Management
116

ROOT COMPUTERS LIMITED
Saunderson House
Hayne Street
London
EC1A 9HH
UK
(01) 606 7799 Telex 885995 root g
1980 5M Sterling
Tom Norris
Marketing Manager
Software house for UNIX products.
Software/Compilers/Languages
Software/Office Automation
Software/Systems Tools
Software/Word Processing
117

SAFE COMPUTING LTD
89-91 High Street
Leicester
LE1 4JB
UK
(0533) 29321
1973 4M Sterling
J. Everington
Marketing Manager
Specialists in computer systems for the manufacturing industry.
Software/Manufacturing
118

SAMNA INTERNATIONAL LTD
South Bank House
Black Prince Road
London
SE1 7SJ
UK
(01) 587 1121 Telex 295555 LSP G
1985 Sterling
Charles Hall
Director
Development, marketing, support and training of word-processing/office automation software.
Software/Word Processing
119

SEQUENT EUROPE
1 Martindale Road
Hounslow
Middlesex
TW4 7EW
UK
(01) 570 2066 Telex 946114
1983 2M US Dollars
Bill Jordan
Sales Analyst
Manufacturer of high-performance parallel computers.
Hardware/Multi-user Systems
121

SERVICE IN INFORMATICS AND ANALYSIS LTD
Ebury Gate
23 Lower Belgrave Street
London
SW1W 0NW
UK
(01) 730 4544 Telex 916635
1968 8M Sterling
Janice Mabert
Manager, Marketing Unit
Software development and consultancy services in engineering, information technology and business systems.
Software/CAD/CAM/CAE
Software/Database Management
Software/Information Management
122

SIEMENS LTD
Data Systems
St. Catherine's House
2 Hanworth Road
Feltham TW13 5BA
UK
(0932) 785691 Telex 8951091
1858 DM 50Bn Deutschmark
B. V. Foot
Product Marketing Manager, Small Business Systems
Electronics and electrical manufacturer and information technology company.
Hardware/Multi-user Systems
Hardware/Personal Systems
Software/Operating Systems/Enhancements
123

SOFTWARE IRELAND LIMITED
26 Linenhall Street
Belfast
Northern Ireland
(0232) 247433 Telex 747327
1979 1M Sterling
Gordon Bell
Managing Director
Software/Compilers/Languages
Software/Operating Systems/Enhancements
Software/Systems Tools
124

SPHINX LIMITED
43-53 Moorbridge Road
Maidenhead
Berkshire
SL6 8PL
UK
(0628) 75343 Telex 849812
1983 3.5m Sterling
Mike Maunder
Marketing Director
Provide a one-stop shop service for professional users of UNIX/XENIX products.
Software/Applications Generators
Software/Compilers/Languages
Software/Communications/Networking
Software/Database Management
Software/Education
Software/Financial Planning
Software/Graphics
Software/Office Automation
Software/Operating Systems/Enhancements
Software/Systems Performance
Software/Word Processing
Services/Consultancy
125

SPSS EUROPE BV
PO Box 115
4200 AG Gorinchem
Nederland
1984 Sterling
Joost Rombouts
Sales Support manager
Devlopment and distribution of software for data analysis, tabulation, report writing, graphics and mapping.
Software/Mathematical/Statistical
127

STATISTICAL SOFTWARE LTD
Cork Farm Centre
Dennehy's Cross
Cork
Ireland
+353 21 42722 Telex 75659 SSWL EI
1984 Sterling
Mary Byrne
General Manager
Wholly owned subsidiary of BMDP Statistical Software Inc with responsibility for distribution/support throughout Europe, the Middle East and Africa.
Software/Mathematical/Statistical
128

STRUCTURED METHODS INC
7 West 18th Street, 5th floor
New York
NY 10011
USA
+1 212 741 7720
1977 850k US Dollars
William Jensen
Sales Manager
Services/Training
129

SUN MICROSYSTEMS UK LTD
Sun House
31-41 Pembroke Broadway
Camberley, Surrey
GU15 3XD
UK
(0276) 62111 Telex 859017
1982 210M US Dollars
Mrs S. Crozier
Marketing Assistant
Hardware/Multi-user Systems
Hardware/Workstation Systems
130

SYSTEMS AND TELECOMS LTD
Pheonix House
1 Station Hill
Reading, Berkshire
RG1 1NB
UK
(0734) 500451 Telex 849921 SYSTEL G
1980 Sterling
Donald McDonnell
Unix Sales Executive
Supplier of communications software, packages for Telex and message handling on major operating systems.
Software/Communications/Networking
131

SYSTIME COMPUTERS LTD
Systime House
Leeds Business Park
Morley, Leeds
LS27 0NH
UK
(0532) 529292 Telex 556283
1973 10M Sterling
Eric Rainbow
Technical Products Group Manager
Developer and manufacturer of multi-user micro and mini computers and terminals.
Hardware/Multi-user Systems
Software/Accounting
Software/Compilers/Languages
Software/Manufacturing
Software/Office Automation
Software/Operating Systems/Enhancements
133

SYSTEMS UNION LTD
Northampton Lodge
Canonbury Square
London
N1 3AN
UK
(01) 354 3131 Telex 261507
1981 1M Sterling
H. Bruce
Director
Software house.
Software/Accounting
Software/Database Management
134

TELEVIDEO SYSTEMS INTERNATIONAL BV
Saturnusstraat 25
Hoofddorp
2132 HB
Nederland
(31) 2503 35444 Telex 74615
1976 100M US Dollars
Han Klinkspoor
General Manager
Manufacturer of video display terminals, microcomputer systems and local area networks based on microcomputers.
Hardware/Multi-user Systems
Hardware/Workstation Systems
135

TERMINAL DISPLAY SYSTEMS LTD
Lower Philips Road
Whitebirk Industrial Estate
Blackburn, Lancashire
BB1 5TH
UK
(0254) 676921 Telex 635693
1974 6M Sterling
Stephen Gaskell
Marketing Manager - Imported Products
Manufacturer of industrial colour displays and digitisers. Distributor of high resolution colour graphics systems, supermicros and drawing capture systems.
Hardware/Multi-user Systems
Software/Operating Systems/Enhancements
136

THE INSTRUCTION SET
City House
190 City Road
London
EC1V 2QH
UK
(01) 251 2128 Telex 295467
1984
Simon Hawken
Business Development Manager
Systems house, specialising in system level software such as UNIX and providing a full range of information technology transfer services.
Software/Communications/Networking
Software/Operating Systems/Enhancements
Services/Consultancy
Services/Other
Services/Training
137

THE INT'L MARKETING & MANAGEMENT GROUP
Amsterdamsestraatweg 23
1411 AW Naarden
Nederland
+31 2159 40697 Telex 73413 CEMO NL
1983
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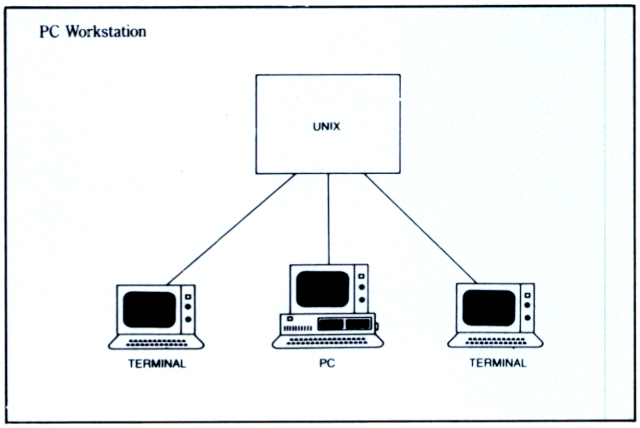

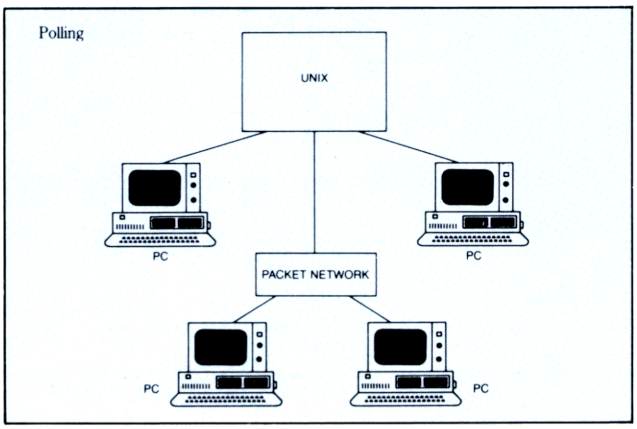

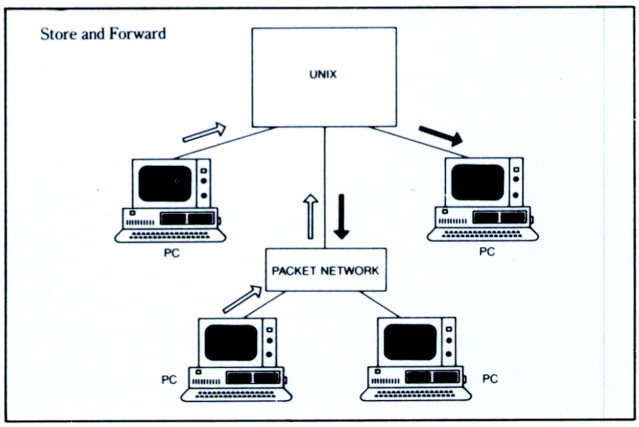

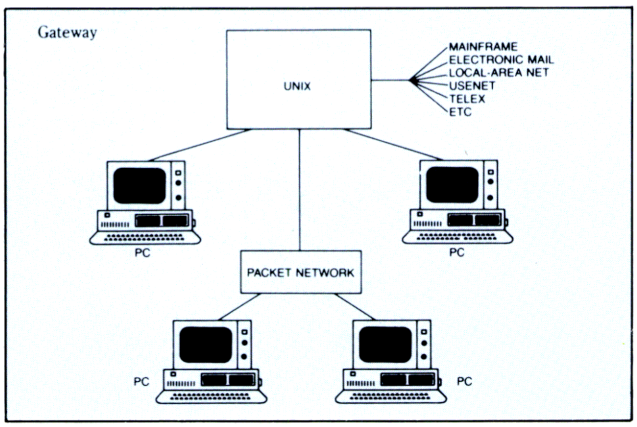

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HARDWARE SECTION

FEATURES

Image Processing 35
Once upon a time, UNIX was conceived as an operating system for a single user workstation. Over the last few years, the moves have been towards more and more general purpose operating systems: one vendor – MASSCOMP – has planned products around the real-time user of UNIX. We look at some of the facilities available for creating and controlling real-time applications under UNIX.

Really Big Unix 49
UNIX was introduced originally as a single user operating system, MULTICS for multi-users, UNIX for single. SEQUENT has recently introduced a sophisticated multi-processor configuration for UNIX which has received widespread acclaim, and a considerable amount of interest.

Workstations for the 90's? 52
SUN, APOLLO, DEC and IBM will be the major suppliers of Workstations in the 90's. Product offerings from the major four are examined in this article.

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NOTE: Each company listed in the Master Suppliers Index (MSI) offering hardware products is further listed within these tables. Hardware types are grouped as above.

For further information on the companies listed in the Hardware Product tables complete the card at the end of the Master Suppliers Index.

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IMAGE PROCESSING –
Creating Real-Time Applications

MASSCOMP can claim to be the only company producing a version of UNIX™ which supports both Real-Time and Multiprocessor applications. The software is called RTU™ and this document will provide an introduction to these capabilities. Topics covered in this article by Steve Mullen include: Virtual Memory Concepts, DA/CP (Data Acquisition and Control Processor) Support, Real-Time UNIX Operation, Use of C and FORTRAN, and Programming Real-Time Applications.*

Virtual Memory Concepts

In the past, real-time applications were written for mini- and micro-computers which did not have virtual memory. In a virtual memory computer the user's program is handled by the hardware and operating system as a set of 4K byte "pages".

Each program consists of one, or more, processes. Part of each process includes several tables:

1. Text/Data Page Table – this table contains a list of the Text (code) and Data pages that are part of the process. The Data pages are located "below" the Text pages.

2. Stack Page Table – this table contains a list of the Stack pages for the process. A processes' stack grows "upward" toward the Data and Text pages.

3. System Data Segment – holds items such as saved processor registers, accounting information and a scratch pad area.

Demand Paging

Upon each Page Fault (Page Miss) the operating system selects one (or more) pages to be placed on disk and then brings the required page(s) into memory from disk. (Pages selected to be removed are ones which have not recently been referenced). The number of pages for each process that are kept in memory is a function of how much total memory is required by all the processes currently running on the system. As the total requirement increases, fewer pages for each process can be kept in memory. In general, a heavily loaded memory can use an increased rate of paging.

Swapping

If the paging rate becomes too large, an entire process (except for certain tables) is swapped-out to disk. The process to be chosen is one which is waiting for slow (non-disk) I/O, is not currently running, and has been in memory for the longest period.

DA/CP Support

The DA/CP and all of its analog and digital interfaces are fully supported by a MASSCOMP library of subroutines. This library may be used by both C and FORTRAN programs. When this library is used it makes use of several of special RTU capabilities. The user's program is paged locked automatically and Asychronous System Traps (AST's) are utilised to provide "completion routine" support to the user's program.

The DA/CP library provides a special facility called "bus window mode". This mode enables a C or FORTRAN program directly to access registers on STD devices. This allows STD bus cards to be purchased and supported without writing DA/CP assembly language code.

In special cases, MASSCOMP interfaces (as well as STD cards from other vendors) may need to be controlled in ways not available from the library of MASSCOMP subroutines. In this case the user can write code for the DA/CP using the DA/CP Assembler. This assembler is easy to use because it makes the DA/CP look like a popular minicomputer. Once the code is assembled and loaded into the DA/CP, it can be debugged using the debugger supplied with the assembler.

Real-time Operation

Real-Time programming is characterized by the need to respond to events in the "real world" - events that will not wait. RTU has been designed to provide the fastest possible response to real-world events. In order to create real-time applications it is important to understand how RTU handles such events.

* Suppose a real-time application is executing with a priority higher than all other user processes, but is waiting for an event. During this waiting period, the operating system allows other processes to run. When an event arrives there is an interval during which the operating system must:

    1. Restore the real-time process to the list of "runnable" processes.

    2. Stop the currently executing process.

    3. Begin the execution of the real-time process.

  This interval defines the system **context switch time.**

* There are system requests which, once started, must run to completion before calling process can be swapped out and a different process substituted. The **system service preemption time** is the maximum amount of time such system calls can consume. This time must be added to the context switch time in determining how long a real-time application may have to wait from the sensing of some event to the actual resumption of the execution of the process which will handle this event.

* The operating system must periodically service hardware interrupts. These may come, for example, from I/O devices signaling completion of an I/O operation. When an interrupt is received, the operating system must respond to it. This **interrupt service time** represents an interval during which real-time processes cannot execute.

* The operating system performs certain background tasks on a regular basis. For example, every second the scheduler scans the list of runnable processes and makes a determination whether to substitute a different process for the one currently running. In addition, most systems run the **cron,** or "clock daemon", which checks a table every second for a list of commands to execute in the background. (However, **cron**, may be selectively disabled). Background tasks, if present, can add to the potential delay of a real-time response.

The mechanism by which an external event is sent to a process is called an Asychronous System Trap (AST). This mechanism, and the latencies involved in its use, are more fully described in the section on AST's.

Use of C and FORTRAN

The examples shown in this paper are in C. The FORTRAN programmer is not, however, prevented from developing real-time applications. MASSCOMP has made many UNIX system requests available in a FORTRAN callable library. Whenever a system request name appears in this document in uppercase the routine is part of this FORTRAN library and may be executed by a CALL statement in the same manner as any FORTRAN subroutine.

However, by following a very simple calling convention it is also possible to call all UNIX requests from a FORTRAN program. A C subroutine can be directly called by appending a "$" to the name of the routine. A MASSCOMP provided function, %VAL0, enables the value of a variable to be passed to a C routine by "value" as is required by C convention. The following example shows how the *open, read,* and *write* UNIX requests can be called by a FORTRAN program.

```
      INTEGER OPEN$, READ$,
      WRITES$
      CHARACTER BUFFER (512)
      I = OPEN$(%VAL("/usr/dict/
      words"), %VAL(0))
      IF (I .LT. 0) THEN
        PRINT *, 'Open failed'
      ENDIF

10    CONTINUE
      N = READ$(%VAL(I), BUF-
      FER,%VAL(512))
      IF (N.LE.0) GOTO 20
      N= WRITE$(%VAL(I), BUF-
      FER,%VAL(512))
      GOTO 10
20    STOP
      END
```

Programming Real-Time Applications

Process Creation

The following two system requests can be used to create a processes:

1. *fork* – makes an exact copy of the current process and starts it running (also FORK).

2. *exec* – replaces the current process with a different process.

These two requests enable a process to "spawn" a different, new process (*vfork* – may be used rather than *fork* when the *fork* will be immediately followed by *exec.*).

Processor Control

A process can start another process running on a different processor, by the following technique.

1. The original process (running on one of the system's processors) issues a *fork* or *vfork* which causes an exact copy of itself to start running on the same processor. After the *fork* the code checks (using *getpid* or GETPID) its own process ID. If the ID is non-zero, then the process knows it's the "parent". If it's zero, then it knows it's a "child".

2. The child process then issues an *exec* which causes a new process to replace the child process. Now two different processes (parent and child) are running on the same processor.

3. The child process then issues an *mpadvise* request which specifies upon which processor the child can execute. If the new processor is different from the current one, the process is moved to the one specified.

The *mpadvise* request is a very simple request. The following example causes the current process to only run on CPU #2"

```
mpadvise
(MPA—CPU-SET,CPU2);
```

The next example causes the current process to run on either CPU #3 or CPU #4 (UNIX handles the scheduling):

```
mpadvise
(MPA—CPU—SET,CPU3|CPU4);
```

It is important to understand that the mechanisms for process creation (*fork, vfork, exec, etc.)* and process communication (signal, AST, etc.) are the same whether the process involved are running on the same or on different processors. This is what MASSCOMP means by *Transparent Multiprocessing*.

Process Communication

A parent process may need to communicate with its children, and the children may need to communicate amongst themselves. Two different sets of mechanisms are necessary to accomplish inter-process communication. One set of mechanisms support the actual passing of information between processes. The other set of mechanisms support the synchronization of the communication. Information can be passed using five mechanisms: **files, pipes, sockets, messages,** and **shared memory.**

Files – Files are a very easy way to share information , but the information exchange rate may be too slow for real-time applications.

Pipes – A pipe is a non-duplex, FIFO implemented in virtual memory. One process can "write" data to a pipe and another process can "read" this data. Pipes are a simple mechanism, and because memory is utilised, are quite fast. If, however, large buffers of data need to be communicated, or shared, then shared memory is more optimal. To establish a pipe, the *pipe* request can be used:

```
int stat,
fd[2],n—written,n—read,n;
char buf[];
stat = pipe(fd);
```

Bytes can be sent (n = number of bytes):

```
n—written = write (fd[1], buf,n);
```

Bytes can be received (n – number bytes desired):

```
n—read = read(fd[0],buf,n);
```

If the pipe is full (4096 bytes) the process waits at the *write* until the requested number of bytes can be moved into the pipe. The value that niread returns is the number of bytes (up to n) that were available in the pipe. Unless "non-blocking I/O" is utilized, the reading process will "wait" until there is data available to be read. A pipe can be removed by using the *close* request:

```
close(fd[0]);
close(fd[1]);
```

Although file descriptors are returned by *pipe* for both reading, fd[0], and writing, fd[1], a pipe is a half-duplix device that, at any one time, can only move data in only one direction.

The *read* and *write* requests move a specified number of bytes as a block. The *sscanf* and *sprintf* requests can be used to effect "formatted" read and write through a pipe. (In this case the data in buf is treated as a text string).

Sockets – Operate much like a pipes except that the processes can be on different computers connected by Ethernet™

Messages – A process can create a "mailbox" into which another process can deposit a message.

Messages are queued until the receiving process removes the message.

1. A process can create a message queue with the *msgget* request which returns an ID.

2. Using the requests *msgsnd* and *msgrcv* processes can send and receive messages. The ID numbers are used to "address" the mail.

3. The status of a message queue can be obtained using *msgctl* , and removed by using *ipcrm.*

Shared Memory – Allow two, or more, processes to share a segment of memory. Two different shared memory mechanisms are available: AT&T System V™ and MASSCOMP.

The AT&T shared memory mechanism utilizes the *shmget* request to create a shared memory segment of some specified size and then return an ID. Any process that has the ID can read and write into the shared segment. Before it can do so, however, it must attach the segment to its own virtual address space. The *shmat* request will attach a segment, while the *shmdt* request will detach a segment. Status information can be obtained using *shmctl*, and the shared memory segment can be removed by using *ipcrm*.

The MASSCOMP shared memory mechanism not only allows memory to be shared, but enables a process to access memory and registers on Multibus™ devices. The MASSCOMP mechanism can be used in the following manner:

1. First, specify a non-zero value for the **RESMEM** parameter in the System Configuration File. This value specifies the number of pages to be reserved for sharing. Then the pages must be declared to be "external" by entering **extmb** (base page number) and **extml** (segment length) specifications in the System Configuration File. Each segment is numbered starting at zero, and there can be up to three segments. For example, on a 5400 with 2MB, the base page number is **0x3fc** (the base address is **0x3Fc000**). If the number of pages to be reserved is four, then the entries would be:

   extmb0 0x3fc

   extm10 4

   If a portion of Multibus address space needs to be accessed, the **extmb** parameter is set to the base page number of this space. The **extml** parameter specifies the number of 4K byte pages involved. An example of a device with Multibus memory is the frame buffer of a video digitizer.

2. A process can map any portion of a segment into its virtual data space by using the *pmapm* request. This can be done as follows:-

   pmapm(addr,size,dst);

   The virtual base address in the user's Data segment is specified by **addr,** while **size** specifies the length (in bytes) of the shared area, and **dst** specifies the base address of the reserved area to be shared.

   The value of **addr** can be obtained in a FORTRAN program by using the LOC subroutine. This routine provides the virtual base address of an array whose name is supplied as the argument to LOC. Typically the array will have been made global by including its name in a COMMON statement. Because **addr** must lie on a page boundary (i.e. must be evenly divisible by 4096) a slightly more complicated procedure must be followed. First, the array must be declared to be 4096 bytes larger than required by the program. Then the value returned by LOC must be "rounded-up" (by up to 4096) so that it is evenly divisible by 4096.

   The value of **dst** is simply the address that corresponds to the page number specified in the **extmb** definition. For example, if the page number was **0x3fc**, then the address is **0x3fc000**.

   In a C program the value of **addr** can be obtained using the *sbrk* request to extend the program's data segment. Then the value of **addr** must be rounded-up so that it points to a page boundary. Once the shared segment has been mapped into a processes' data space, the variable **addr** can be used as a normal array variable.

   A segment can be unmapped by a *punmap* request.

Process Synchronisation

There are three process synchronisation mechanisms: **signals, AST's,** and **semaphores.**

Signals – A process can catch a signal and ignore it, terminate itself, or execute a "signal handling" routine. The *signal* (or SIGNAL) request handles signals. A process can send a signal using the *kill* (or KILL) request. The operating system can also send signals (such as from a CTRL/C).

When using 4.2 bsd signals, if three or more signals arrive almost simultaneously, the third and successive signals will be lost. When using AT&T signals, if two signals occur in rapid succession the process will be terminated.

When the signal request is issued, one parameter specifies the signal to be caught (there are 32 possible signals) and the other specifies the address of a function (subroutine) to be "called" when the specified signal arrives.

AST – An Asynchronous System Trap is the software analog of a priority interrupt. When one process sends an AST to another, its priority, as well as the current priority of the receiving process, determines whether the receiving process will be "interrupted". AST's are sent with the *—sendast* request:

—sendast (pid, lohandler, hihandler, param, priority);

pid – The process ID of the process to which you are sending the AST.

lohandler – The address of the low-level AST handler in the receiving process. For C programs this is *—asthandler.*

hihandle – The address the subroutine in the receiving process which will actually handle the AST.

param – An integar value that is sent to the receiving subroutine.

priority – Specifies the priority of the AST. If it is greater than the priority of the receiving process, then the AST is delivered; else it is queued. Queued AST's are not lost. AST's, unlike signals, are reliable. The following describes how one process interrupts another using an AST:

1. The sending process must obtain (via, for example, a pipe) the ID of the receiving process, and the address of **lohandler** and **hihandler.** These can be obtained as follows:-

   ```
   int pid, lohandler, hihandler,
   —asthandler, userhandler;
   pid = getpid ();
   lohandler – (int —asthandler;
   hihandler = (int) userhandler;
   ```

2. An AST handling subroutine must be defined in the receiving process:

   ```
   int param, oldpc, oldpri;
   userhandler(param, oldpc, oldpri)
   ```

3. The receiving process can run at default AST priority zero; or it can set its priority using the *setpri* request.

4. Whenever the sending process wants to send an AST it uses the *—sendast* request. It can set the values of **param** and **priority** as is appropriate.

5. Once the AST has been sent, the sending process continues to execute.

6. If the AST priority is higher than the current priority of the receiving process then *——asthandler* automatically "interrupts" the flow of the process and calls **userhandler.** When it calls **userhandler** it supplies values for **oldpc** and **oldpri** (which can be ignored). It also supplies the value of **param** which has been sent along with the AST.

7. The **userhandler** process runs at the value determined by the AST **priority** parameter.

8. When **userhandler** has accomplished its task, it issues a **return.** Automatically the receiving process continues its execution at the point where it was interrupted (at its previous priority).

AST's are typically posted by a device driver to some user process upon receipt of an interrupt from the device. The next section describes what can happen between the time the device interrupts and the time

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SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
MULTI USER SYSTEMS			
ABS COMPUTERS LTD Model 900	**RISC, 32bit** 4Mb System V.3, BSD 4.2	**3Mips** Multibus	C language, Nroff, Documenters workbench and standard Unix utilities.
AES DATA (UK) LTD AES 7600-16	**68010** 1Mb/8Mb System V.2 NCR release 3.0	**10Mhz/0.7Mips** Seperate buses	C, Fortran-77 languages, VI, ED, System admin, Menus, Systems Accounts, TTY, UUCP, CU utilities. **£16,000 £58,000**
AES 7600-32	**68020** 2Mb/16Mb System V.2 NCR release 1.02	**16.7Mhz/2Mips** Seperate buses	C, Fortran-77 languages, VI, ED, System admin, Menus, Systems Accounts, TTY, UUCP, CU utilities. **£20,000 £150,000**
AMS SYSTEMS & SOFTWARE LTD	**68010/68020** 1Mb/16Mb System V.2, V.3	**12.5Mhz** VME, SCSI	
ANDOR SYSTEMS (UK) LTD	**68020** 1Mb/24Mb System V	**12.5Mhz/3Mips** VME	C, Cobol, Fortran, Pascal, Basic languages. **£5,500 £18,000**
ARCAID HARDWARE LTD Opus 100 & 300 systems	**32020, Clipper** 1Mb/16Mb System V, V.2 R2 and R3	**10Mhz/1-5Mips** PC Bus	Allows IBM PCs & compatibles to be upgraded to Unix V2 or V3 to provide multi-user business systems/workstations **£1,700 £11,000**
ARMSTRONG MICRO ELECTRONICS Armstrong Cavalier	**68010/68020** 2Mb/8Mb	**12.5-16Mhz/3Mips** VME V.2	C, SVS Fortran, PAscal Basic, Ace Cobol, Level II Cobol Et, RM/Cobol languages, Uniplex II, Uniplex II Plus. **£15,000 £30,000**
BLEASDALE COMPUTER SYSTEMS PLC	**68020** 1Mb/16Mb Uniplus V	**16Mhz/** MultiBUS I	C language and all standard Unix utilities. **£10,000**
BLK BUSINESS SERVICES LTD	**68000,68010,68020** 1Mb System V.2, V.3	**12-16.67Mhz** 32bit Multibus	**£13,000 £300,000**
BRITISH OLIVETTI LTD Olivetti - AT&T 3B1	**68010** 1Mb/4Mb System V	**10Mhz** 16/32 bit	Unix system V Core package, 3B1 User Agent Menu and Windowing System. **£4,095 £8,995**
3B2/600	**WE 32100** 4Mb/16Mb System V.3	**18Mhz/2.2Mips** Proprietry AT&T Bus	Operating system Core utilities bundled with the hardware.

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
BRITISH OLIVETTI LTD 3B2/300	**WE 32100** 0.5Mb/4Mb System V.2, V.3	**7.2Mhz/0.6Mips** 32/32	Operating system Core utilities bundled with the hardware. **£7,495 £12,595**
BRITTON LEE (EUROPE) LTD	**Prop. Database m/c**2Mb/6Mb	**10Mhz**Proprietary	IDL (Quel), SQL, C, Fortran, Cobol languages. 4GLs. **$55,000 $150,000 US Dollars**
COMPASS PERIPHERAL SYSTEMS Culler PSC	**Culler CPU**8Mb/96MbBSD 4.2	**200ns/15Mips 10Mflops**VME	C, Fortran languages. **£99,500 £135,000**
Parallel 500XR	**68020**2Mb/8MbBSD 4.2	**16Mhz/3Mips**Multibus	C language. **£30,000 £68,400**
COMPASS PERIPHERAL SYSTEMS Sequent Balance	**32032** 2Mb/32Mb BSD 4.2, System V extensions	**0.8 Mips** Multibus	C, Lisp Languages, PdBx - parallel debugging tool and parallel programming library utilities. **£47,127 £98,000**
COMPUTER CONSOLES (EUROPE)	**Power 6/32 Family** 4Mb/16Mb System V.2, BSD 4.2	**5,8,15 Mips** Versa Bus	Cobol, Basic, Fortran, Pascal, C Languages and OfficePower text utility. **$70,000 $250,000 US Dollars**
CONVERGENT TECHNOLOGIES (UK) LTD S/120	**68020** 5Mb System V.3	**12.5Mhz/2Mips**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
S/220	**68020** 5Mb System V.3	**12.5Mhz/2Mips**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
S/320	**68020** 16Mb System V.3	**12.5Mhz/2Mips**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
S/640	**68020** 64Mb System V.3	**25Mhz/4.25Mips**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
S/1280	**4 x 68020** 24 + Mb System V.2	**16.67Mhz/8.8Mip**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
COREN ASSOCIATES LTD	**80286, TI S1100** 1Mb/15Mb XENIX 2.2, System V	**12Mhz**	T-Isam, DXIO & DNOS Business shell. **£12,000 £25,000**
CROMEMCO GMBH	**68020** 2Mb/16Mb Uniplus	**16.7Mhz/2.4Mips** S-100 Wide Bus	C, Fortran, Pascal, Basic, Cobol Langs. Uniplex, Q-Office and Lex 68 text utils. Informix, Unify, Today, graphics aplctns **$16,995 $53,995 US Dollars**

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
DATAWARE LTD	**NS Series 32000** 1Mb/16Mb Unix V2.2 and V.3	**10Mhz/3.5Mips** Back Plankless	C, Fortran-77, Assembler, Troff, Nroff All series 32000 support tools, streamer File and record locking and PWB utilitys **£9,145 £16,737**
DIGITAL EQUIPMENT CORPORATION	**VAX 32bit range** 4Mb/128Mb BSD 4.2, 4.3 plus System V.2	**0.9-12 Mips** Q-Bus or Unibus or BI-bus	Franz Lisp, Fortran-77, Portable C, VAX C Languages plus full set of standard utilities. **£10,000 £1 M**
DIGITAL TECHNOLOGY HELLAS	**NS 32332, LSI-11/73** 2Mb/14Mb System V.2, V.3	**15-18Mhz** Q-Bus, VME, Busless	Fortran-77 and C Languages, Standard Unix Utilities. **$8,000 $500,000 US Dollars**
DYADIC SYSTEMS LTD IBM 6150-115/125	**RISC** 4Mb/16Mb AIX	**4.5Mips** IBM	C Languages, VI, ED, INED text utilities plus Unix system V and BSD 4.2 enhancements. **£15,000 £23,000**
DYADIC SYSTEMS LTD Altos 3068	**68020** 2Mb/16Mb System V.2	**16.7Mhz/2.5Mips** Multibus	C Languages, VI, ED text utilities and full range of Unix system V plus Altos enhanced utilities. **£25,000 £35,000**
EASTMAN-STUART LTD	**68020** 1Mb/64Mb System V.2	**16.7Mhz** Multibus	
ENCORE COMPUTER CORPORATION	**NS 32032, 32332** 8Mb/128Mb System V.3, BSD 4.2	**10-15Mhz/1.5-40Mips** Proprietary	C Compiler, GNU EMACS, Troff, Nroff utilities. **$112,000 $500,000 US Dollars**
GEC COMPUTERS GEC Series 42	**68020** 4Mb/32Mb BSD 4.2/AT&T system V	**20Mhz/1.5-4Mips** VME	C, Fortran-77, Pascal assembler, NFS Sunpro, Sunview, Suncore, Suncei Utilities, PWE. **£250,000**
GOULD ELECTRONICS LTD	**PN 6000 family** 4Mb/16Mb UTX/32	**2.2-3.6Mips** Selbus, MP Bus	C, Fortran, Pascal Languages, NFS utilities. **On application**
GOULD ELECTRONICS LTD	**PN 9000 family** 4Mb/16Mb UTX/32	**7.4-15Mips** Selbus, MP Bus	C, Fortran, Pascal Languages, NFS utilities. **On application**
GOULD ELECTRONICS LTD	**NP1** 64Mb/4Gb UTX/32	**10-96Mips**	C, Fortran, Pascal Languages, NFS utilities. **On application**
HARRIS SYSTEMS LTD	**68020** 2Mb/32Mb HS/UX	**16.7Mhz/14Mips** Multibus	C Language and standard Unix utilities. **On request**

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
HARRIS SYSTEMS LTD	**Schottky TTLbitslice** 4Mb/128Mb System V.2/ 4.2 BSD	**10Mhz/8Mips** VME/Versabus	High multiuser performance processor ideal for teaching, scientific work, databases and CAD/CAM. **On request**
HARRIS SYSTEMS LTD	**80186** 0.5Mb/2Mb XENIX 3.0	**10Mhz/1Mips**	IBM PC compatible interface card to connect to X300 server. **£5,000 £20,000**
HEWLETT-PACKARD SA Model X40	**Proprietary RISC** 8Mb/24Mb HP-UX 1.04	**8Mhz/7.5Mips** Memory Bus & I/O Bus	C language, optionalgraphics and library utilities. On request
HONEYWELL INFORMATION SYSTEMS LTD	**68010** 1.5Mb/5.5Mb Uniplus (Unix system V.2)	**10Mhz/0.57Mips** System Bus Proprietary	C Language. **£10,950 £28,450**
HONEYWELL INFORMATION SYSTEMS LTD	**68020** 2Mb/10Mb System V.2	**16.7Mhz/2.1Mips** System Bus Proprietary	C Language. **£21,000 £42,600**
HONEYWELL INFORMATION SYSTEMS LTD	**Dual 68020** 4Mb/20Mb	**16.7Mhz/3.7Mips** System Bus Proprietary	C Language. **£27,500**
IBM (UK) LTD	**IBM 6150/10, 15** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£8,630 £11,894**
IBM (UK) LTD	**IBM 6151/115** 4Mb/16Mb AIX	**4.5Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£10,196 £13,460**
IBM (UK) LTD	**IBM 6150/ 20,25** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£12,580 £31,182**
IBM (UK) LTD	**IBM 6150 125** 4Mb/16Mb AIX	**4.5Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., async terminal emulator, etc. **£14,968 £33,570**
INTEGRATED SOLUTIONS Optimum V	**68020** 2Mb/56Mb BSD 4.2, 4.3/System V.3	**16.67-25Mhz/2.5-4Mips** VME	C, Fortran, Pascal, assembler, Lisp Unix text processing, X windows, desktop manager, spanned disks. **$10,500 $60,000 US Dollars**
INTEL SCIENTIFIC COMPUTERS LTD Intel IPSC	**80286, 80386** 4Mb/1024Mb XENIX, Unix V.3	**1280 Mflops** Hypercube,Multi	Vectorising Fortran and C. Concurrent common Lisp, Concurrent Prolog, standard Unix utilities. **£40,000 £950,000 US Dollars**

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the user's AST-handling routine begins executing. For purposes of this discussion we will assume that the device in question is a DA/CP and that there is only one processor in the system. The following occurs when a DA/CP sends an interrupt:-

* The operating system responds to the interrupt by executing the interrupt-handling code of the DA/CP driver. This response is almost always immediate and has the effect of suspending execution of any process currently running. The only time a delay occurs is when some other piece of interrupt code is running at interrupt levels 6 or 7. The DA/CP and the printer port are the only devices that normally interrupt at level 6 (although some multi-processor control locks occur at level 7).

* The DA/CP interrupt code posts an AST to the user process, clears the outstanding interrupt, and returns. This causes the interrupt level of the machine to return to whatever it was before the interrupt – somewhere between levels 0 and 5. If there are any other interrupts outstanding they are handled at this time. Interrupts with the highest priority are handled first.

* When there are no longer any outstanding interupts, the interrupt level will have become zero. If the previously running process was executing a system call at the time it was suspended, the system call is now allowed to finish. This occurs regardless of the scheduling priority of the process on whose behalf the system call is executing. (Note that scheduling priority and interrupt level priority are two entirely separate issues). If any interrupts are posted while the system call is executing, they are also handled.

* After the system call – if there was one – finishes execution, the operating system determines which process has the highest priority. If a process other than the one to which the AST was posted by the DA/CP interrupt routine has a higher priority, it will run first. A process is not selected for execution until it has the highest scheduling priority. The process must also reside in primary memory. If it has been swapped out to disk it must be swapped in again before it can execute.

* When DA/CP process is finally selected for execution, a special AST stack frame is written onto the user's stack. Then, the AST-handling routine specified by the process is called. The time range required for all these events to occur is typically 2 to 8 milliseconds. To be conservative, an AST latency of 10 milliseconds should be assumed. When interrupt latencies shorter than this are required, code should be written for the DA/CP. Interrupt latencies in the DA/CP are always less then 3 microseconds.

Semaphores – A process can coordinate its communication with another process in the following manner:-

1. A process can create a semaphore set with the *semget* request which returns an ID.

2. Using the request *scmops* the value of a semaphore within the semaphore set can be increased or decreased. A process can also "wait" (the process is suspended until a semaphore reaches or exceeds some value, or until it becomes zero).

3. The status of the set of semaphores can be obtained using *semctl,* and removed by using *ipcrm.*

ASYNCHRONOUS I/O

Real-Time applications often require a data output operation to be initiated by a system request without the program "waiting" until the operation is complete. Likewise it is often necessary to initiate an input operation without waiting for the operation to be complete. These "no-wait" operations are called asynchronous I/O because their completion is asynchronous with respect to the program's flow. There are two aspects to such I/O operations: the initiation of the data transfer and the notification that the operation has been completed.

The I/O operation is initiated by an *ioctl* request which has three parameters. One specifies the file descriptor, the second specifies the I/O command, while the third points to a data structure. The data structure provides the buffer address and byte count, as well as several special specifiers. These include:-

1. Where to put the I/O "complete" status.

2. Where to put the I/O error status.

3. The address of the low level AST handler.

4. The address of a high level AST handler.

5. A general purpose parameter to be passed upon I/O completion, via an AST, to the high level handler.

6. The AST priority.

Asynchronous I/O is available for streaming tape, terminal I/O, and devices supported by user written UNIX drivers. Disks and other devices can be supported in a no-wait manner by transferring data (via a pipe or shared memory) to a separate process. This process executes synchronous I/O which may, of course, cause it to be suspended until the I/O is complete. When the I/O is complete, the process is restarted, it can send as AST to the first task thereby activating a "completion" routine within it. Because the first task continued to execute after sending the data to the I/O process, asynchronous operation has been achieved.

Scheduling

The *alarm* (or ALARM) request instructs the operating system to send a specific signal to the calling process after a specified number of seconds. This signal can be caught and handled by the *signal* request.

The *pause* request causes the calling process to be suspended until it receives a signal. The signal can be caught and handled by the *signal* (or SIGNAL) request.

The *sleep* (or SLEEP) request sets an "alarm clock" and then causes the calling process to be suspended until either the alarm clock goes off, or until some signal is received. The resolution of the alarm clock is one second.

The *wait* (or WAIT) request causes the task to be suspended until its child terminates, or until it receives a signal.

Page Locking

It is usually desirable for a real-time application to not be subjected to paging or swapping. These two operating system actions can be prevented from occuring by using a *plockin* (or PLOCKIN) request. The pages to be locked can be Text (code), Data, or both. When at least one page within a process is locked, the entire process is prevented from being swapped (although non-locked pages can still be paged).

When the *plockin* request is executed the specified pages are all loaded into memory. The *punlock* (or PUNLOCK) request will eliminate page locking for the specified pages.

Process Priority

At any point in time, a process has a priority which is used by UNIX to determine which process should next be given a slice of time for execution (note that process priority is completely different from AST priority).

Process priorities can be modified within an application by using the *nice* request. By setting the process priority between -11 and -20 (highest priority), the process is given a "real-time" priority and is scheduled ahead of non real-time processes (those with a priority between +19 and -10). The *nice* request accepts a positive or negative argument which is added to the current process priority.

Contiguous Files

MASSCOMP's RTU enables a file to be created which is located in a single, contiguous portion of a disk. Continguous files maximize data transfer rates to/from disk. A file may be opened as a contiguous file by C program using the *open* request with the **0—CTG** and **O—CREAT** specifiers for the "oflag" argument. A FORTRAN program can create a contiguous file calling the CONTIG subroutine.

To maximize disk transfer efficiencies,

all reads and writes to the files should be exact multiple of 512 bytes. By using transfers of greater than 4096 bytes, the disk controller will move the data directly into, or out of, the user's application arrays. If transfers shorter than 4096 bytes are used, RTU performs the transfers in two stages. When the process requests I/O the data is moved to/from a 4096 byte I/O buffer (within the operating system). Then, whenever this buffer is empty (during a read) or full (during a write) the entire buffer is sent to/from disk.

While this "virtual buffering" scheme is very efficient for the transfer of small amounts of information, it is much less efficient (because of the "data move" operation) for large amounts of data. By using large transfers (>4096 bytes) the virtual buffering scheme is bypassed.

* More information is available from MASSCOMP in the form of (a) the RTU Programming Manual, (b) UNIX Programmers Manual, Volume 1b, (c) FORTRAN Language Reference Manual, (d) FORTRAN Users Compilers Manual and (e) C Language for FORTRAN programmers.

Dr. Stephen L. Mullen is currently the Asia/Pacific/Americas Distributor Sales Manager for MASSCOMP. Dr. Mullen joined MASSCOMP in 1982 to initiate the marketing department. Prior to joining MASSCOMP, he worked both at Data Translation and, for eight years, at Digital Equipment Corporation. Dr. Mullen joined Digital in 1973 where he was the Product Manager for both the highly successful DECLAB-11 and MINC product lines. In 1973 he also completed a Ph.D. from the University of Minnesota.

WINDOWS ON UNIX ARE OUT OF THE QUESTION

PC BUSINESS WORLD Vol 2 No 27, 8th July 1986

WINDOWS allow several tasks to run ... where does that leg...
concurrently on one sc...
Pull down men...

Incredibly, some people still believe that windows are only for pc users.

They don't know that JSB Computer Systems make portable windowing software available for any Unix or Xenix based system, using any kind of terminal.

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SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
JAROGATE LTD	**80286/80386** 4Mb/16Mb System V	**8-16Mhz/3-4Mips** S100/PC/AT bus	C and Macro assembler, tron, troff, standard unix utilities. **£4,500 £20,000**
KDG COMPUTER SYSTEMS LTD	**NS 32000** 1Mb/128Mb System V.2, V.3	**10-20Mhz/0.8-10Mips** Q-Bus, SCSI-Bus, Maxi-Bus	C, Pascal, Fortran-77, Dibol, Mumps, Basic+, Cobol, Inf-4GL languages, LEX, Uniplex, RDBMS, SQL, TCP/IP, GKS. **£10,000 £80,000**
KODE LIMITED Intel 310 AP	**80286** 1Mb/16Mb XENIX 3.2	**8Mhz** Multibus	C Language, Nroff, Troff text utilities. **£10,263 £17,329**
LOGITEK PLC	**80286** 4Mb/170Mb XENIX 3.0	**12.5Mhz/**	**£4,750 £31,950**
MARI ADVANCED SYSTEMS LTD System 20	**68020** 2Mb/64Mb System V.2	**16-25 Mhz** VME	C language, Nroff, troff and standard system V.2 utilities. **from £19,450**
MD/8	**Intel 80x8x** 512Kb/8Mb Microport V.2, V.3	**PC-AT**	C, Fortran languages. TEX text utility. **£2,000 £8,000**
MD/8	**NS 320xx** 0.5Mb/12Mb System V.3	**8-16Mhz/1-3Mips** Proprietary	C Language, TEX text Utility. Transaction Log to Tape, ANSI C standardisation. I/O Bus Support. **£3,500 £15,000**
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MIPS COMPUTER SYSTEMS	**R2000 CPU** 2Mb/4Mb System V.3, BSD 4.3	**12Mhz/8Mips** VME	Fortran, Pascal, C, Cobol, ADA, PL/1 languages and standard Unix Utilities. **£50,000 £80,000**
	68020 2Mb/4Mb V/68	**16.67-20-25Mhz/2.5Mips+** VME	C, Fortran-77, 68020 assembler and Vi, Ed text utilities. **On application**
NATIONAL SEMICONDUCTOR GMBH ICM-332-1	**NS 32332, 32016** 2Mb/14Mb System V.3	**10Mhz** MiniBus	C and 32000 Assembler. VI and standard Unix facilities.

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
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NCR LTD Mini Tower	**68010** 1Mb/2Mb System V	**10Mhz/0.25Mips** MultiBus	Menu system utility. **£3,650 £7,700**
Tower XP	**68010** 1Mb/8Mb System V	**10Mhz/0.35Mips** Multibus	Menu system utility. **£9,700 £10,800**
Tower 32/400	**68020** 1Mb/8Mb System V	**16.7Mhz/1Mips** Multibus	Menu system utility. **£10,400 £16,500**
Tower 32/600	**68020** 1Mb/16Mb System V	**16.7Mhz/1Mips** Multibus	Menu system utility. **£17,700 £25,400**
Tower 32/800	**68020** 4Mb/64Mb System V	**16.7Mhz/1-3Mips** Multibus II	Menu system utility. **£64,000 £230,000**
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SEQUENT EUROPE	**32032** 2Mb/32Mb BSD 4.2 & System V.2	**10Mhz/1.4-21Mips** Sequent Bus & Multibus	C, Lisp, Pascal languages, Nroff text utility and Usual Unix Utilities. **$50,000 $500,000 US Dollars**
SIEMENS LTD	**NS 32032** 2Mb/16Mb SINIX 5	**10Mhz** High speed, Multibus,SCSI	CED Text editor. **£25,000 £150,000**
SIEMENS LTD	**NS 32016** 1Mb/4Mb SINIX	**10Mhz** Multibus	CED Text editor. **£6,000 £17,000**
SUN MICROSYSTEMS UK LTD	**68020** 4Mb/32Mb Converged 4.2/System V	**15-25Mhz/1.5-4Mips** VME	Pascal, C, Fortran, Modula-2, Lisp languages. **£7,100 £88,000**
SYSTIME COMPUTERS LTD	**80286/80287** 1Mb/8Mb XENIX 5	**8Mhz/2Mips** Multibus	**£25,000 £66,000**
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TORCH COMPUTERS LTD	**68010** 7Mb System V.0 and V.2	**7Mhz/** VME	Full Unix Operating system. **£4,750 £13,000**

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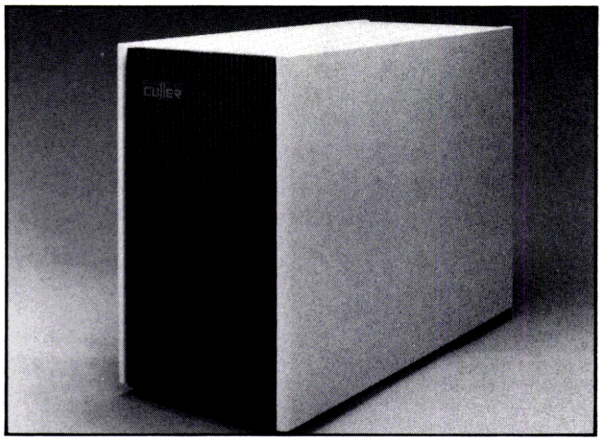

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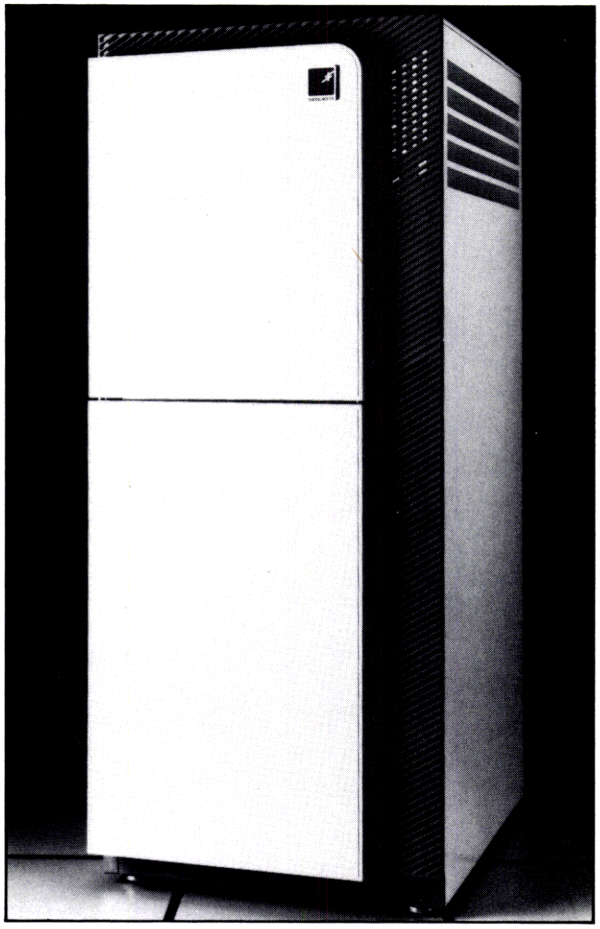

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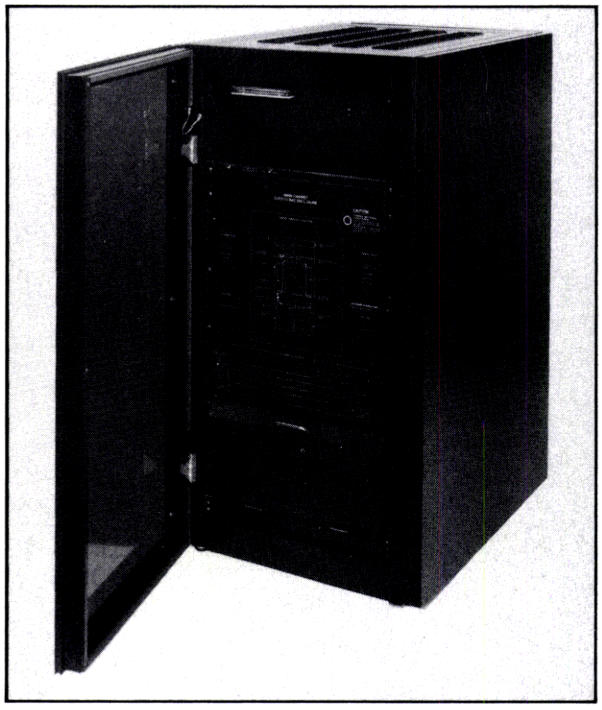

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REALLY BIG UNIX – The Parallel Processor Supermini

Recent years have seen an increasing number of new computer architectures being launched, one of the most significant of these being the parallel processor supermini. The creation of a true parallel architecture has been the goal of many computer companies for years gone by. Through the use of industry standard hardware and software, including an enhanced version of Unix capable of supporting System V and BSD 4.2 simultaneously, Bill Jordan describes the break-through of one company, Sequent Europe Limited.

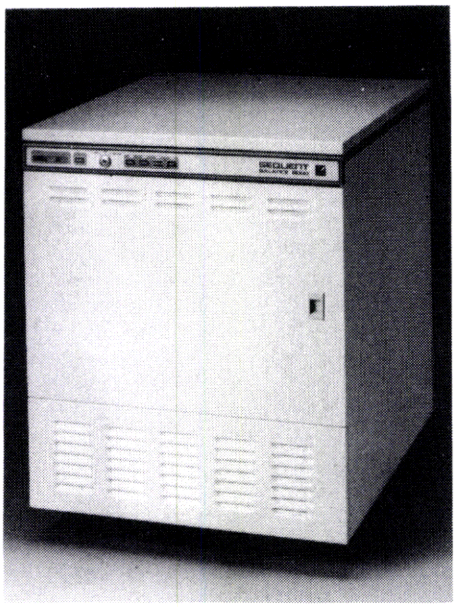
The hardware design used by Sequent is known as a scalable pool architecture in which all resources (memory, I/O devices, interrupt systems etc) are accessible to all processors. These resources are dynamically assigned to processes, not hard-wired rigidly to a processor, and the process scheduler assigns processors from a pool. It is referred to as "scalable" because the number of processors can be changed: Sequent's computer systems can accommodate from two to 30 CPUs.

The implication of this approach are paramount to the user as it means that he can grow the power of his system to meet his changing requirements rather than having to spend tens of thousands of pounds on replacing a computer system which is no longer capable of the job in question. Thus, with Sequent, the same computer which was purchased to run, say a 10-user application can be scaled to run up to 256 users, all for a fraction of the cost of purchasing a new machine.

Upgrading the balance in this way is inexpensive, costing typically 3,000 for each pair of processors with each processor delivering the power of a VAX 750. To achieve this level of flexibility, however, has required careful design of the operating system, DYNIX (Dynamically balanced UNIX), to ensure that mutual access is properly synchronised and where necessary excluded, and clever balancing of the hardware to minimise performance degradation.

A critical element for a scalable processor pool architecture is the system bus. It must provide software transparent, symmetrical access between all processors and the system resources, including I/O subsystems of widely varying access times. Furthermore, it must do so with careful regard to the high bandwidth of the 32-bit CPUs. For economy, it must also provide minimal interface complexity.

The system bus achieves these objectives via a combination of techniques. A single, global 10 MHz synchronous bus, which interconnects all processors to all other resources, supplies the required symmetry and yields the necessary performance via a 64-bit parallel time-multiplexed address and data path with a sustained data rate of 53 Mbyte/sec.



Sequent Europe

Efficiency is further enhanced by a multiple pipeline protocol which splits responses from requests and thus ensures that the bus is tied up only for those cycles needed to transmit the request and response information. The storage access itself causes no bus delays and instead occurs in parallel with the traffic from other requests and responses. Moreover, the write response has its own dedicated set of wires on the bus and so happens "out of band", thus freeing the main data path for more traffic.

One of the controllers that fits on the bus is the SCED board (Small Computer system interface, Ethernet and Diagnostic) which allows connection of SCSI devices as well as supplying the Ethernet and Diagnostic capabilities which are standard on all Sequent machines. Up to four SCED cards can be supported on the system allowing large numbers of users to log on over Ethernet as well as giving access to large numbers of peripherals which conform to the SCSI interface.

Of particular innovation is a custom designed system link and interrupt controller (SLIC) chip.

The diagnostics on Sequent's machines are menu driven and simple to use. The SCED card supplies remote dial-up facilities into Sequent's customer services, although with an MTBF (mean time between failures) of over 10,000 hours, they are rarely needed.

Of particular innovation on the Sequent machine is a custom-designed System Link and Interrupt Controller (SLIC) chip. The SLIC -- there is one to every processor as well as every memory controller, I/O channel and bus controller board -- is connected via a SLIC bus which has a 1 bit data path in the system backplane.

The various subsystems and CPUs use the SLIC bus to exchange interrupts and other low level control signals, configuration information and error information. (The SLIC mechanism is similar to the corresponding mechanism in the proposed IEEE 896 Futurebus). Contention for the SLIC bus is resolved according to the following guidelines:-

1. If a packet is being transmitted all stations (except the responder) stay off the bus until the packet has been completed.

2. Each packet begins with the priority of the command followed by the identity of the transmitter. Thus if two stations start to transmit simultaneously, the station that transmits the lower priority (or lower identity number) eventually sees a "1" on the bus when it has transmitted a "0". The station realises that a higher priority packet is in processes and waits to retransmit.

The SLIC chip, in communication with the SCED boards, also has a large part to play in Sequent's autoconfiguration routine. Whenever a serious error occurs the hardware records the identity of each party involved and then freezes the bus so that the error does not create further trouble. Next,

a diagnostic processor takes control and, though the SLIC chips, investigates the problem. Each SLIC chip tests out its controller for any hardware errors. If there are no errors, it communicates with the SCED controller and writes all the relevant configuration details into memory. If any errors are found, such as a hardware fault on a CPU, then the SLIC chip leaves a note of this in memory and "configures out" the appropriate device. Once this is done, DYNIX is booted from disk, reads the information in memory and reconfigures itself accordingly. This means that the systems, whilst not being "fault tolerant" do offer an exceptionally high level of availability.

Whereas, traditionally, process scheduling has been handled by software, Sequent has written much of the task into the SLIC chip. In particular, this overcomes the traditional master/slave approach where the master processor is responsible for the scheduling of all the other processors. On the Sequent system, any process can execute on any processor, whether it is in supervisory or user mode. As for priorities, the basic scheduling philosophy is always to run the highest priority ready-to-run process first.

In operation, the SLIC controls the selection of which CPU is scheduled for a particular process in the following way. First, the CPU programs its SLIC to accept a selected range of interrupts. The SLIC then sifts through the "interrupt processor" commands on the SLIC bus and presents its processor only with the appropriate interrupts. The SLIC that issues the interrupt learns immediately whether the interrupt has been accepted by another SLIC even if the accepting SLIC's host CPU is not able to process the interrupt immediately.

In a conventional UNIX system, a single processor receives all device interrupt signals. In a processor pool architecture, any processor can accept any interrupt signals. This reduces interrupt latency and therefore provides further improvements over single-processor systems.

A peripheral board such as the dual channel disk controller does not interrupt a particular CPU. Instead, it issues a command on the SLIC bus to interrupt the CPUs as a group. Each CPUs SLIC decides whether it should accept the interrupt. When one CPU has accepted the interrupt, and the controller requesting service has a dedicated CPU allocated to it, the remaining CPUs are left to carry on with other tasks.

Up to four high-performance disk controllers can be attached to the system bus, and each controller can drive up to eight disks (four on each of two independent channels), providing a total capacity of 32 disks. Each controller performs independent overlapped seeks on all eight drives simultaneously and is capable of transferring data at over 24 Mbits/sec. Each channel can transfer data simultaneously, hence each controller can be viewed as two separate controllers. This high-speed mass storage subsystem is particularly appropriate for database systems and multi-user computing.

Another part to the system are the multibus adapter boards. These provide an inexpensive, yet effective interface to a plethora of devices including terminal multiplexers, tape controllers and additional OEM devices.

The last piece of the jigsaw which is mandatory for a parallel processing system is a "re-entrant" operating system: That is to say that only one copy of the operating system is needed regardless of the number of processors installed.

DYNIX makes the parallel architecture completely transparent to existing software.

Adhering to its philosophy of using industry standards, Sequent chose as its base, the UNIX operating system. From this base it developed a much enhanced version, DYNIX (Dynamically balanced UNIX), to accommodate the various complexities of the parallel architecture.

DYNIX is a powerful operating system with a rich, easily expandable set of utilities. It supports the Berkeley fast file system, with demand-paged virtual memory support and integrated networking. It also supports both bsd 4.2 and System V concurrently, and programmers are able to use these environments either separately or together within individual applications. Of particular importance, DYNIX makes the parallel architecture completely transparent to existing user software while automatically balancing the process load across the multiple processors for maximum efficiency in conjunction with the SLIC bus.

In adapting UNIX for parallel processing, Sequent has included several modifications in its DYNIX operating system in the areas of mutual exclusion, virtual memory management, interrupt distribution and process scheduling.

On a uni-processor system, mutual exclusion of processes from the operating system is achieved simply by disabling processor interrupts so that no other processor will get control until the interrupts are enabled. With a processor pool architecture, however, this technique is not enough to guarantee mutual exclusion, since other processors may be executing processes simultaneously via the kernel. DYNIX solves the problem by using three mechanisms: gates, locks and counting semaphores.

As for virtual memory management, DYNIX allows multiple processes to share common regions of virtual address space. Any process that has access to a shared memory region can read or write in that region in the same way it reads or writes in ordinary memory. Shared memory allows interprocessor communication and synchronisation to be very straightforward and efficient and simplifies the task of parallelising conventional algorithms. This is only true for tightly-coupled parallel architectures where all processors physically share the same memory rather than have separate memories.

However, to achieve near-zero wait states and minimise bus traffic, each processor contains a cache memory of 8 Kbyte to store recently accessed instructions and data. Thus subsequent requests for the same data are satisfied from the cache rather than the main memory, saving on both bus and memory bandwidth.

Included with DYNIX is the parallel programming library, a collection of utilities that allow programmers to exploit the architecture of the machine to the fullest extent. These utilities allow users to run processes which parallelise across the CPUs available in a machine. Simple examples of this are DO-LOOPS in Fortran programs, independent procedures in C or FORTRAN programs, or even dependent routines in these languages.

One of the greatest potential areas of new languages which will heavily use parallel processing is ADA development. The guiding body of the ADA language had the foresight to see that, in the future, computers would be capable of parallelising code and they hence designed this into the language. This means that Sequent machines are ideal for ADA development but more importantly are superb at running real ADA production code.

This is not to say, however, that the Sequent machine is only suitable for technical applications. Far from it. The sheer power provided by the parallel processor architecture, along with the balanced I/O capability, makes the Sequent product ideal for commercial applications, particularly database management systems. Furthermore, the scalability of the Sequent machine (the ability to add processing power) matches exactly the growth needs of Database systems.

It is also worth noting that Sequent's computers offer near linear increases in power, which is in complete opposition to the generally accepted rule of thumb that each additional processor adds only 80 per cent of the power of the one previously added. Following this rule, no matter how many CPUs are added, the maximum effective computing power will not exceed five processors.

However, we at Sequent have clearly demonstrated that in applications such as database management systems, we can achieve 29.5 effective processors out of 30 installed.

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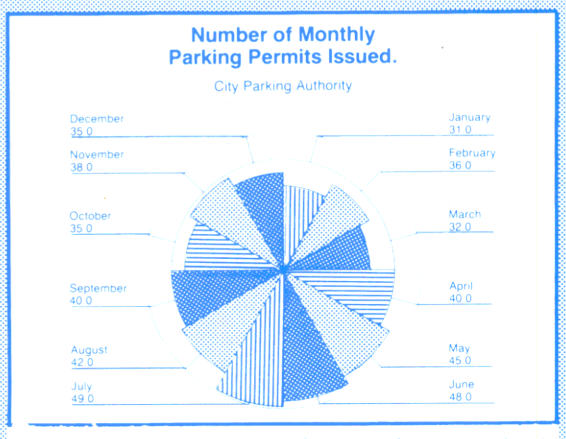
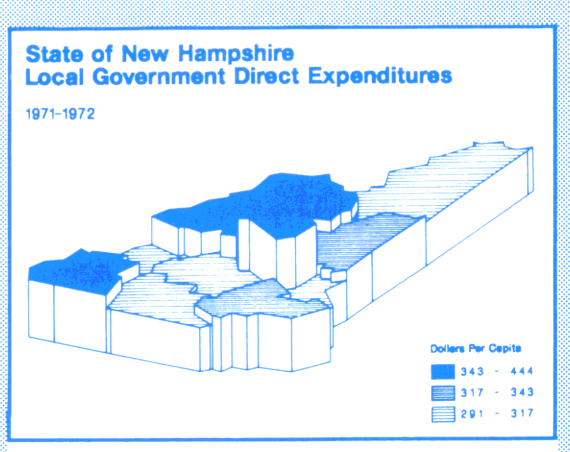
The user is completely independent. He doesn't need a programmer at all, simply the use of a terminal. Another point of interest is that SPSS has adapted almost all the procedures in these programs for stand-alone use on Personal Computers. Afterwards, if necessary, they can communicate with a mainframe.



A pie-chart like this doesn't leave any doubt as to where you want to put the emphasis. It's one of the many uses of SPSS Graphics.



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Workstations for the 90s? – SUN, APOLLO, DEC and IBM

In the "old" days, one very wise man was heard to say "If the present rate of workstation maker start-ups continues, then by the year 2000 there will be more workstation manufacturers than customers". Your editor examines if this holds for today, and indeed for the 1990's.

Once Upon a Time

Once upon a time, dearly beloved, in the days when computers were just computers, the process of selection, though tortuous, was more a matter of identifying possible suppliers from a list of five. Then the hardware became cheaper (and cheaper and cheaper ...) and the bandwagon of the "here today, gone tomorrow" suppliers of workstations began to roll. Indeed in the middle ages, (that is to say, reader, because we know you long for exactitude, round about 1979/1980) new workstation manufacturers were springing up at such a rate that one very wise man was heard to say "If the present rate of workstation maker start-ups continues, then by the year 2000 there will be more workstation manufacturers than customers". Then he left, to found his own workstation start-up company. By the present eon, the mammoths have selected themselves out from the dinosaurs; the workstations which will survive into the nineties as opposed to those which came and went in five years. The interesting thing is to see just who has survived, and to note the features in common and of difference between the major survivors. It is certainly possible to name a dozen or more reasonably successful workstation companies, but there are now three or four clear leaders only. SUN and APOLLO are two of the start-up companies which survived; DEC and IBM are the other two major players, but this time with a longer history of computer development to build upon. We shall look first at SUN and APOLLO.

Definitions

It is probably useful to define at this stage what is meant in this article by a workstation. We mean a single-user computer with a window-icon-mouse-pull-down-menu (WIMP) interface, which has a high resolution graphics screen and the ability to link to other similar devices by some sort of local area network. For the purposes of this book, it must also run UNIX, or one of its close relations. It must be powerful enough to run multi-tasking, so that network tasks can operate without significant degradation of the response to the user but it must be true multi-tasking, such that a user can work on something else while waiting on a time consuming task to complete. It may or may not have a disk, and peripherals are usually connected to the network rather than to the workstation.

SUN – The Sun 3 Series

SUN is a California based company with a strong record in the University and Software Engineering markets particularly. Its product is typical of the multitude of start-up workstation products referred to above, with the single exception that it has survived the shake-out. It uses all of the industry standard components and interfaces: MOTOROLA 68020 processor, VME Bus, SCSI device interface and a version of UNIX based upon BSD 4.2. Graphics resolution is 1152 x 900 and colour versions can display up to 256 colours.

The SUN comes in a variety of forms ...

One of its strengths is its speed, it uses the 16.7 MHz versions of the 68020 and of the 68881 floating point unit. It also uses a high speed private bus linking both processors and memory to enable it to turn in a 2 MIPS performance. It comes in a variety of forms; stand-alone diskless or disked, monochrome or colour and a separate disk server is available claimed to be able to support up to ten diskless nodes.

SUN has probably gained its high reputation, and owes its survival, not to any of these hardware virtues, though. It has the unusual position of having developed software which has become the sector standard for networking; NFS is dealt with elsewhere in the book, but was and is developed by SUN as a non-proprietary, UNIX optimised distributed file system. NFS has been taken up by over a dozen other suppliers, not all of them even UNIX. SUN also has realised that (in DEC's words) The Network IS the System, and has developed other networking protocols allowing SUN workstations to interface to IBM (SNA or BSC), DEC (DECnet) or any system supporting OSI protocols.

APOLLO – DN3000 Series

APOLLO use similar hardware to SUN, but configured somewhat differently. Again the hardware is the 68020/68881, this time in the 12 MHz version, ESDI interfaces to disks, and IBM PC/AT buses as the interface standards. However the software is a dual port of BSD 4.2 and SYSTEM V running under the APOLLO proprietary operating system, AEGIS. Again there is a private bus linking memory to the processors, but the speed is less, finally clocking in at about 1.3 MIPS. Graphic resolution is 1024 x 800 (colour) and 1280 x 1024 (monochrome). The local area network is the distinguishing feature of Apollo; DOMAIN is a twisted pair, proprietary system. Unconventionally the APOLLO LAN is a token-ring, non-IBM compatible one. Gateways are available, however to Ethernet etc. Partly because of the length of time they have been operating, partly because of their basic philosophy, APOLLO license the software for systems, not for individual workstations, recognising the essentially single-user nature of a workstation, but multi-user nature of the system. APOLLO do not advocate the ten-to-one ratio of diskless to disked which SUN seem happy with; instead they suggest about two diskless per disked workstation as a happy ratio.

APOLLO has a sound base particularly in CAD, although not all of it is in UNIX based systems. Much of the strength of APOLLO is based in its graphics. A full set of standard graphic software – like GKS - and emulations are available on the APOLLO. The operating system, as has already been mentioned is not UNIX; instead it is an object oriented system with compilers, user interfaces and network handling all treated as objects. It is possible to tailor a Domain system to appear like most anything one wishes, if one has the technical skill.

DEC VAXStation 2000

DEC has had a somewhat ambiguous relationship with UNIX. For many years the party line was that the *only* operating system for the VAX was VMS. Then came ULTRIX and DEC joined the Live Free or Die brigade. They announced ULTRIX for PDP-11s and ULTRIX for VAX, different versions of UNIX of course; with the introduction of the microVAX there came another variation. Now DEC seems to have stabilised and has a single version of ULTRIX-32 running on all of its 32-bit processors; note that I said processors and not systems. DEC has not yet released versions of ULTRIX on its dual-processor systems (VAX 8300/8350, 8800), nor is there an equivalent of DEC's successful clustering strategy for their VAX product. However they have recently made it clear that they

are heavily committed to the UNIX workstation market. They have produced firstly the VAXstation-I then the VAXstation-II, which came in three basic flavours – vanilla VAXstation-II, the high performance graphics VAXstation-II/GPX and the low cost VAXstation-II/RC. Most recently, they have introduced the VAXstation 2000.

It was noted above, when talking about SUN and APOLLO, that there was a similarity in the standards adopted. DEC, in the VAXstation 2000 use their own proprietary processor and floating point unit. They do stick to standards in other areas though; the operating system is developed from BSD 4.1; DEC were amongst the first batch of manufacturers to adopt MIT's X-Windows system. (Indeed DEC have announced that this will form the basis of DECwindows, a standard window interface to be available under ULTRIX, VMS and MS-DOS). ULTRIX version 2, announced at the same time as the VAXstation 2000, supports SUN's Network File System (NFS).

Networking hardware is Ethernet – thin wire in the case of the VAXstation 2000 – and DECnet and TCP/IP and NFS can apparently all coexist and co-operate on the same machine. GKS is also part of the software shipped with VAXstations, again DEC demonstrating their committment to standards. So far all the news has been good. But the VAXstation 2000 is not quite so fast as the other three systems discussed, clocking in at about 1.1 MIPS, although it is also cheaper.

The VAXstation 2000 apparently is faster than its predecessor, chiefly due to the better graphics processor. The graphics resolution is 1024 x 864 and the colour version, not yet available, will support the 16 from 256 palette originally provided with the VAXstation-II/GPX, from where the chip-set, the so-called DRAGON chip set – comes. A diskless version is available, but not yet supported under ULTRIX. DEC are more conservative even than APOLLO, suggesting that, although files can be shared using NFS, paging should be done to a local disk; this is slightly at odds with their VMS suggestion, which implies that an RA series disk on a VAX 750 or above accessed over Ethernet is of comparable speed to the local disk for access time.

A diskless version is not yet supported under ULTRIX

IBM – The 6150 or RT PC

It is not really clear whether IBM can be considered a real competitor in this arena. The IBM 6150, known in other parts of the world, particularly the US, as the RT-PC, is not only a late entry but is also on a new processor and from a company renowned more for setting standards than adhering to them. Little that IBM does, though, can be ignored. The whole concept of the 6150 was seen at the time of announcement to represent a change of heart by Big Blue, part of its strategy to recover market share.The 6150 is based on not one, but three processors; two real, one virtual. The virtual one is the most important, in that IBM have implemented the software for a non-existent machine; the operating system "executes" using a Virtual Machine Interface (VMI) and a Virtual Resource Manager (VRM). This architecture is implemented at a high enough level to provide, for example, device transparency; it also allows AIX (IBM's UNIX System V implementation) to deal with a machine without virtual memory, with no real-time I/O capabilities and without dynamic install and configuration features. All of these features are provided at a level conceptually "under" the operating system. Of the two real processors, one is the 80286, provided to allow for co-existence of UNIX and MS-DOS; the other is the so-called ROMP processor – a 2 MIPs RISC architecture machine. The 6150 has the largest address space of any of the four machines discussed here – the 40 bits wide compared to 32 bits for the DEC, 26 for Graphics resolution is 720 × 512 and in colour, a 16 from 64 colour map is provided. The operating system was done in two parts; IBM provided the non-standard UNIX features, whilst IBM bought in the UNIX System V port from Interactive Systems Corporation. IBM has also chosen to layer a "usability" interface on top of UNIX. This has some features in common with the windowing environments provided by the other vendors, and is specifically aimed at hiding the complexities of UNIX from the user. Usability also sits above the VMI so it is quite possible that we shall see both available on other hardware. IBM has not really demonstrated its dedication to standards except for C, Fortran and SQL. The 6150 is also the most expensive of all of the workstations. Interesting too is the fact that the launch of the RT PC was accompanied by a book, giving fascinating insights into the design of all aspects of the 6150 except that no mention is made of interconnect facilities to other systems except as terminals. Since then, however, IBM have announced Ethernet connectivity for the 6150. Also in February 1987 the processor speed was enhanced somewhat and a recommitment made to the 6150.

Feature	SUN	APOLLO	DEC	IBM
Processor	Motorola 68020	Motorola 68020	VAX	6150
Max addressable memory	256Mbyte	64 Mbyte	4 Gigabyte	1024 Gigabyte
Max Physical memory	16 Mbyte	8 Mbyte	6 Mbyte	4 Mbyte
Graphics H resolution V	1152 900	1024 800	1024 864	720 512
Colours	256/16M	16/256	16/256	16/64
Screen size	19″	15″/19″	19″	12″/14″
Bus	VME/SCSI	PC/AT, ESDI	none	PC/AT
Network	Ethernet NFS	Domain	Ethernet DECnet NFS	–
UNIX base	BSD 4.2	BSD 4.2 System V	BSD 4.1	System V

››› *FIGURE 1* ›››

Summary of Features
of the
Four Workstations Discussed

A Summary

Workstations are one area where IBM have never been strong. The RT PC is an interesting newcomer, but still has to make its mark. The VAXstation, SUN and APOLLO are all well established systems, each with their own strengths and weaknesses. Choosing between these three is largely a matter of personal preference, price and considerations of compatibility with existing equipment. DEC's lack of colour display is currently a disadvantage, but should be remedied soon; the APOLLO system suffers from – and gains from – the fact that connection to the outside world must be through a gateway. SUN have not had as good a reputation for after-sales service as APOLLO or DEC and there may be some doubts as to whether with 10:1 ratio of diskless machines to servers will not prove over-optimistic as applications programs grow rapidly in size and complexity.

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
WORKSTATIONS			
APOLLO COMPUTER (UK) LTD	**68020** 2Mb/16Mb System V.2, BSD 4.2	**12-20Mhz/1.2-3.5Mips** AT Bus/VME	Display Manager text utility plus graphics and networking utilities. **£9,340 £77,080**
ARMSTRONG MICRO ELECTRONICS Victor Multimicro	**80286** 1Mb/10Mb XENIX V	**8Mhz** PC-AT	
ARMSTRONG MICRO ELECTRONICS Sperry PC Range	**80286** 0.5Mb/8Mb XENIX V	**8Mhz** PC-AT	
CONVERGENT TECHNOLOGIES (UK) LTD S/50	**68010** 2Mb System V	**10Mhz/0.75Mips**	C, Fortran, Cobol, Pascal, Basic Languages. **On application**
CROMEMCO GMBH	**68020** 2Mb/16Mb Uniplus	**16.7Mhz/2.4Mips** S-100 Wide Bus	C, Fortran, Pascal, Basic, Cobol Langs. Uniplex, Q-Office and Lex 68 text utils. Informix, Unify, Today, graphics aplctns **$16,995 $53,995 US Dollars**
DIGITAL EQUIPMENT CORPORATION	**VAX 32bit range** 4Mb/128Mb BSD 4.2, 4.3 plus System V.2	**0.9-12 Mips** Q-Bus or Unibus or BI-bus	Franz Lisp, Fortran-77, Portable C, VAX C Languages plus full set of standard utilities. **£10,000 £1 M**
DIGITAL TECHNOLOGY HELLAS	**NS 32332, LSI-11/73** 2Mb/14Mb System V.2, V.3	**15-18Mhz** Q-Bus, VME, Busless	Fortran-77 and C Languages, Standard Unix Utilities. **$8,000 $500,000 US Dollars**
GEC COMPUTERS GEC Series 21	**68020** 4Mb/32Mb BSD 4.2/AT&T system V	**20Mhz/1.5-4Mips** VME	C, Fortran-77, Pascal assembler, NFS Sunpro, Sunview, Suncore, Suncei utilities. **£7,100**
HEWLETT-PACKARD SA Series 300	**68020** 4Mb/8Mb HP-UX 5.2	**16.67Mhz/2Mips** I/O Bus & Memory Bus	C, Fortran-77, Pascal and ADA. Starbase Graphics Library 2D/3D, device I/O Lib. Windex windowing system. **On request**
Series 300/68020 2	**68020** 8Mb/32Mb HP-UX 5.2	**25Mhz/4Mips** I/O Bus & Memory Bus	C, Fortran-77, Pascal and ADA. Starbase Graphics Library 2D/3D, device I/O Lib. Windex windowing system, utilities. **On request**
Series 300/68010 1	**68010** 1Mb/7.5Mb HP-UX 5.2	**10Mhz/0.7Mips** Prop. I/O & Memory Bus	C, Fortran-77, Pascal and ADA. Starbase Graphics Library 2D/3D, device I/O Lib. Windex windowing system, utilities. **On request**

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency
IBM (UK) LTD	**IBM 6150/10, 15** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£8,630 £11,894**
IBM (UK) LTD	**IBM 6150/ 20,25** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£12,580 £31,182**
IBM (UK) LTD	**IBM 6150 125** 4Mb/16Mb AIX	**4.5Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., async terminal emulator, etc. **£14,968 £33,570**
KODE LIMITED Wyse 286	**80286** 640Kb/12Mb XENIX V.2	**10Mhz** PC-AT	**£2,995 £4,561**
NATIONAL SEMICONDUCTOR GMBH ICM-3216	**NS 32016** 1Mb/8Mb System V.2, V.3	**10Mhz** MiniBus	C and 32000 Assembler. VI and standard Unix facilities.
NIXDORF COMPUTER LIMITED	**68020** 4Mb/16Mb System V.2	**16.6Mhz/1.6Mips** 32bit	C Compiler, assembler, E- text editor and wordprocessor, Error logging and diagnostics utilities. **£15,000**
PRIMAGRAPHICS LTD	**68010/68020** 40Mb System V	**8Mhz** VME	C Language, Uniplus and standard text utilities, Torch opentop, windows, menus icons and mouse. **£12,500 £40,000**
SUN MICROSYSTEMS UK LTD	**68020** 4Mb/32Mb Converged 4.2/System V	**15-25Mhz/1.5-4Mips** VME	Pascal, C, Fortran, Modula-2, Lisp languages. **£7,100 £88,000**
TELEVIDEO SYSTEMS INTERNATIONAL BV Telenix 286	**80286** 1Mb/15Mb System V.2	**8Mhz/**	Only runtime version bundled with system DOS merge utility. **$5,995 US Dollars**
WHITECHAPEL WORKSTATIONS LTD	**NS 32016/32332** 2Mb/12Mb 42-Nix (BSD 4.2)	**1-2Mips**	C Language, VI and DED text utilities. Oriel window manager. **£5,000 £15,000**

SUPPLIER Product Name	Processor Type Min/Max Memory Unix Version (s)	Speed/Unit Bus	Description Price (Min/Max Conf.) Currency

SINGLE USER SYSTEMS

DIGITAL EQUIPMENT CORPORATION	**VAX 32bit range** 4Mb/128Mb BSD 4.2, 4.3 plus System V.2	**0.9-12 Mips** Q-Bus or Unibus or BI-bus	Franz Lisp, Fortran-77, Portable C, VAX C Languages plus full set of standard utilities. **£10,000 £1 M**
IBM (UK) LTD	**IBM 6150/10, 15** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£8,630 £11,894**
IBM (UK) LTD	**IBM 6150/ 20,25** 1Mb/8Mb AIX	**23.5294Mhz/2.1Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., TCP/IP, full 8bit native lang. support. **£12,580 £31,182**
IBM (UK) LTD	**IBM 6150 125** 4Mb/16Mb AIX	**4.5Mips** PC, PC-AT	C language, assembler, Full screen editor, Advanced graphics support lib., async terminal emulator, etc. **£14,968 £33,570**
OASYS (A DIVISION OF XEL INC)	**32032, 68020** 1Mb/16Mb System V.2	**12-20Mhz/1-4Mip** PC-Bus	C, Pascal, Fortran, Ada (optional) languages. **$1,200 $10,000 US Dollars**
SIEMENS LTD	**80186** 512Kb/1Mb SINIX	**8Mhz** Proprietary	CED Text editor. **£3,064 £4,700**

SUPPLIER Product Name	Description	PRICE Currency
OTHER HARDWARE		
ENCORE COMPUTER CORP. Annex Terminal Server	Servers allow open access to Ethernet regardless of Host environment, and supports up to 3 multiple host sessions from one terminal.	**$6,000-8,000 US Dollars**
IBM (UK) LTD 9332 DASD	Up to 14 drives of either 200 or 400Mb High function DASD - 19.0ms as access, 1.4-1.9 Mb/sec data transfer rate.	**£6,922-10,200**

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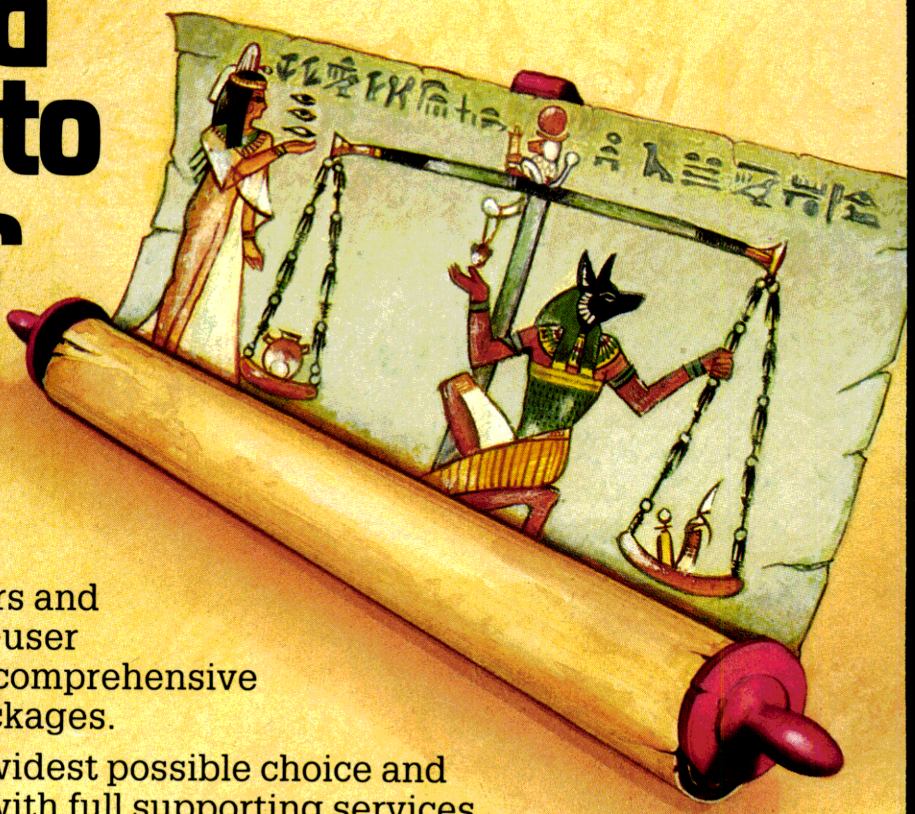

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Circle No. 272

SOFTWARE SECTION

FEATURES

Databases on UNIX 61
Seldom do we see those ideas, which, with the benefit of hindsight are obvious, implemented in an everyday area like Database handling. SPIRES is an example of such an implemented idea. In this, the first of a series of articles on various Database systems, the features of SPIRES are presented.

Migration to UNIX 71
Whilst the concept of a standard operating system is attractive to many users, moving from wherever they are to UNIX can be a daunting task. However, not all the move needs to be done in one jump: tools exist to help this migration process, by providing a UNIX environment under a "foreign" operating system or vice-versa. This article looks at some of the tools which make this process possible, and at the restrictions on the developer which are imposed.

UNIX & GRAPHICS 87
More than 60% of the UNIX systems installed, whether in commercial or scientific shops, have graphics packages installed. This article looks at one aspect of this large user base and also the extensive range of laser printer based graphics

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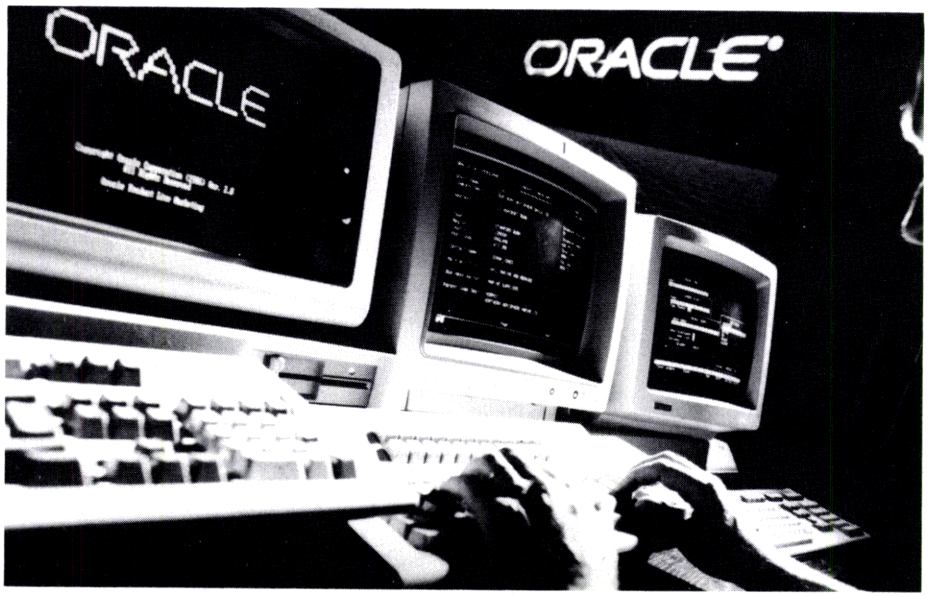
SOFTWARE COMPATIBILITY KEY	
A = System V.3 B = System V.2 C = System V D = System III E = 4.3 BSD	F = 4.2 BSD G = 4.1 BSD H = Version 7 I = XENIX J = Uniplus
NOTE: The above key refers to UNIX versions represented in the following software tables	

THE RELATIONAL DATABASE MANAGEMENT SYSTEM

ORACLE UK



Relational database management systems are foremost in providing flexible, responsive and easy to use application systems. Amongst relational database systems, ORACLE is a world leader. Thousands of companies all over the world, in all areas of business and in government, entrust their valuable company information to the Oracle system.

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Telephone: 01-948 6911.

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Oracle Corporation UK Ltd,
Broad Quay House, Prince Street,
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Telephone: 0272 266441.

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Capital House, 2 Festival Square,
Lothian Road, Edinburgh.
Telephone: 031-228 4583.

Circle No. 282

SPIRES – A Database on UNIX

Seldom do we see those ideas, which, with the benefit of hindsight are obvious, implemented in an everyday area like Database handling. SPIRES is an example of such an implemented idea. In this, the first of a series of articles on various Database systems, the features of SPIRES are presented.

SPIRES is a DBMS based on the relational model, in that it is similar to most relational DBMSs when it comes to comparing conceptual structure of data and basic functionality.

Some important differences arise, however, when the way SPIRES is used both by end users and application programmers is compared with the way many other DBMSs are. These differences are due to two factors:

- Presentation and Actions
- The extent of applicability of the Data Dictionary.

Presentation and Actions

Traditionally, the contents of a field in a record are presented as some suitable conversion of its contents on screen, paper, or magnetic medium. For example a binary pattern stored in some field called "salary" is eventually displayed on the screen as the string "£10,000.00".

In designing SPIRES such conversions have been treated as arbitrary actions by the system. The user is thus free to impose a different interpretation by the system to the data being presented. For example, a field can contain a pointer to an external file of "TEXT"; the definition of presentation in such a field is the action of clipping the top right hand corner of that text and displaying it into a window of a size defined by the user.

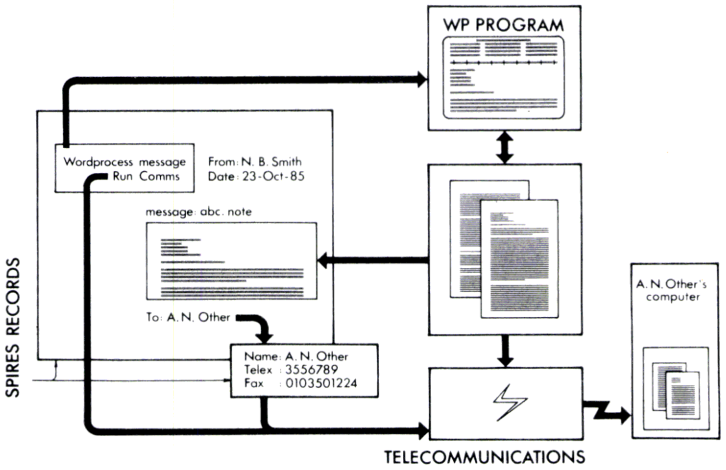
Clipping presentation, as just defined, is a default provided by SPIRES. The user can define alternative actions. For example, a field can point to a graphics file, and the presentation can be defined by the user as an external program which processes that file and displays a graph alongside other data displayed by SPIRES itself.

Once it is possible for the user to define an action related to presentation it becomes even easier for the user to define any other action on the data.

Using the example above, a field whose contents are presented as a window onto an external file, can have an action associated with it consisting of the invocation of a word processor of the user's choice with the file being pointed at as its argument.

There is no limit to the number of actions a user can associate with the information being stored – indeed a characteristic of SPIRES is that all actions are expressed in information stored within the database itself and finding the actions associated with an entity consists simply of constructing a very simple join between the file containing the entity and the file containing the definition of actions.

A trivial example of the association between ordinary data and actions is shown below.



Given a file of "documents" (A) the user has just retrieved a document addressed to "Smith" and written "around the 5th of April". The process of clipping and windowing is already carried out in the presentation process. Pressing 'X' (for ACTION) produces a pull-down menu containing the actions defined by the user as associated with the records of this file.

In this simple example, the actions are either to "word-process" the text, or to "send" it to its destination by running a communications program.

A mechanism for deciding whether the destination receives internal Electronic Mail or external telex can be consulted automatically, and the telex number sought in another file of addresses.

Word processing is simple in that all the information needed to invoke the word processor is contained within their current record. "Sending" the document can be more complicated without presenting any difficulties.

These characteristics make SPIRES a suitable tool for creating integrated systems from heterogeneous components.

An example of such an integration is given in an actual SPIRES site in which the user can invoke the following actions:

(a) FIND in the SPIRES database what information is needed to be sought in that of another DBMS.

(b) INVOKE an SQL script in the other DBMS to extract this information.

(c) CONVERT the resulting information into a form suitable for processing with some widely used SPREAD-SHEET program.

(d) INTERACT with the spread-sheet program, and when this is finished,

(e) CREATE a standard letter with a widely used word-processor for each line in the spread-sheet substituting variables with strings from the spread-sheet.

The user participates in this process at steps "a" and "d" above. At the end of step "a" he invokes the action which will put the chain of events in motion, one of which is to invite the user to interact with the spread-sheet program at step "d". Finally, on completion of this step, he may decide to interact with the word processor, to customise the standard letters even further.

To put a context in such an application, the user wishes to extract from an accounting application some overdue invoices, but wishes to process them further with a spreadsheet dealing with the "cash-flows" of his firm. Only after deciding, with the help of this spread-sheet which customers must be reminded of their overdue invoices does the user want the standard letters to be printed, and then he wants some individual polite notes added to the letters.

Admittedly, this is a complex application which took a software house about a week

to design and implement. It can be argued, however, that such an application would be very difficult to design without extensive coding in a traditional programming language, and then it would take considerably more than a week. If the user decided to adopt a different word processor, the adjustments necessary to the function would probably take a matter of hours to implement.

The user can also specify actions to be invoked automatically. This allows complicated triggering mechanisms to be implemented.

There exist certain key points in the life of a database – files are opened and closed, records are added, deleted or changed. The user can specify actions that can be invoked automatically at any or all of these key points. Examples:

- The user may specify that whenever a particular file is opened, mail ought to be sent to the system administrator, informing him or her by whom and when opened the file.

- Whenever a record is added to a personnel file, a TELEX program ought to be invoked automatically to send a standard message to the agency that supplied the new member of staff. Optionally, if the TELEX program fails, say because that agency does not have a TELEX, the record should not be added, and instead a message should be sent to the personnel administrator reminding him or her that a letter ought to be sent instead.

- Whenever a record is deleted from a file of suppliers, all outstanding shipments from this supplier ought to be deleted also, and if they can't, the supplier should not be deleted either.

- Whenever any change occurs in a file (adding, deleting or editing), a record of the change and the time of the change should be logged into a human-readable file. This file could then be used for restoring the file from a backed-up starting point in case of failure, or simply to examine the history of the file.

- Impose restrictions that no new records should be added to a personnel file between 10.00 a.m. and 2.00 p.m., unless these records refer to staff expert in chemistry!

Given that all actions are treated by SPIRES as entities of the database, operations which apply to information also apply to actions – Just as the user can specify that a member of staff is of grade "C", and a relationship in the database can cause the salary associated with the grade to be retrieved automatically from a file of "grades", the user can specify that the action to be taken on a specific document (in a file of documents), is "SEND", or "DATE STAMP", or "REFER TO DEPARTMENT X" etc, and the interpretation can be made by the system by looking up his shorthand description in a file "repertoire of actions".

The Data Dictionary

The data dictionary consists of a set of ordinary SPIRES files. Its applicability however is very wide. At its simplest, when a file is opened by the user, SPIRES forms the join of one record in a table of file descriptors, and a number of records in a table of field descriptors (selecting the fields associated with that file).

However, SPIRES does not support the notion of a program in the sense of an SQL or other type of script which is independent of the database but acting on the database. A program in SPIRES is a set of actions – SPIRES actions, external (UNIX) actions, or a mixture of both – whose order may or may not be relevant and which form themselves part of a table of actions, therefore to be selected in a join of the "program name".

This approach has a number of significant advantages:

- Given that a "program" is a set of records in the database, it does not need to be compiled. Development and testing, or building of prototype applications, therefore, can be very rapid.

- A program can itself be transformed by another program, although this is operation that needs considerable expertise and knowledge of the precise implications.

- Just as relational operations can be carried out on ordinary data, they can also be carried out on actions, or programs. Thus the notion of the join of actions is perfectly acceptable, and though in practice no one has been known to use this notion, uses of it can be found.

The main advantage of this approach, however, is that the user interface in specifying a program becomes very simple: The user edits a simple table, as if it were a spreadsheet. A sample definition of a "reporting" action, and the resulting report, are shown in Figure 2. Each line in the table becomes a record in a file of report definitions and can be retrieved by the name of the action at any time.

Similarly a table can be defined for transformations to the database, using a similar syntax which allows assignments to fields, invocation of external actions, conditionals (including conditionals depending on the success or otherwise of external actions), timestamping etc.

Conclusions

SPIRES was designed specifically for the UNIX operating system. In the process of its design, both the flexibility and the openness of this operating system were the aspects to take greatest advantage of.

The result has been a system characterised by flexibility and openness itself. Its flexibility means that not only it is symbiotic to other applications, but it can also enhance them becoming the glue for integrating heterogeneous applications.

Its openness is proven by the fact that an MS-DOS version of SPIRES is also available, as a first step in constructing distributed systems with distribute query optimisers, and above all distribution not only of databases but also of actions.

SPIRES may be seen as competing with traditional DBMSs using query languages such as SQL, but it need not be seen as such. Although it provides a complete and self-contained alternative approach, it can also be seen as an additional layer for their user friendly integration with other applications or with the operating system.

Author's Note

Simon Bensasson Dipl. Ing, MSc., RIBA., MBCS has been a director of Bensasson & Chalmers Limited since 1980. He wrote the first version of SPIRES and has been directing its development. He is a consultant to small and large organisations, including the CEC. (Commission of the European Communities).

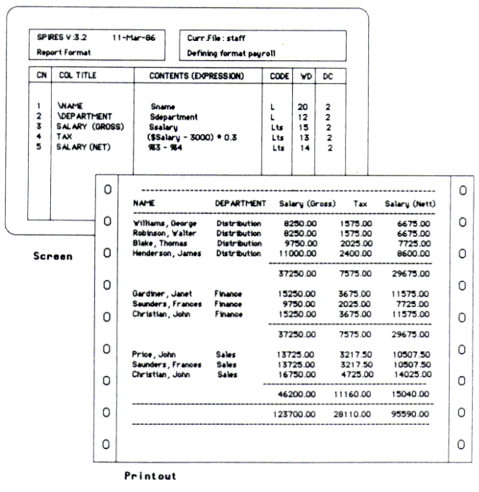
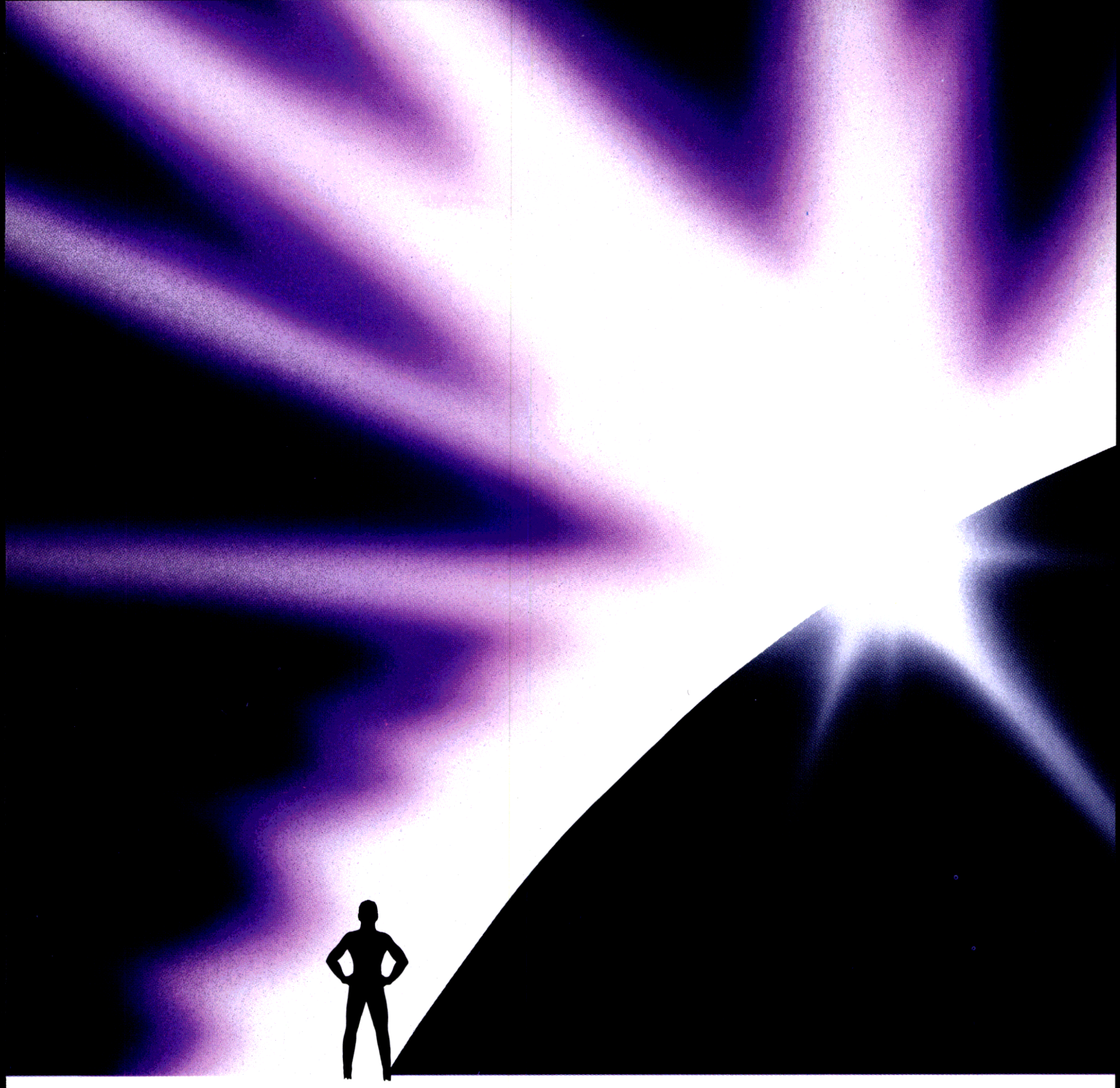


Figure 2



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Circle No. 275

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
ACCOUNTING			
AMS SYSTEMS & SOFTWARE LTD AMS Systems & Software Ltd	**Property Management PMS MkIII** Commercial property management including rents, accounts, insurances, services, etc.	**AB**	**On application**
BLK Business Services	**IBIX General Accounting** Integrated Sales, Purchase and General Ledgers based on Informix DBMS. Multi company, Multi-currency.	**AB**	
BLK Business Services	**IBIX Payroll/Personnel Records** Payroll & Personnel Records, based on Informix DBMS.	**AB**	
BLK Business Services	**IBIX Sales Orders** Integrated Sales Order Processing, Invoicing and Sales analysis, based on Informix DBMS.	**AB**	
BLK Business Services	**IBIX Purchase Orders** Comprehensive Purchase Order Control. Integrated with Stock and Purchase ledger, based on Informix DBMS.	**AB**	
ARMSTRONG MICRO ELECTRONICS Plusmark Ltd	**Plusmark Business Management** Modular accounts package - bespoke work done to customers requirements.	**IJ**	
Tetra Business Systems Ltd	**Tetra Plan** Modular package containing facilities required by most companies.	**IJ**	
BLK BUSINESS SERVICES LTD BLK Business Systems	**IBIX** Fully integrated Unix accounting package written in C.	**ABCDHI**	**from £900**
CIS COMPUTER SERVICES LTD CIS Computer Services Ltd	**CIS Accounting software** Fully integrated suite of financial accounting software: multi-user, multi company and multi-currency.	**I**	**On application**
COMPUTER CONSOLES (EUROPE) Computer Consoles (Europe)	**Terraplan** Full integrated flexible accounting system.	**BF**	
DIGITAL TECHNOLOGY HELLAS Digital Technology Hellas	**Accounting** Package for entire spectrum of businesses regardless of size including payroll, order taking/delivery.	**ABI**	**from $800** US Dollars
EASTMAN-STUART LTD Eastman-Stuart	**ES-Accounting** Comprehensive set of Accounting systems covering Sales, Purchase and Nominal ledgers with management reporting.		**from £1500**
GOLDCREST COMPUTER SERVICES LTD Goldcrest Computer Services Ltd	**Distribution/Business Software** Distribution and Accounting System	**ABCEFGHI**	**from £2000**

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Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
IBM (UK) LTD IBM	**TETRAPLAN** Fully integrated modular suite of BUS. Accounting S/W designed for the user who requires a multi-user system	AIX	**£1249/module**
KALAMAZOO BUSINESS SYSTEMS Kalamazoo 4-Front Computer Services	**Appgen Payroll** Multi-user, Multi-company with multiple pay cycles - supports build up to gross and deductions.	**BCDFIJ**	**£675+**
Kalamazoo 4-Front Computer Services	**Appgen Accounting applications** Sales, Purchase, General ledgers, Payroll, Job Cost, Stock Control, Invoicing - developed in Appgen.	**BCDFIJ**	**£675+**
KDG COMPUTER SYSTEMS LTD SMB	**SMB Business Software** Written in Cobol and very comprehensive in features.	**ABC**	**£1000 - 2000**
MD/8	**Accounts Manager** Configurable Accounts system:- User configuration/variable modular component		**£450**
SYSTIME COMPUTERS LTD Systime Computers Limited	**UTOPIA** Financial ledgers, stock control, purchasing & order processing.		**£1000+ (module)** Sterling
SYSTEMS UNION LTD Systems Union Ltd	**Sunaccount** Combined ledger accounting system for Sales, Purchases, project and general accounting.	**ABCDEFGHIJ** ULTRIX	
Systems Union Ltd	**Sunbusiness** Business accounting system.	**ABCDEFGHIJ** ULTRIX	
THOMSON COMPUTERS LTD Thomson Computers Ltd	**Sea Change Accounts** Set of accounts written with Sea Change application generator and programmers tools. Sales, Purchase & Nominal Ledgers	**ABCEFIJ** AIX, PCDOS, MSDOS	**£595 - 2350**
WHARFEDALE DATA SYSTEMS LTD Wharfedale Data Systems	**CTRAX & CTRAX+** Integrated accountancy systems or as stand alone modules can be tailored to suit.	**ABCIJ**	**from £450**

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
APPLICATIONS GENERATORS			
COREN ASSOCIATES LTD PRO LAB plc	**PRO IV** Complete application development environment for DP professional.	**CI**	
DATAWARE LTD Thomas Thompson International	**CADP** Designed to meet the widest range of graphics requirements.	**AB**	**from £4500**
GEC SOFTWARE LTD The Verdix Corporation	**VERDIX ADA Development system** Complete ADA development system includes validated compiler, runtime and library facilities and symbolic debugger.		**On application**
IBM (UK) LTD **IBM**	**Sea-Change** Suite of programs allowing the user to produce commercial software. The ability to write large & complex programs	AIX	**from £950**
INTASOFT LIMITED Intasoft Ltd	**SYNDIE Syntax Directed Editor** Language-independent, Menu-driven program construction - prohibits syntax errors.	**ABCEFJ**	**from £2500**
KALAMAZOO BUSINESS SYSTEMS Software Express Inc	**Appgen** 4GL applications generator using prompts and responses to define an application.	**BCDFIJ**	**£2450 +**
MICROPROCESSOR DEVELOPMENTS LTD Microprocessor Developments Ltd	**Sculptor** Powerful Fourth Generation Language. Development language for programmers.	**ABCDEFGHIJ** MS-DOS, QNX, OS9	**from £495**
ORACLE CORPORATION UK LTD Oracle Corporation	**SQL** Forms 4GL applications generator based on the ORACLE relational database & associated software.	**ABCEFI** ULTRIX	**from £1800**
PRO-LAB PLC PRO-LAB plc & PCS Inc	**PRO-IV** 'The professionals 4GL Application Generator' to replace 3GL/Cobol for all commercial systems.	**BCIJ** MS-DOS, PC-DOS, C-DOS	
SPHINX LIMITED Informix Inc	**Informix-4GL** 4GL designed specifically for the UNIX environment		
THOMSON COMPUTERS LTD Thomson Computers Ltd	**Sea Change** Simple to use but very powerful application generator for use by para-programmers.	**ABCEFIJ** AIX, PCDOS, MSDOS	**£395 - 1560**
TORCH COMPUTERS LTD Torch Computers Ltd	**Opentop** Interface between Unix and the operator using keyboard and a mouse.	**B**	

Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
UNIFY CORPORATION Unify Corporation	**Accell/IDS** Designed for high performance in production transaction oriented applications.	**ABCDEFIJ**	**from $2995** US Dollars
Unify Corporation	**Accell/CP** Option to Accell/IDS offloads human i/f from Unix-based host system to a PC connected by a serial link.	**ABCDEFIJ**	**from $300** US Dollars
VENTURCOM INC Venturcom, Inc	**Prelude Application Generator** Designed to build user-friendly i/fs to Prelude based solutions using menus, data entry form screens & help facility.	**ABC** VENIX	US Dollars
XITAN LTD Zanthe Inc	**ZIM** Based on the entity-relationship model. High levels of relational functionality.	**I**	**from £840**

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
CAD/CAM/CAE			
ADVANCED SOFTWARE APPLICATIONS Advanced Software Applications	**Diamond** State of the art Design and Draughting system, featuring easy to use, wide ranging facilities and performance.	**BCDFGJ**	**On application**
HARRIS SYSTEMS LTD **Harris Systems Ltd**	**Harris CAD** Modular integrated design, modelling, analysis and drafting system. CAM capabilities are also an integral part.	**BF**	
HEWLETT-PACKARD SA Hewlett-Packard	**ME Series 10** Design and drafting system providing an advanced set of tools for 2D design.		
Hewlett-Packard	**Microprocessor Cross Assembler** 17 Cross Assembler products supporting more than 30 Microprocessors.		
Hewlett-Packard	**Teamwork SA/SD/RT** Environment for structured analysis and design with extensions for real time processes.		
Hewlett-Packard	**Microprocessor Emulators** 3 general purposes, 17 16-bit, 5 8-bit, 5 single chip and 1 32-bit in circuit microprocessor emulators.		
Hewlett-Packard	**Pascal & C Cross Computers** 14 different Computers supporting more than 20 Microprocessors.		
Hewlett-Packard	**Electronic Design System** Digital Design Capture and Simulation System.		
Hewlett-Packard	**Printed Circuit Design System** Couples printed circuit board layout to electrical engineering design, manufacturing and test.		
Hewlett-Packard	**Analog Worksbench** CAE System for Analog circuit design.		
Hewlett-Packard	**ME Series 30** Modeling, Design and Drafting system integrates full solid modeling into the 2D system.		
IBM (UK) LTD IBM	**CIEDS** For the Electronic designer, it provides design support using an integrated database	AIX	**from £8114/mod.**
IBM	**Professional CADAM** CAD package for designers, draughtsmen, engineers and technical professionals in a variety of industrial & non-ind apps.	AIX	**£12213**
IBM	**CAEDS** Integrated interactive design system for conceptual modelling, mechanical design & finite element pre & post processing	AIX	**from £1348**
SERVICE IN INFORMATICS AND ANALYSIS LTD Service in Informatics and Analysis Ltd	**LEAP 5** Civil engineering frame and finite element analysis and design system.	**ABCI**	from 2500

Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

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UNIX As a Development System

Unix is one of the most popular operating systems for software development. This article describes the use of UNIX and UNIX-style operating systems in a development environment, with particular reference to cross development and embedded systems. In an embedded system, a microprocessor is used for a single, fixed purpose, rather than as a component of a general-purpose computer.

There are many different types of development environment. For example, the only hardware requirements that have to be taken into account when writing a word processor for a personal computer are the characteristics of the particular machine. These are usually clearly defined, and include type of processor and amount of memory.

The development requirements for a processor which is to control a specific device (such as a washing machine) are likely to be much more complex, in that it will be difficult to test the product without actually building it. There are several means of testing such products, including hardware emulations to emulate the target board and software simulators to test the software as far as possible on the development machine. However, all these methods have drawbacks, due to differences between the development system and the hardware of the finished product.

Requirements of a Development System

Features of a development system will vary, depending on the application, but some general requirements may be identified:-

- Availability of suitable development software, for example cross assemblers.
- A choice of high-level languages, so that the most appropriate may be selected for the task in hand.
- An adequate range of general software tools.
- A larger user base, to ensure continuity of supply and steady release of new software.
- A choice of hardware on which to run the development software; some applications may require a machine which can support dozens of users, whilst others may have more modest requirements.

Cross Development

Many software developers develop their applications on the machine (for example, an IBM PC) on which it is to run. This may be adequate in some cases, but is often less then satisfactory and is sometimes totally impractical, as in the case of an embedded system.

More software developers are now writing and testing the software on one machine (the host), prior to transferring it to the machine or processor on which it will eventually run (the target).

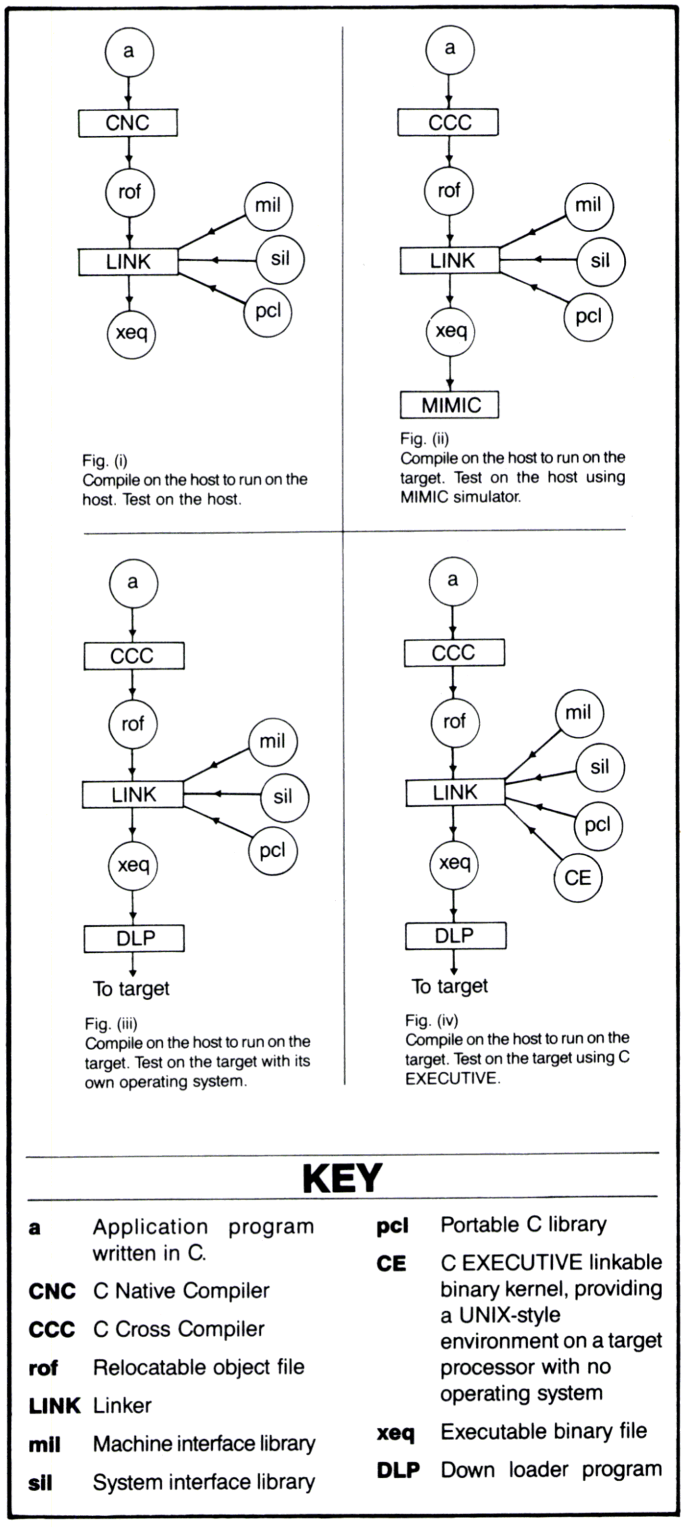

Figure: Native and Cross Development — UNIX provides an excellent environment for this type of development work.

This is known as cross development, and is very useful in cases where the target machine lacks some or all of the features for development. For example, the target machine may only support one user, or it may not support the required software tools; in the case of an embedded microprocessor, there might not even be an operating system.

Advantages of using UNIX for Cross Development

With the appropriate development software, a wide choice of hardware is available, including PDP-11, Gould, Prime, Pyramid, PC/AT, Sequent Balance, Tolerant Eternity, Whitechapel MG-1, VAX and MicroVAX.

Different varieties of UNIX are available, each with different strengths; for example, Berkeley (BSD) UNIX is well known for its development tools, whilst Whitesmiths' IDRIS has excellent support for real-time applications and embedded systems.

Support is available for all popular programming languages, some of which may be mixed if required. In particular, a very large range of C compilers and cross compilers is available; since C is the UNIX system implementation language, it is in many respects the natural language to use under UNIX. It is also the most suitable language to use for the majority of development tasks, offering the flexibility and power of assembly languages with the features of high-level languages; it is particularly suitable for use in developing embedded applications. C is becoming increasingly widely used, not only for development.

A further advantage of C is the portability of suitably written source code, allowing the transfer of applications between machines, if this is required.

Much software development is now carried out on a VAX or MicroVAX running some variety of UNIX. For those who also need to use VMS, the CO-IDRIS operating system from Whitesmiths co-exists in memory with VMS, allowing different users simultaneous access to both systems, or an individual user rapid access to either. A user may write, compile, debug and test the application on the VAX and then download it to the target system, which may be a computer such as an IBM PC or a board with an embedded microprocessor such as a 68000 or 8086. Some vendors can supply all these systems software components in an integrated package; Real Time Systems can even supply the operating system (IDRIS for 68000-based machines and PDP-11 or CO-IDRIS for VAX) as well as the compilers, assemblers and debuggers for a wide range of targets.

An important feature of cross development under UNIX (or any other operating system for that matter) is the ability to test the application as far as reasonably possible on the host machine. This is particularly important in the development of software to run on embedded processors, where it is usually much more productive to carry out most of the testing before starting to use an emulator (hardware simulator).

An Ideal Target Environment

Thus far, this article has attempted to illustrate the merits of using UNIX in software development, both as an operating system on the machine on which the application is to run and as a system on a host machine for cross development to a target processors. A common problem with cross development is moving the application from the development system to the target system. Usually, the software has to be modified to a greater or lesster extent when doing this; clearly, the less modification required, the more efficient the overall development process will be.

The implications of a UNIX-style *target* environment will now be considered. Features which would be useful or essential in such an environment would include the following:-

- Ability to use UNIX system calls.
- UNIX-style I/O to allow the application to be *tested on the host.* This should also provide the ability for processes to read/write to or from terminals, data queues, disks (directly or via a filesystem) and user-added devices using the *same* system calls ("open", "write" and "close"). Also, standard UNIX runtime I/O redirection, including STDIN, STDOUT and STDERR, should be supported.
- A highly configurable process scheduler, preferably with optional preemption to allow a higher priority process to run in place of a lower priority process, if required.
- Fast context switch times, comparing favourably with assembly language target environments.
- The same general environment for a wide range of target processors.
- Built-in support for C, including ROMable library functions. Most UNIX C compilers do not have ROMable libraries; in particular, the functions for opening and closing files, buffered I/O, and heap management are not usually ROMable.
- Ability to divide applications between RAM and ROM.
- Device-dependent control functions via a UNIX system call.
- A null device, as used in UNIX, to test routines when no output is wanted.
- Ability to accommodate new devices easily by writing device drivers.
- Ability to schedule timesharing *and* real-time processes.
- Ability to use disks for more sophisticated embedded applications, to dynamically load programs into memory as required.
- Ability for the embedded executive/monitor to reside in RAM or ROM in any reasonable combination.
- Configurable buffer sizes for devices operating at different speeds.
- A shared text facility.
- Components of an embedded system which are required by many different types of application should be supplied, so that the developer only has to write code for his specific application.
- The use of data queues, rather than obsolescent methods such as discrete mailboxes.
- A range of operating systems/executives for small to very large embedded applications.

The only products available at the moment which meet all these criteria are IDRIS from Whitesmiths Ltd. and the C EXECUTIVE from JMI Software Consultants Inc. IDRIS is available in different packaging options, ranging from full development system to a disk-based executive and board-based exeuctive. C EXECUTIVE is a compact monitor, which supports an optional filesystem. Both extend the UNIX concepts of flexibility and portability to board-level, providing the same environment on a wide range of popular microprocessors.

The C EXECUTIVE is particularly designed to facilitate the use of dataflow design methods, in which a system is viewed as a collection of modules communicating with eath other via streams of data known as queues. This allows processes to be written as if their I/O consisted of continuous data streams. Byte-serial data queues also allow data multiplexing by configuring two or more processes to read from different input ports and write to the same data queue. The benefits from this type of design methodology are that implementation of embedded systems is simplified by using common interfaces, and that processes can easily and reliably be located in separate CPUs, since the interface between a process and a queue is the same as the interface between a process and a peripheral device. This enables embedded processes to be tested easily, by (for example) supplying input to a process from a terminal, and when the process is operating satisfactorily, substituting the output from (for example) a sensing device which will be used in the finished embedded system.

A UNIX-style environment is thus available from initial development in testing the finished product. Flexibility, portability, reliability and ease of maintenance of embedded applications derive naturally from this design philosophy, which emphasises the use of a real-time UNIX-style environment and C as much as possible.

Robert Farrington graduated from Leeds University in 1983 and gained an MSc from Loughborough in Information Technology in 1985. His specialist responsibility with Real Time Systems involves the technical aspects of product marketing.

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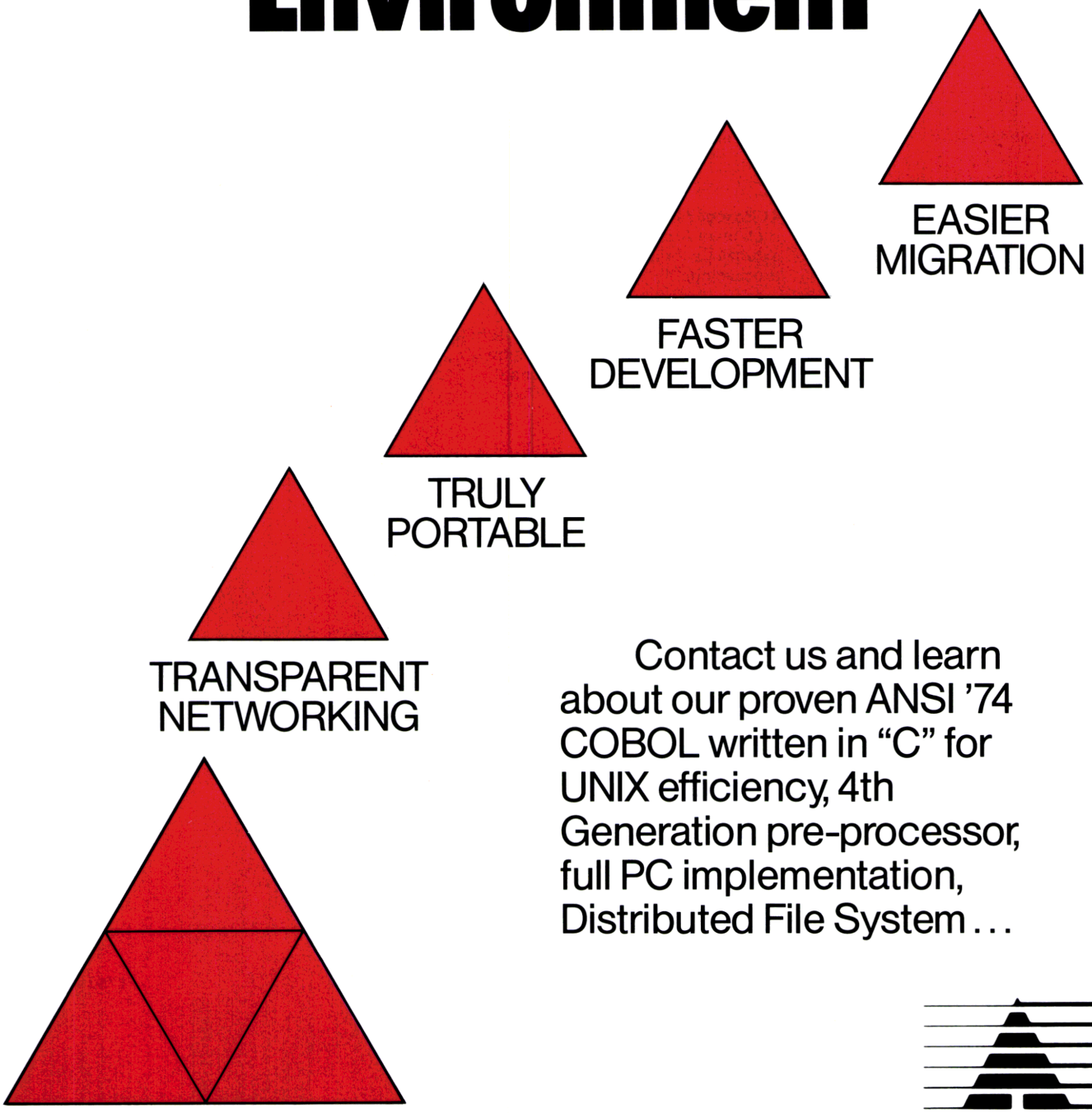

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Circle No. 298

Compilers/Languages

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
ARMSTRONG MICRO ELECTRONICS	**ACE-Cobol** Provides a truly portable Cobol environment with development tools incorporated.	**IJ**	
Austec Ltd			
Unisoft Inc	**PC Interface** Allows Unix System to act as Fileserver to PCs and PCs to run as terminals on Unix system.	**IJ**	
Microfocus	**Level II Cobol ET** High performance Cobol with animator and forms generator.	**IJ**	
Ryan McFarlane Inc	**RM Cobol**	**IJ**	
Silicon Valley Software Inc	**SVS Fortran, Pascal, Basic +**	**IJ**	
AUSTEC LTD	**ACEcobol 74** High level ANSI 74 Cobol compiler with extensions for multi-user interactive processing.	**ABCDEFGHIJ** MSDOS, PCDOS	
Austec			
Austec	**ACEgen** Fourth generation programming techniques available to Cobol programmers by generating ACEcobol source code.	**ABCDEFGHIJ** MSDOS, PCDOS	
BLEASDALE COMPUTER SYSTEMS PLC	**RM Cobol** Designed for developing and executing professional business applications on Bleasdales range of systems.	**J**	**On application**
RM			
Microfocus	**Level II Cobol** Allows ANSI 74 Cobol applications to move between mainframes & microcomputers with minimal code modification.	**J**	**On application**
SVS	**SVS Languages** Fortran, Basic, Pascal		**On application**
CREATIVE DATEN SYSTEME GMBH	**C Cross Compilers** Family of C Cross compilers targeted for a wide range of processors.	**CEF** Ultrix	**$4000 - 8000** US Dollars
Creative Daten Systeme			
DATAWARE LTD	**Dixbol** Commercial programming language allowing existing Dibol programs to run under Unix.	**AB**	
Minihouse NV			
Quantic Computing	**BLS** New, portable implementation of Basic providing migration path for Basic + users to the Unix environment.	**AB**	**£750 - 1500**
DYADIC SYSTEMS LTD	**Dyalog APL** Second generation version of APL designed for Unix Systems.	**BCDFI**	**£3000**
Dyadic			

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
GOULD ELECTRONICS LTD Gould Electronics	**Ada - APLEX** A Family of validated Ada compilers for all Gould Computers.	**BE**	On application
IBM (UK) LTD IBM	**VS FORTRAN** Compiler Version 1 is a high performance optimising compiler that produces object code for execution on the 6150	AIX	**£812**
IBM	**VS PASCAL** Accepts source code as defined by PASCAL/VS with minor restrictions. Performance improvement over 1.1 PASCAL	AIX	**£781**
IBM	**RM/COBOL** Designed for application developers and end-users. For the developer there is a 'Full System' i.e. with compiler	AIX	**from £297**
IBM	**DYALOG APL** General purpose language for the problem solving needs of a wide range of users in industry, commerce, & education	AIX	**£3014**
KDG COMPUTER SYSTEMS LTD National Semiconductor	**GNX Technical Compilers** 'C', Pascal, Fortran-77 and NS32000 Assembler all based on AT&Ts Common Object File Format.	**ABC**	**£1350 - 6000**
Various	**Q-Frame Commercial Compilers** Cobol, Basic+ and MUMPS all being able to operate concurrently in a UNIX environment.	**ABC**	**£800 - 3000**
LANGUAGE PROCESSORS, INC Language Processors, Inc	**LPI Basic** High performance implementation of Basic source compatible with Microsoft BASIC and CBASIC and is GSA certified.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-C** Full implementation of Industry standard C as defined by Kernighan & Ritchie.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-Cobol** GSA certified implementation of ANSI standard Cobol-74 at the high level.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-Fortran** GSA certified implementation of ANSI Fortran-77 standards.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-PL/1** ANSI standard PL/1 general purpose subset.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-Pascal** ANSI/IEEE and ISO level 0 Pascal language.	**ABCDFIJ**	US Dollars
Language Processors, Inc	**LPI-RPG II** Full implementation of IBM RPG-II.	**ABCDFIJ**	US Dollars
MICROTEC RESEARCH Microtec Research	**High Level Debugger (XRAY)** XRAY 68k is a high level C language debugger for developing/testing 68000 020 code.	**CF**	**£2000 - 13000**
Microtec Research	**Cross Compiler** Range of highly optimising Cross compilers for C and Pascal, for targets 68000/020, 8086/286, Z80, 64180, 8085.	**CF**	**£1500 - 7000**

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Microtec Research	**Cross Assemblers** Range of relocatable MACRO Assemblers for a wide range of microprocessor targets.	**CF**	**£500 - 2000**
MIPS COMPUTER SYSTEMS Various	**Series of Compilers** IEEE/ASNI Pascal, System V C, FORTRAN 7 with VMS extensions, ANSI 85 COBOL X/OPEN (Micro Focus Level 11)	**AE**	
The Verdix Corporation	**Verdix** ADA development system	**AE**	
OASYS (A DIVISION OF XEL INC) OASYS	**Compilers** C, Pascal and Fortran compilers.	**BCDFG**	
PRODUCTIVITY PRODUCTS INTERNATIONAL Productivity Products International	**Objective-C** Object-orientated precompiler allows C programmers to build programs with reusable software components.	**EF**	US Dollars
REAL TIME SYSTEMS LIMITED JMI Software Consultants/Real Time Sys.	**Pascal Compiler/Cross Compiler** Reliable, field proven compilers for 32016 based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1400 - 5000**
JMI Software Consultants/Real Time Sys.	**C Compiler/Cross Compilers** Reliable, field proven compilers for 32016 based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1200 - 4300**
Real Time Systems Ltd	**C Cross Compilers for 9900** Reliable, field proven compilers based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1200 - 4300**
Real Time Systems Ltd	**Pascal Cross Compilers (9900)** Reliable, field proven compilers based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1400 - 5000**
Real Time Systems Ltd	**C cross compilers for 6809** Reliable, field proven compilers based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1200 - 4300**
Real Time Systems Ltd	**Pascal cross compilers (6809)** Reliable, field proven compilers based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1400 - 5000**
Whitesmiths Inc	**Pascal Compilers/Cross Compilr** Reliable, field proven compilers based on the Whitesmiths technology.	**ABCDEFGHIJ**	**£1400 - 5000**
Whitesmiths Ltd	**C Compilers/Cross Compilers** Reliable, field proven compilers portable across a wide range of machines and operating systems.	**ABCDEFGHIJ**	**£150 - 7980**
Real Time Systems Ltd	**XA8 Series of Cross Assemblers** Todays most comprehensive range of cross assemblers for 8-, 16- and 32-bit microprocessors.	**ABCDEFGHIJ**	**£420 - 3200**
Whitesmiths Ltd	**PTC** Pascal to C Language translator, which conforms to ISO Level 1 Standard.	**ABCDEFGHIJ**	**£5000**
JMI Software Consultants Inc	**BASTOC** Basic to C translator, which can be tailored to specific versions of Basic.	**ABCDEFGHIJ**	**£5000**

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
ROOT COMPUTERS LIMITED	**Optim 2** Compensates for shortfalls in existing C Compilers and optimisers. Largely machine independent.		
Root Technical Systems			
Root Computers	**Rootexec** Improves performance of exec, the system call within Unix responsible for loading programs from disk into main memory.		
SOFTWARE IRELAND LIMITED	**UNIBOL/RPG II** Bridge product which provides a full runtime and development environment for IBM RPG II applications	**AB**	
Software Ireland Ltd			
Software Ireland Ltd	**UNIBOL/DIBOL** Bridge product which provides a full runtime and development environment for DEC DIBOL applications	**ABCDEFGHIJ**	
SPHINX LIMITED	**Level II COBOL** COBOL compiler		
Micro Focus			
SYSTIME COMPUTERS LTD	**Ace COBOL** Range of COBOL products including Ace COBOL 74 and 85 compilers.	1-4K	
Austec			
UNIQ DIGITAL TECHNOLOGIES INC	**Philon Fast Cobol** High level ANSI 74 compiler not an interpreter optimized for highly efficient executable code.		**$4950 - 16500** US Dollars
Philon			
Uniq Digital Technologies	**Pascal**		**$1375 - 1925** US Dollars
Ryan McFarland	**RM/Cobol** Uniq port of RM/Cobol to Unix system V, Ultrix 32, Ultrix 11.	**ABC** ULTRIX	**$3500 - 6500** US Dollars
UNISYS EUROPE-AFRICA LIMITED	**Philon Fast/BASIC M** Intended for applications development on Series 5000. Syntax compatible with 'M' BASIC from Microsoft	**B**	
Unisys			
Austec	**ACE COBOL** COBOL compiler designed cognisant of present & anticipated future software technology. Interpretive & native modes.	**B**	
Ryan McFarland	**RM/COBOL** Provides immediate access to hundreds of application packages. GSA-certified implementation of ANSI X3.23	**B**	
Unisys	**Philon Fast/FORTRAN** Full implementation ANSI Standard FORTRAN 77 for scientific/engineering application development environment	**B**	
Unisys	**SVS FORTRAN** ANSI Standard FORTRAN 77 system. Includes natice code compiler, run-time i/o system and symbolic debugger.	**B**	
Unisys	**SVS PASCAL** ISO Standard PASCAL (ISO DP-7185) superset (except conformant arrays), with most features of UCSD PASCAL	**B**	

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Language Processors Inc	**LPI - RPG II** IBM System/34 compatible compiler with runtime libarary.	C	
XITAN LTD Microsoft Inc	**MS-Fortran** Subset of Fortran 77. Access to 65536 records in a 4MB file, multiple code segments handling.	I	**£375**
Ryan McFarland	**Cobol** Interactive screen handling, cross reference generation, interactive debugging, utilities.	I	**£962**
Microsoft Inc	**Compact Level IV Cobol** Original level II Cobol implemented for a microcomputer. Multi-user support, built in support facility.	I	**£1450**
Microsoft Inc	**MS Cobol Compiler** ANSI X3.23 74 Standard. Trace style debugging, screen handling and flexible data access.	I	**£795**
Microfocus	**Animator for Level II Cobol** Debugging tool for use with Microfocus Cobol family. Interactive screen debugging at source code level.	I	**£750**
Microsoft Inc	**Microsoft Basic Interpreter** Extensive implementation of ASCII Basic supports 4 variable types, multi-dimensional arrays.	I	**£275**
Microsoft Inc	**Pascal** 3-pass compiler with many compile time options. 3 levels of program development	I	**£375**
Ryan McFarland	**RM Fortran** Extensive optimisation of object code/ Non-recalculable common sub expressions.	I	**£577**

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Communications/Networking			
ARMSTRONG MICRO ELECTRONICS Root Computers Ltd	**Root Net** Transparent distributed file system based on Newcastle connection.	**IJ**	
AUSTEC LTD Austec	**Acenet** Network file system for commercial applications used by Acecobol for networking applications.	**ABCDEFGHIJ** MSDOS, PCDOS	
CONVERGENT TECHNOLOGIES (UK) LTD Convergent Technologies (UK) Ltd	**SNA PU Type2.1 Network Gateway** Allows S/Series workgroup server to function as a physical unit type 2.1 and 2.0 control unit in SNA communication.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**CTIX X.3/X.28/X.29 PAD** Conforms to CCITT 1980 recommendations. Full support of 18 X.3 parameters, ASCII file transfer capabilities.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**CTIX SNA LU 6.2 APPC Server** Advanced program-to-program server implements IBMs logical unit 6.2 protocols providing basic verb support.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**BSC 2780/3780** Allows users of the S/Series workgroup servers to exchange data and do program development with IBM mainframes.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**WGS/Mail** Fully-featured mail system allows users to send messages created in editor and attach other files in WGS/Mail envelope.	**AB**	**On application**
Network Innovation/Convergent Tech.	**Multiplex** Networking tool that links a PC to the Convergent S/Series.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**SNA Network Gateway** S/Series workgroup servers communicate with mainframes in a IBM system Network Architecture environment.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**Ethernet TCP/IP** CTIX users can configure high speed LANs efficient means of exchanging info and sharing resources.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**PC Exchange** Lets DOS PC users access and share files printers and mail service, and provides access to Unix or other host resources.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**X.25 Network Gateway** Provides user with interface that application software can use to control the transfer of data over PDNS.	**AB**	**On application**
GEC SOFTWARE LTD The Wollongong Group	**WIN/VX** Software communications package which connects VAX/VMS systems to Unix machines over Ethernet.		**On application**
The Wollongong Group	**WIN/NFS** VMS Implementation of NFS (Network File System) - The industry standard for transparent file access.		**On application**

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
The Wollongong Group	**WIN/PC** Software communications package which links IBM PCs to machines which support TCP/IP eg UNIX		**On application**
IBM (UK) LTD IBM	**6150 Distributed Services** Allows access to files on a distributed network without knowing on which node the file is situated.	AIX, Ethernet	**£725**
IBM	**X-Windows** Provides a facility for running multiple application processes in multiple simultaneous windows on a 6150 graphics	AIX, Ethernet, Token Ring, LAN	**£593**
IBM	**Network 3270-PLUS** 3278/9 terminal emulation, supporting the base 3270 data stream. For 6150 console displays and attached ASCII devs	AIX, SNA	**from £777,**
IBM	**Network RJE-PLUS** Provides user with the ability to interact with host programs supporting RJE workstations	AIX, HASP	**from £777**
KDG COMPUTER SYSTEMS LTD KDG Integrated	**Q-Net** Ethernet LAN with TCP/IP protocol and functionality.	**ABC**	**from £3000**
MARI ADVANCED SYSTEMS LTD	**The Newcastle Connection** Unites computers running Unix operating system creating a transparent, fully functional distributed system.	**B**	
MIPS COMPUTER SYSTEMS Sun Microsystems	**NFS** Network File System	**AE**	
PH INTERNATIONAL Corporate Microsystems Inc	**MLINK** Data Communications System designed to satisfy wide area networking requirements.	**ABCDEFGHI**	**2,600/11,400 Franc**
PHILIPS EXPORT BV Philips Div. I&E	**UNIFIVE - NFS** The SUN-NFS (Network File System) implementation on the Philips Unix SV system (Unifive).	**BJ**	**DFL 1500 DFL**
SPHINX LIMITED SPHINX Limited	**SPHINXLINK** File transfer between UNIX machines using asynchronous communications		
SCO	**SCO XENIX-NET** Local area network for computers running XENIX		
Systems & Telecoms Ltd	**S-TELEX** Allows Telex to be transferred to and from the UNIX environment		
Touchstone	**PCWORKS** Communications package for PCs to UNIX, VAX/VMS and Apple Macintosh		

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Touchstone	**MACLINE** Communications package for the Apple Macintosh to UNIX, VAX/VMS and IBM PCs.		
SYSTEMS AND TELECOMS LTD Systems and Telecoms Limited	**S-TELEX** Fully automated Telex management system usable on any equipment based on UNIX.	**ABCDEFGHIJ**	
THE INSTRUCTION SET Sun Microsystems	**Network File System (NFS)** Networking service provides for transparent file access among different computers over one or more networks.	**ABEF**	**On application**
THE SANTA CRUZ OPERATION LTD The Santa Cruz Operation Ltd	**SCU UniPATH SNA-3270** Allows terminals connected to XENIX machine or DOS PCs connected on network to interface to IBM host.	**I** DOS	
The Santa Cruz Operation Ltd	**SCO XENIX-NET** Local Area network to tie together industry standard 286 and 386 based PCs running both XENIX and DOS	**I** DOS	
UNIPALM Network Research Corporation	**Fusion** Fusion Networking software can net IBM PC, UNIX, PDP/11, VAX, IBM using TCP/IP, XNS or ISD.	**ABCDEFGHIJ** VENIX	**from £450**
UNIQ DIGITAL TECHNOLOGIES INC Uniq Digital Technologies	**Passage - TCP/IP/Ethernet** Complete implementation of TCP/IP protocols for VAX processors under UNIX system.	**ABC** ULTRIX	**$3300 - 16500** US Dollars
UNISYS EUROPE-AFRICA LIMITED Unisys	**IS-5000** Allows communication between 5000 series and Series 1100	**BC**	
Unisys	**NET-5000** Enables Series 5000 systems to be connected to an Ethernet local area network	**BC**	
Unisys	**PCWORKS & UNIHOST** Complementary products which link Unisys PCs under MS-DOS to Unisys 5000 or 7000 series	**BC**	
Unisys	**Uniscope** Allows Unisys PC to communicate with the 1100 series	**B**	
VENTURCOM INC Venturcom, Inc	**VENIX E-Net 205** Connects PCs to PCs, servers and other computers over an Ethernet LAN with TCP/IP protocol.	VENIX	**$595** US Dollars
XOREN COMPUTING LTD Xoren Computing Ltd	**IPL-11 File Transfer Software** Range of file transfer/terminal emulation software linking PDP/VAX, IBM PC/XT/AT, UNIX/XENIX.	**ABCEFGI**	**from £360**

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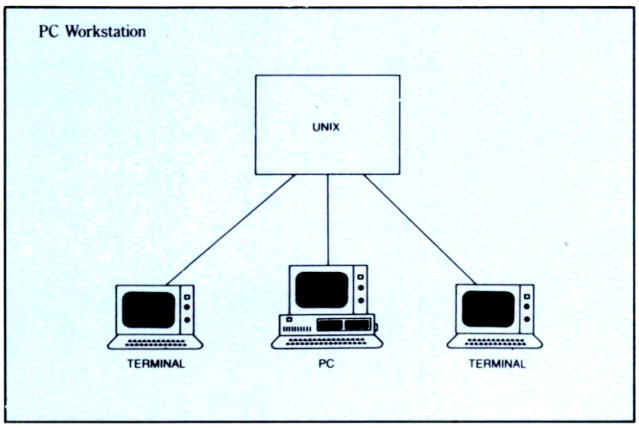
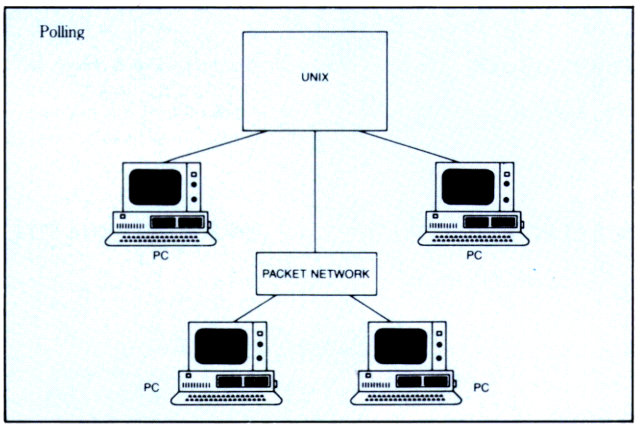
MLINK

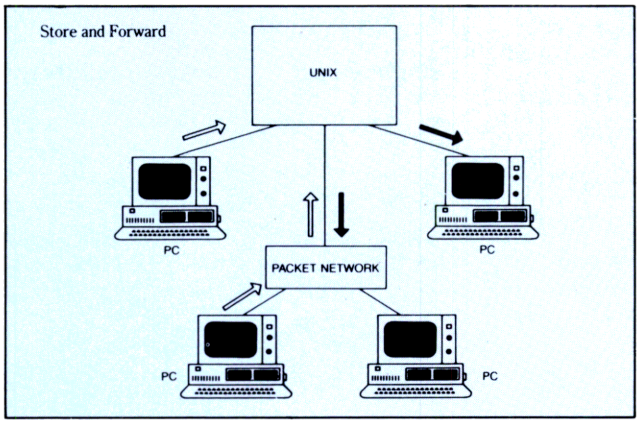
DATA COMMUNICATIONS SYSTEM

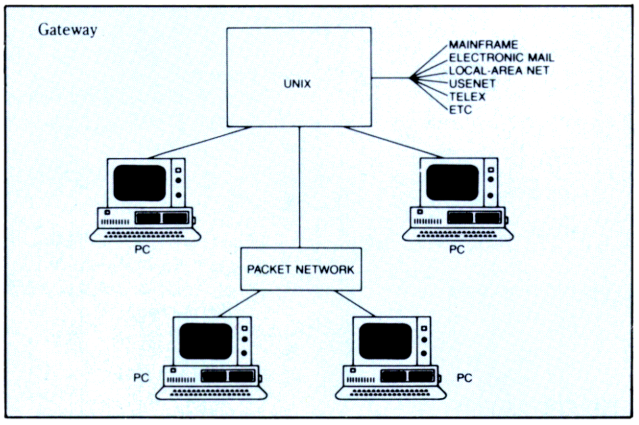
Make the Right Connection!

MLINK is designed to satisfy the widest range of data communications requirements. It is the most powerful and sofisticated communications sofware your system can run.









MLINK provides three sets of features allowing terminal mode, data transfer and applications customization using a built-in script language.

TERMINAL MODE

Terminal emulation
Autodial modem support
Directory based autodialing
Automatic logon
Session capture
System commands
Configuration, etc.

FILE TRANSFER

Error free data transfer
MLINK protocol
KERMIT and XMODEM protocols
Text and binary file transfer
File transfer lists
Host (server) mode
Scheduled operation, etc.

SCRIPT LANGUAGE

Over 65 instructions
Symbolic and system variables
Communications instructions
File I/O instructions
User interface adaptation
Program run
Object code independance, etc.

MLINK has menu driven interface and on line help facilities.

MLINK AVAILABLE FOR: UNIX System V • UNIX System III • UNIX Version 7 • BSD 4.2 • XENIX • VM/CMS • MS/DOS • CP/M • VMS • MACINTOSH.

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Circle No. 281

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Database Management			
ARMSTRONG MICRO ELECTRONICS Unify Corporation Inc	**Unify** RDBMS, Report writer, SQL Query Language Screen painting, host language interface	**IJ**	
Informix	**Informix** RDBMS incorporated into many applications.	**IJ**	
Santa Cruz Operation Inc	**Sco Foxbase** An enhanced DBase II Workalike.	**IJ**	
BENSASSON & CHALMERS LTD Bensasson & Chalmers Ltd	**Spires** Relational/Textual DBMS with object management.	**CIJ** Ultrix, Aegis	
BLEASDALE COMPUTER SYSTEMS PLC Informix	**Informix 3.3** Relational Database.	**J**	**On application**
Unify Corporation	**Unify** Relational DBMS.	**J**	**On application**
BRITTON LEE (EUROPE) LTD Britton Lee Inc	**Intelligent Database Machine** Fully relational database system running on a specialised computer (IDM/RS).Allow heterogeneous hosts to access database.	**BEFG** Ultrix	
CARE BUSINESS SOLUTIONS LTD Rhodnius Inc	**Empress/32+ M-Builder (4GL)** User friendly relational database with excellent SQL and powerful 4GL.	**ABCDEFGHIJ**	**£2250 - 30000**
CONVERGENT TECHNOLOGIES (UK) LTD Unify Corporation/Convergent Tech.	**UNIFY/E run-time system** Allows application developers to resell Unify base applications at a much lower cost.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**CTIX/ISAM** Server-based implementation of indexed sequential access to data. Upto 100 different keys can be supported.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**CTIX Sort/merge** Allows the sorting of CTIX data or ISAM files on up to 100 keys. Unlimited record length.	**AB**	**On application**
Unify Corp./Convergent Tech.	**UNIFY/E** UNIFY Enhanced RDBMS allow users with no programming skills to create fully functional applications.	**AB**	**On application**
IBM (UK) LTD IBM	**6150 SQL** RDBMS for organising, maintaining, storing, calculating, combining and retreiving information	AIX	**£744**
LATICORP, INC Laticorp Inc	Sync Electronic mail, appointments, group and resource scheduling, reminders and telephone messaging.	**ACEFI**	**$195 - $3995** US Dollars

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
MARI ADVANCED SYSTEMS LTD Root Computers	**Informix SQL & ESQL** Relational DBMS, Embedded SQL facility for C programmers.	**BJ**	**from £1200**
MIMER INFORMATION SYSTEMS AB Mimer Information Systems AB	**MIMER** Multi-user relational DBMS. Includes 4GL tools for application development.	**AB**	**From 20000** Swedish Kr
NIXDORF COMPUTER LIMITED Nixdorf	**Reflex** RDBMS with 4GL capability & distributed databases.	**B**	
OFFICESMITHS INC Officesmiths Inc	**Officesmith** Handles text combining info retrieval and word processing capabilities with full range of database management tools.	**ABCF**	
ORACLE CORPORATION UK LTD Oracle Corporation	**ORACLE** Leading distributed relational DBMS using the SQL language. Available on a wide range of hardware.	**ABCEFI** ULTRIX	**from £2250**
PA CONSULTING GROUP PA Consulting Group	**dataSET** Data structuring system which provides high performance whilst supporting large complex data structures.	**BEFG**	**£3500 - 14000**
PA Consulting Group	**sqlSET** Comprehensive implementation of IBMs SQL.	**BEFG**	**£6000 - 24000**
RELATIONAL TECHNOLOGY Relational Technology	**INGRES** Full function RDBM and application development system that includes fourth generation visual programming tools.	**ABCF** ULTRIX	**£2000 - 100000**
RHODNIUS S.A. - EUROPE Rhodnius Inc	**Empress** RDBMS designed with the adaptability to addres the new range of high tech applications.		
SERVICE IN INFORMATICS AND ANALYSIS LTD Inter Systems Inc	**SIR/DBMS** Relational DBMS. Powerful 4GL interfaces to SAS and SPSS. Portable from PC to Cray.	**ABCI**	**from 1500**
SPHINX LIMITED Informix Inc	**Informix-SQL** Comprehensive implementation of the query language SQL		
Informix Inc	**File-It!** Offers compatibility at file and data dictionary levels		
Informix Inc	**Informix** DBMS for UNIX systems.		
Informix Inc	**Informix-ESQL/C** Allows query and manipulation of an SQL database from a C program		

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Informix Inc	**C-ISAM** File management system		
SCO	**SCO FoxBASE** Relational DBMS, compatible with dBASE II		
SYSTEMS UNION LTD Systems Union Ltd	**Suntrend** Multi-dimensional modelling with data base facilities, report generator, command files, graphics, colour, etc.	**ABCDEFGHIJ** ULTRIX	
THE SANTA CRUZ OPERATION LTD The Santa Cruz Operation Ltd	**Informix** Relational DBMS, ideal for a wide variety of applications and designed for the multi-user environment	**I**	
The Santa Cruz Operation Ltd	**SCO FoxBASE +** Enhanced dBASE III plus workalike with improved performance for the true multi-user XENIX environment	**I**	
The Santa Cruz Operation Ltd	**SCO FoxBASE** Enhanced dBASE II workalike. Fast, efficient, fully sourced language and data file.	**I**	
UNIFY CORPORATION Unify Corporation	**Unify RDBMS** Multiuser, menudriven, fully interactive Unix relational DBMS for high performanc transaction oriented applications.	**ABCDEFIJ**	**from $995** US Dollars
UNIQ DIGITAL TECHNOLOGIES INC Unify Corporation	**UNIFY** Uniq port of the relational data base from Unify.	**ABCEFG** ULTRIX	**$2475 - 33000** US Dollars
VENTURCOM INC Venturcom, Inc	**Prelude Database & DML** Allow the smooth flow of data from the database to other Prelude modules and external applications. Easy to use.	**ABC** VENIX	US Dollars

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Financial Planning			
ACCESS TECHNOLOGY Access Technology	**20/20** Worlds most widely installed multi-user, integrated spreadsheet with over 30,000 licences sold worldwide.	**ABCDEFGIJ**	**from £395**
ARMSTRONG MICRO ELECTRONICS Santa Cruz Operation Inc	**Xenix Tutor** Self-paced interactive Unix training programme.	**IJ**	
CONVERGENT TECHNOLOGIES (UK) LTD Convergent Technologies (UK) Ltd	**WGS/Spreadsheet** Capabilities/features of Lotus 1-2-3 and Multiplan made available to users of S/Series systems.	**AB**	**On application**
SPHINX LIMITED Access Technology Inc	**ACCESS 20/20** Multi-featured speadsheet		
UNIQ DIGITAL TECHNOLOGIES INC Uniq Digital Technologies	**UNICALQ** Virtual Memory spreadsheet with paging and multi-user security.	**ABCEFGH** ULTRIX	**$825 - 2125** US Dollars
VENTURCOM INC Venturcom, Inc	**Prelude Spreadsheet** 32000x32000 matrix with easy to use interface including macros and commmand menus for manipulating data.	**ABC** VENIX	US Dollars

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INTELLIGENT PAGE PRINTING SYSTEMS – An overview

This article looks at the extensive range of laser printer based graphics.

The arrival of intelligent page printing systems has opened up new markets for the in-house production of corporate and technical documentation. Incorporating a blend of image processing and non-impact laser printing technology, these systems enable users to prepare and print complex mixtures of graphics, shaded images and textual information in a manner previously only available with litho printing methods.

There are essentially four elements to intelligent page printing systems: a software package that generates the required image consisting of text and or graphics; a page description (document description) language that should provide an efficient communication of the image; the image processor that converts the description to control signals; and the laser print engine itself.

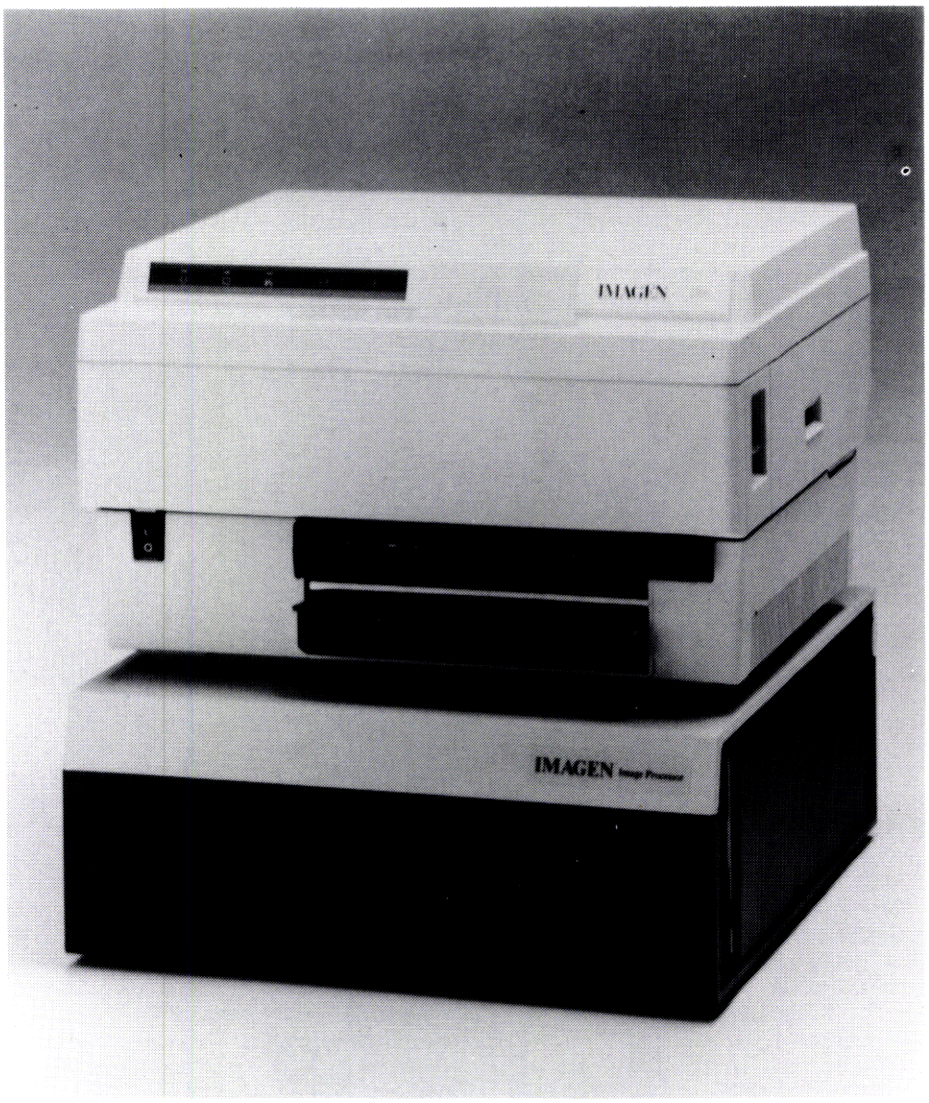
Overall system performance is rarely limited by the capability of the print engine, any degradation is usually attributable to the efficiency of the page description language and system's image processor. These shortcomings are becoming even more apparent as multi-page documents rather than single page output becomes the norm.

It is the level of intelligence within the laser printing system that principally determines the speed, complexity and quantity of images that can be handled.

The least sophisticated controllers, for example, provide a low-level of intelligence capable only of transmitting a ready formed bit-map with the relevant print engine control instructions. Producing the bit map is so memory intensive, that these laser printing systems are usually restricted to printing text and the simplest of graphics. *The page description language (PDL) has a vital role in determining the capabilities of the intelligent page printing system.*

On the other hand, image processors include the intelligence to process data sent in page description language format and consequently have the ability to understand vectors, shapes and textures in addition to the bit-maps and text. The page description language (PDL) then, has a vital role in determining the capabilities of the intelligent page printing system.

Most of today's languages have a common ancestor : the Press language developed at Xerox Palo Alto Research Centre (PARC) in the mid 1970's. Although used within Xerox and the university community, Press was never a commercial product. The first commercial derivative, imPRESS was introduced by



The Imagen 2308, an 8ppm system designed to keep throughput at the designated rate irrespective of the complexity of the graphics.

Imagen Corp. in 1981. Development of Press within Xerox continued, but a group from PARC split off in 1983, formed Adobe Systems, and introduced Postscript in 1984. Soon Xerox made public their successor to Press : Interpress, which may be considered a first generation document description language.

While one PDL has predominated in the low-end systems market, users are well aware of the shortcomings in speed of these systems. Performance limitations are also clearly evident in most mini-computer based image processors too, as shown by their inability to match the demands of the new generation of 40ppm print engines whenever significant graphics printing is required. It is worth stressing that all laser printing systems will run at their rated speed if producing multiple copies of the same page, but in the genuine applications of most users, processing is centered around the printing of multi-page documents.

Software writers requiring direct control of the image processor have a choice of PDLs with human readable or binary format commands. The human readable languages create larger page descriptions which take longer to send to the image processor and longer to process. The binary languages on the other hand, while they produce more efficient code, do appear harder to deal with. However, some may be easily translated into a human readable form which may then be compiled for a

compact and efficient binary coded page description. An example of such a compiler is 'Enco' for UNIX and MS-DOS systems that produce binary imPRESS code from the 'publication' format.

Page description languages should be transparent to the end-user. A driver program produces the page description code from the application-generated description of the page that the user has created. The user should only be concerned by the quality and speed of output.

Another factor having a dramatic effect on the page production speed is the method of font generation. Fonts that are scaled unintelligently from a vector outline are very efficient in terms of memory used but do use a considerable amount of processing time. In addition, the resultant font can become very ragged as it is scaled up, and can become virtually unreadable when scaled down, with both horizontal and vertical registration suffering badly.

A second method of font generation is by specifically accessing ready formed bitmaps for each point size required. There are not only considerable performance advantages, this method additionally ensures that characters are typographically correct in both proportion and positioning and results in a page layout that is typographically correct. Using this method of font generation, a fast PDL and laser printer can make corporate publishing a viable proposition. The typographically correct page often resembles output from a higher resolution typesetter and can be used as the camera ready artwork, an important fact on very large print runs.

If the document preparation software is chosen properly it will have options of driving typesetters and laser printers using different output file formats. This provides the best solution for each of the tasks.

Beyond the level of individual page generation the user should consider the document handling facilities of the PDL and image processor combination. The simplest document level facility involves the production of multiple copies of a multipage document. For this the image processor should be able to store a large multipage document and produce as many copies as required.

One company has adopted parallel processing and proprietary software techniques to ensure printer performance is not degraded by the provision of sophisticated document handling facilities. The Imagen image processor utilises a proprietary method of 'Real time' rasterisation that produces a compact description of the page internally occupying only 10-20 Kbytes in contrast to the Megabytes required by full bit maps.

Consider producing ten copies of a 100 page report or manual. If the image processor can store all 100 pages, the document is sent only once by the CPU and the host freed for other tasks while the Image Processor does its job. If the image processor cannot, however, store the multipage document because of memory limitations it must be sent ten times as required by the printer and seriously burden the host CPU. In the case of an 8ppm printer constantly working at full output speed this would take some two hours.

The ability to store large documents is a function of the PDL's efficiency and its ability to process documents rather than pages. Languages such as imPRESS and Interpress, although not true document languages, do understand multi-page prints and can produce multiple copies, as well as collage and reverse which becomes an important feature for printers producing face-up output.

Despite the current pre-occupation in some quarters with languages that degrade system performance, many manufacturers as well as hardware and software suppliers are taking advantage of the power afforded by the type of facilities detailed above to ensure their systems offer the maximum performance available.

If the image processor cannot store a multi-page document, then producing 10 copies implies that the document must be sent 10 times.

This was well proven at 1987's Hanover Fair where a large manufacturer used Imagen's image processor and the imPRESS page description language to achieve throughput of 92 different A4 pages per minute. In addition the Canon LBP-20 was duplexing at the fully rated speed of 20 images per minute. Other systems using other page description languages were lucky to peak at half of the printers rated performance when printing sequentially different pages.

The ability to store a multi-page document becomes even more important in duplex (two sided) printing. Canon's LPB-20, the heart of the Imagen 7320 system, takes 54 seconds to print an image of both sides of an A4 sheet even if the data is processed fast enough. To achieve its rated speed of 20 A4 images per minute instead of 2 per minute, Canon have fitted a 20 page holding tray in the print engine, this will require the image processor to hold a minimum of 80 A4 images when duplexing A3 paper. It can if required, using the optional 6 Mbyte of memory, store more than 600 A4 images.

In the event of an occasional paper jam, the facility for storing large documents within the controller also enables only the required pages to be reprinted without intervention from the host. Currently Imagen are the only company offering a page description language-based image processor capable of doing this. It would of course be totally impractical to expect this function of a language requiring a minimum of 80 Mbyte for 80 A4 images.

The DTP market continues to evolve and as application complexity increases, the need for higher functionality printing solutions also increases. For that reason Imagen has launched DDL (document description language). DDL has been designed to address the emerging need in the larger Electronic Publishing market for complete document manipulation facilities.

In DDL, a document consists of a collection of images and a set of rules for placing these images on paper. This allows separation of a document's image set from its format. A given image may appear on many pages, multiple images may appear on the same page (in various orientations), and the order in which images are sent need bear no relation to the order in which they are printed.

The layout section of a DDL file, which provides the rules for placing images, is syntactically separate from the rest of the document. A document's format may be altered by changing this section alone, usually with much less effort than would be required to reorder the entire set of images.

For example, a document may be printed with two page images per sheet during writing and editing, one page image per large sheet during proofing, and double-sided for later folding and stapling for distribution.

These features alone give rise to a powerful new language that has not only been designed to provide a very high-level document definition interface, but also to allow for document representations that are compact and fast to interpret. Application-defined operations and composite objects make descriptions more compact and may be interpreted more quickly than the corresponding sequences of primitive actions. Two additional features of DDL also provide for improved efficiency: a binary and/or ASCII representation and the potential for parallel processing.

Mick Sollars is the Sales Manager for the Terminals & Printers Division of Sintrom Electronics, Reading. This article has been put together with the expertise of Sheridan Hall, the Product Specialist at Sintrom Electronics for Imagen Products, who are based in Santa Clara, California, United States of America.

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Graphics			
CAMBRIDGE GRAPHICS Cambridge Graphics	**Grape** Graphics Tools written in C offering hardware independence.	**ABCDEFGHIJ**	**from £1950**
IBM (UK) LTD UNIRAS	**UNIRAS** Set of programs based on a raster technique for graphics display and manipulation of pictures in colour	AIX	**from £1350/mod.**
IBM	**Professional Graphics Series** 4 programs for the graphics programmer:- Development Toolkit, Terminal Emulator, Plotting System, & Graphical File System	AIX	**from £464/mod.**
IBM	**Personal GraPHIGS** Advanced programming i/f based on the proposed ANSI standard for Programmer's Hierarchical Interactive Graphics System	AIX	**£736**
LATICORP, INC Laticorp Inc	**High Tech Business Graphics**	**ACEFI**	**$195 - $4995** US Dollars
SPHINX LIMITED Southwind	**GRAFSMAN** Graphics tool set that can be used to build monochrome and colour graphs.		
Laticorp	**High Tech Business Graphics** Low cost answer to the graphics needs of the small user/department		
VENTURCOM INC Venturcom, Inc	**Prelude Report Writer/Graphics** Transforms data manipulated by Prelude tables, spreadsheets & external software into presentation graphics and reports.	**ABC** VENIX	US Dollars

Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Information Management			
ABS COMPUTERS LTD ABS Computers Ltd	**WIMS** For maintenance and works departments. Works activity reports for inspections, preventative tasks/mgmt control info.	**B**	
AMS SYSTEMS & SOFTWARE LTD Quadratron	**Q-Office** Integrated Office Automation	**AB**	
TIS Applications	**Engineering Call Control** Monitors engineering maintenance activities, based on Informix DBMS.	**AB**	
ARMSTRONG MICRO ELECTRONICS Microbell Ltd	**Strix** Flexible text retrieval, word by word search and variable record length.	**IJ**	
BLEASDALE COMPUTER SYSTEMS PLC Tetra	**Tetraplan** Stock control package.	**J**	**On application**
Olympus Software	**Ultracalc** Advanced Electronic Spreadsheet.	**J**	**On application**
DIGITAL TECHNOLOGY HELLAS Digital Technology Hellas	**Management Information System** Complete integrated package - can be adapted. Complete management info system - no. 2 in Europe.	**ABI**	**from $800** US Dollars
Digital Technology Hellas	**Medical** Standard package following whole process from illness to full patient recovery.	**ABI**	**from $800** US Dollars
GOULD ELECTRONICS LTD Gould Electronics	**Hypersearch** Full free text search and retrieval productivity tool, based on a single PCB	**BE**	**On application**
ICS COMPUTING LIMITED ICS Computing Ltd	**Distributex** True Multi-user, multi-company, multi-currency, multi-stock location system.	**AI** AIX	**On application**
NCR LTD NCR Ltd	**Tower Family** Business Information Processing Systems.	**B**	
SERVICE IN INFORMATICS AND ANALYSIS LTD Service in Informatics and Analysis Ltd	**WORKPLAN** Roster production and costing system.	**ABCI**	**On application**
THE SANTA CRUZ OPERATION LTD The Santa Cruz Operation Ltd	**Multiplan** Electronic worksheet simplifies "what if" tasks for XENIX users. On-line help facility, supports most terminals.	**I**	
The Santa Cruz Operation Ltd	**SCO Professional** Lotus 1-2-3 workalike for multi-user XENIX environment. Capable of handling complex spreadsheet tasks.	**I**	

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
UNIFY CORPORATION Unify Corporation	**Query/CP** Multi-featured productivity tool linking popular PC software with UNIFY DBMS and Accell databases running on Unix system.	**ABCDEFIJ**	**from $795** US Dollars
VENTURCOM INC Venturcom, Inc	**Prelude Info Management system** Application generator, RDB, spreadsheet, typeset quality report writer, word processor and advanced graphics.	**ABC** VENIX	US Dollars
XITAN LTD Abtex Inc	**Pertmaster** Powerful project control and critical path analysis package.	**I**	**£650**

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Manufacturing			
ARMSTRONG MICRO ELECTRONICS Productivity Solutions Ltd	**Makit** Comprehensive package covering all areas of production and accounts.	**IJ**	
CONCEPT COMPUTER SYSTEMS LTD Concept Computer Systems	**Production Control System** Sophisticated but easily used computer based production control system.	**AI**	**£9000 - 20000**
DBSI INFORMATION SYSTEMS, INC DBSI Information Systems Inc	**Systems for Manufacturing Co's** On-line MRPII Financial package. Handles multiple foreign languages, currencies as well as foreign taxes.	**A**	**from $25000** US Dollars
GOLDCREST COMPUTER SERVICES LTD Goldcrest Computer Services Ltd	**Manufacturing Software** Manufacturing system	**ABCEFGHI**	**from £10000**
MARI ADVANCED SYSTEMS LTD Root Computers	**Rootmas MCS, FCS** MCS : Manufacturing Control System. FCS : Financial Control System.	**BJ**	
SAFE COMPUTING LTD Safe Computing Ltd	**SaFeS** Bill of materials management, costing, inventory control, requirements planning and WIP, Sales/Purchase order, ledgers	**A** Unisys 5000, ICL, VAX	**15000 upward** Sterling
SYSTIME COMPUTERS LTD Systime Computers Limited	**JOBMAN** Job or project costing, estimating, planning, purchasing, stock control. Links to ledgers and payroll.		**from £5350**
Systime Computers Limited	**SYSIMP** 13 modules, including stock, purchasing, SOP, BOM, MRP, works orders, WIP, costing and ledgers.		**£1000 per module**

Mathematical/Statistical

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
IBM (UK) LTD IMSL	**IMSL** 5 problem solving system packages :- IMSL Library, SFUN/Library, MATH/PROTRAN STAT/PROTRAN, and LP/PROTRAN	AIX	**from £1265/pack**
IBM	**RS/1** Set of functions for research data analysis. Creation and use of any number to include numbers, text, graphs.	AIX	**£4654**
NAG LTD NAG Ltd	**Fortran Library & Supplements** Fortran routines for curve and surface fitting, differential/equations, Eigen values and vectors, etc.	**CF**	
SPSS EUROPE BV SPSS Inc	**SPSS-X** Software toolkit that solves a variety of information analysis problems. Data and file management, statistics etc	**CEF**	
STATISTICAL SOFTWARE LTD BMDP Statistical Software Inc	**BMDP Statistical Software** General purpose package for statistical and data analysis, with graphical and data diagnostic supports	**CF** Ultrix, HP UX	**from 1200** US Dollars

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HOLLAND: SCOS Automation BV, Amsterdam. Tel: (20) 106922. **SCANDINAVIA:** Uniware System AB, Solna, Sweden. Tel: 8 764 76 00.
S C Metric A/S, Vedbaek, Denmark. Tel: 2 89 35 00. **ITALY:** ESA computer & software SpA, Rimini. Tel: 0541 741113.

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Office Automation			
AES DATA (UK) LTD AES Data Inc	**AESNET and AESLAN** Integrates AES Office Automation systems into applications running on the Unix processor (7600 or NCR Tower).	**B**	**£6000**
ARMSTRONG MICRO ELECTRONICS Redwood International Ltd	**Uniplex II Plus** Word-processing, database, spreadsheet with electronic mail and diary.	**IJ**	
Santa Cruz Operation Inc	**Sco Professional** A Lotus 1-2-3 Workalike spreadsheet.	**IJ**	
BLEASDALE COMPUTER SYSTEMS PLC Quadratron Systems	**Q-Office** Complete suite of Office Automation software.	**J**	**£1641**
CONVERGENT TECHNOLOGIES (UK) LTD Convergent Technologies (UK) Ltd	**WGS/Desktop Manager** Visual Interface. Users point to/select documents/files by choosing them from a displayed list. Windows application.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**WGS/Calendar** Appointment system supporting scheduling of appointments, maintains daily to-do list and sets an appointment alarm.	**AB**	**On application**
Convergent Technologies (UK) Ltd	**WGS/Office** Work processor, spreadsheet, calendar and electronic mail system, under common user interface WGS/Desktop Manager.	**AB**	**On application**
DIGICOMP AG Jarogate	**J OS Windows** Front end windows package to allow several Unix tasks to run concurrently.	**CI**	**£795**
HARRIS SYSTEMS LTD Harris Systems Ltd	**Harris Desk** PC DOS product served from an X300. Comprises full word processing, electronic mail and diary facilities.	**BF**	**£500**
IBM (UK) LTD IBM	**APPLIX-1A** Integrated application package combining text, graphics, spreadsheet & database information within a single document	AIX	**£1688**
INTEGRATED SOLUTIONS NBI/Integrated Solutions	**ProPublisher Plus** Complete Desktop publishing package featuring full page, high resolution displays.	**AEF**	**$6500** US Dollars
MARI ADVANCED SYSTEMS LTD Root Computers	**Ultracalc** Spreadsheet Package.	**BJ**	**£695**
NEW TECHNOLOGY ASSOCIATES INC NEW Technology Associates Inc	**Prothos Project Management** PERT/CPM based system for planning, tracking and controlling all aspects of a project.	**BCI** VENIX	**$600 - 4800** US Dollars

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
OLYMPUS SOFTWARE, INC.	**UltraCalc** Full featured electronic spreadsheet. Easy to use command interface. On-line help facility.	**ABCDFIJ** MS-DOS	**$395 - 9995** US Dollars
Olympus Software Inc			
QUADRATRON A.G.	**Q-Office** Streamlines routine tasks such as word processing, making appointments, desktop calculating, business forms, etc.	**ABCDEFGHIJ** SINIX, SPIX, MSDOS, PCDOS	
Quadratron			
REDWOOD INTERNATIONAL LIMITED	**Uniplex-11 +** Integrated Office Automation system for Unix based computers combining a range of sophisticated applications.	**ABCDEFGHIJ** ULTRIX	**from £795**
Redwood International Ltd			
ROOT COMPUTERS LIMITED	**Rootisam II** Library of C outines supporting all the standard B-tre features.		**On application**
Root Computers			
Root Computers	**X/Isam**		**On application**
Root Computers	**Index sequential access method based on** Rootisam and is X/Open compatible.		
SPHINX LIMITED	**UNIPLEX-II PLUS** Word processing, spreadsheet, DBMS and graphics.		
Redwood Inc			
Quadratron	**Q-Office** Set of tools for use by non-DP staff.		
SYSTIME COMPUTERS LTD	**UNIPLEX II +** Fully integrated word processing, spreadsheet, electronic mail, database calendar and report generator.		2-4K
Redwood Inc			
UNISYS EUROPE-AFRICA LIMITED	**Office Systems Interface** Gives Q-Office users access to a more powerful environment providing user-friendly screens for all functions	**C** Unisys 5000	
Unisys			
Quadratron	**Q-Office** Integrated office automation package providing word processing, text composition, & administrative services	**C** Unisys 5000	

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Operating Systems/Enhancements			
GEC SOFTWARE LTD The Wollongong Group	**Eunice** Provides a fully supported, fully integrated VMS/UNIX environment on a VAX.		**On application**
GOULD ELECTRONICS LTD Gould Electronics	**UTX/32S** The first commercially available, secure Unix operating system.	**BE**	**On application**
MOTOROLA COMPUTER SYSTEMS Motorola	**V/68 UNIX Release 3** V/68 UNIX is the validated part of UNIX system V for the Motorola 68000 family. Release 3 conforms AT&T UNIX 5.3 spec	**A**	**On application**
PHILIPS EXPORT BV Philips Div. I&E	**Power Fail Safe (PFS)** Hardened file system of Unifive against power failures, user selectable notification of applications.	**BJ**	**DFL 2500 DFL**
Philips Div. I&E	**UNIFIVE - PCI** PC-Interface allows for communication on File level between MSDOS and Unifive, the Unix SV of Philips.	**BJ**	**DFL**
Philips Div. I&E	**ERM-System** Embedded Real Time Operating System. High performance Real Time Kernel with Unix file system and Drivers.	**BJ**	**DFL 1400 DFL**
Philips Div. I&E	**DRM-System** Distributed Real Time Multiprocessor system- an OS for Real Time applications plus a set of development tools of Unix.	**BJ**	**DFL 40000 DFL**
REAL TIME SYSTEMS LIMITED JMI Software Consultants Inc	**C Executive** Real time, ROMable, multi-tasking monitor for C programs in a minimal hardware environment.	**ABCDEFGHIJ**	**from £1000**
Whitesmiths Ltd	**CO-IDRIS** UNIX style operating system for VAX and MicroVAX which co-exists in memory with VMS.	**ABCDEFGHIJ**	**£4980**
Whitesmiths Ltd	**IDRIS** Compact and portable UNIX style operating system for PDP-11 and 68000 based machines.	**ABCDEFGHIJ**	**£350 - 1325**
SIEMENS LTD Siemens AG	**SINIX** UNIX derivative for Siemens multitasking microcomputers.	**AFI**	**£342-3050**
SOFTWARE IRELAND LIMITED Software Ireland Ltd	**UNIBOL/SPOOLER** Provides the printer facilities required by commercial environments for standalone or integrated use	**ABC**	
SPHINX LIMITED SCO	**SCO XENIX System V** Operating system for IBM PC/XT and compatibles		

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
SYSTIME COMPUTERS LTD Systime Computers Limited	**Trans-BASIC** RSTS environment emulator fro UNIX and XENIX systems. Allows BASIC Plus programs to run unchanged.		**1-4K**
TERMINAL DISPLAY SYSTEMS LTD Charles River Data Systems	**UNOS** Unix compatible operating system that has multi-user, timesharing facilities suitable for development environment.	**AD**	**£1900**
THE INSTRUCTION SET Hewlett-Packard	**Native Language Support System** Source code package allows software developers to produce/support software capable of working in multiple languages	**ABEF**	**On application**
THE SANTA CRUZ OPERATION LTD The Santa Cruz Operation Ltd	**SCO MULTIVIEW** Combined multitasking windowing environment and user-friendly interface	**I**	
The Santa Cruz Operation Ltd	**SCO XENIX System V** Powerful multi-user, multitasking operating system. The standard UNIX system implementation for PCs	**I**	
UNIPALM Venturcom	**VENIX** Full system V.2 implementation of Unix on 80x86 and PDP/11 processors.	VENIX	**£495**
UNIQ DIGITAL TECHNOLOGIES INC Uniq Digital Technologies	**Uniq System V.3** The VAX port of AT&T Unix System V.3 with RFS.		**$3600 - 30000** US Dollars
UNISYS EUROPE-AFRICA LIMITED Unisys	**SX 1100** An OS 1100 application program that provides a full implementation of AT&T's UNIX System V	**C** UNISYS 1100 Series	
VENTURCOM INC Venturcom, Inc	**VENIX System V** Provides real-time extensions for data acquisition and process control, and bit-mapped graphics enhancements.	**B**	**$1175** US Dollars

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
System Tools			
ASPEN TECHNOLOGIES, INC ASPEN Technologies Inc	**ASPEN Korn Shell** Many improvements brought to standard Bourne shell, including command history and expanded expressions.	**ABCDI**	**$200** US Dollars
LANGUAGE PROCESSORS, INC Language Processors, Inc	**LPI-Debug** Powerful, easy to use, interactive source level debugger.	**ABCDFIJ**	US Dollars
MORTICE KERN SYSTEMS INC. Mortice Kern Systems Inc	**MKS Toolkit** Over 100 utilities giving UNIX system V.2 functionality on an IBM PC or compatible under DOS 2.0 or later.	**B**	**139** US Dollars
OASYS (A DIVISION OF XEL INC) OASYS	**System Tools** Assemblers, Simulators, Debuggers, Language sensitive editors.	**BCDFG**	
REAL TIME SYSTEMS LIMITED C-Soft	**Mimic** Range of microprocessor simulators/ debuggers, for use with cross compilers or cross assemblers.	**ABCDEFGHIJ**	**£620 - 2500**
ROOT COMPUTERS LIMITED Root Computers	**Rootmerge 386** Allows the simultaneous transparent execution of both the UniPlus+ and MS-DOS operating systems.		
Root Computers	**Rootshare** Reduces disk space occupied by C programs giving considerable performance improvements.		
SOFTWARE IRELAND LIMITED Software Ireland Ltd	**UNIBOL/SORT** Powerful sort/merge for commercial DP. Allows record selection and reformatting.	**ABC**	
THOMSON COMPUTERS LTD Thomson Computers Ltd	**Sea Change Programmers Tools** Set of software tools for the C programmer.	**ABCEFIJ** AIX, PCDOS, MSDOS	**£850 - 3450**
UNIQ DIGITAL TECHNOLOGIES INC Uniq Digital Technologies	**UPS DECport** Proprietary sources of the Unix system V.3 port for VAX processors.		**$25000** US Dollars
Quadratron	**Q-Office** Uniq port of Q-Office, a completely integrated office automated system.		**$5000 - 37400** US Dollars
UNISOLUTIONS ASSOCIATES UniSolutions Associates	**SysAdmin** Full featured system administration package which is flexible, secure and easy to use.	**ABCDEFGHI**	

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
UNISYS EUROPE-AFRICA LIMITED	**Documentor's Workbench** Allows user to format a wide range of documents for printing on a variety of printers or typesetters	**C** Unisys 5000, 7000	
Unisys			
Unisys	**MAPPER C** Provides a general purpose DP system allowing user to generate, update and organise a report-structured database	**B**	
Unisys	**Unisys Menu Development System** Free format menu selection screen generator, with password control, restricted entry to UNIX shell etc	**B**	
XITAN LTD	**Forms II** Table maker utility for use with the Microfocus Cobol family.	**I**	**£185**
Microfocus Inc			
Microsoft Inc	**MS Cobol Tools** Suite of tools facilitates programming in MS Cobol.	**I**	**£350**

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Word Processing			
ACE MICROSYSTEMS LTD Ace Microsystems	**LEX** Integrated word processing and database package, incorporating a calculator function.	**CIJ**	**from £750**
ARMSTRONG MICRO ELECTRONICS Santa Cruz Operation Inc	**Sco Lyrix**	**IJ**	
CONVERGENT TECHNOLOGIES (UK) LTD Convergent Technologies (UK) Ltd	**WGS/Word Processor** Recovery feature saves rekeying time, spelling check, merge-from record and glossary features.	**AB**	**On application**
IBM (UK) LTD Interleaf	**Interleaf WPS** Document preparation package consisting of text entry/edit facility, diagramming and drawing tool, charting tool	AIX	**£1688**
IBM	**Interleaf RT Publishing S/W** Advanced version of WPS, allowing input from word processors for text and CAD systems for graphics	AIX	**£6682**
IBM	**SAMNA** + Capabilities including split screen editing, automatic pagination and foot-noting, automatic search and replacement	AIX	**£1096**
LATICORP, INC Laticorp Inc	**Latitude** Integrated Word processor with tabulator mailmerge and spelling checker facility.	**ACEFI**	**$495 - $9995** US Dollars
MARI ADVANCED SYSTEMS LTD Root Computers	**Uniplex II Word Processor** Menu-driven word processing package.	**BJ**	**£650**
ROOT COMPUTERS LIMITED Root Computers	**Rootmap Menu System** Allows access to Unix commands and application programs through menus.		**On application**
Root Computers	**Rootmap Manager** Enables monitoring of Rootmap menus for specific needs and creation of new menus		**On application**
Root Computers	**Rootdiary** Multi-user electronic desk diary inc. both private and group diaries showing common free periods, overlaps, etc.		**On application**
Root Computers	**Rootmail** Enhanced user interface for the Unix electronic mail system with help screens available.		**On application**
Root Computers	**Rootscreen** Full screen editor developed to be small fast and easy to use with on-line help for the C programmer.		**On application**
Root Computers	**Rootfile** Shared electronic filing system giving solution to document storage/retrieval on a Unix based computer.		**On application**

Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Root Computers	**Rootspool II** Control over jobs to be printed on specific types of queues for different paper or layouts.		**On application**
Root Computers	**Roottelex with Mail** Allows integration of the telex system to Unix allowing sending/recieving of telexes from your terminal.		**On application**
SAMNA INTERNATIONAL LTD SAMNA	**SAMNA PLUS** Word processor with built-in spreadsheet	**C**	
SPHINX LIMITED Quadratron	**Q-One** Wang compatible word processing system		
Ace Microsystems Ltd	**LEX** Word processing with built-in multi-user database manager		
SCO	**LYRIX** Multi-user word processing software written in C		
THE SANTA CRUZ OPERATION LTD The Santa Cruz Operation Ltd	**SCO LYRIX** Built specially for XENIX systems, available on a wide variety of PCs and micros, supports virtually all terminals	**I**	
UNISYS EUROPE-AFRICA LIMITED AT&T	**Writer' Workbench** Provides text critiquing functions to assist in preparation of business and technical reports & manuals	**B** Unisys 5000, 7000	
VENTURCOM INC Venturcom, Inc	**Prelude Word Processor** Menu driven word processor with WYSIWYG orientation, spelling checker, multifile editing, integration between application	**ABC** VENIX	US Dollars

Compatibility Key: A = System V.3; B = System V.2; C = System V; D = System III; E = 4.3 BSD; F = 4.2 BSD; G = 4.1 BSD; H = Version 7; I = XENIX; J = UNIPLUS

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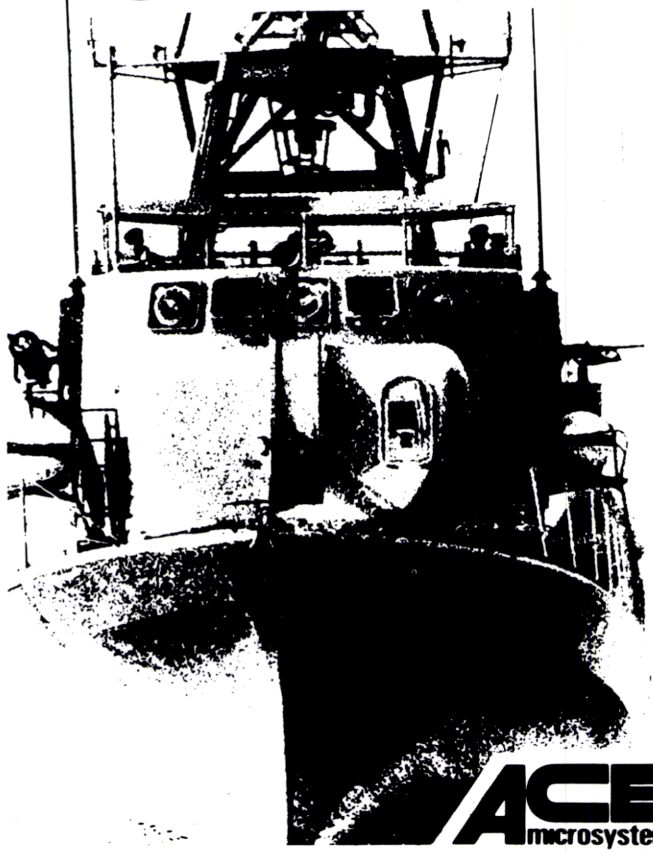

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
Other Software Products			
ABS COMPUTERS LTD ABS Computers Ltd	**C-Pres** Management information system, designed around a database, for full client accounting and time recording.	**B**	
ARMSTRONG MICRO ELECTRONICS Armstrong Micro Electronics Ltd	**Abacas** Local Authority software for management of graveyards and crematoriums.	**IJ**	
Root Computers Ltd	**Root Map** Menu Front-end to Unix with electronic mail and diary.	**IJ**	
BRAINSTORM COMPUTER SOLUTIONS Brainstorm Computer Solutions	**Brainstorm Integrated Software** Communications Server, Viewdata System, Friendly front-end to Unix.	**ABCDEFGHIJ**	
EXCELAN Excelan	**EXOS 8000 Series** TCP/IO protocol packages VMS, Unix, RSX, MicroVMS, DOS.	**ABCEFGI**	**On application**
FCMC PLC FCMC plc	**Staffware** Forth generation language for the automation of document based procedural applications.	**ABCIJ**	**£1000 - 25000**
GEC SOFTWARE LTD GEC Software Ltd	**GENOS** Integrated project support environment.		**On application**
GEC Software Ltd	**G-Taskplan** Project planning and reporting tool for software development.		**On application**
GEC Software Ltd	**GECOMO** Reliable estimates of project cost, duration and staff requirements for software development and maintenance.		**On application**
GEC Software Ltd	**G-Control** Project monitoring and status reporting tool providing up to date information on project progress.		**On application**
JSB COMPUTER SYSTEMS LTD JSB Computer Systems Ltd	**JSB MultiView** Provides a powerful yet simple to use windowing user interface to Unix systems.	**ABCDHIJ**	
PA CONSULTING GROUP PA Consulting Group	**inSET** User interface management system for prototyping and developing advanced user interfaces.	**BEFG**	**£4000 - 16000**
PA Consulting Group	**windowSET** Portable window manager which provides Apollo/Sun-like facilities on most types of terminal and workstation.	**BEFG**	**£2000 - 8000**

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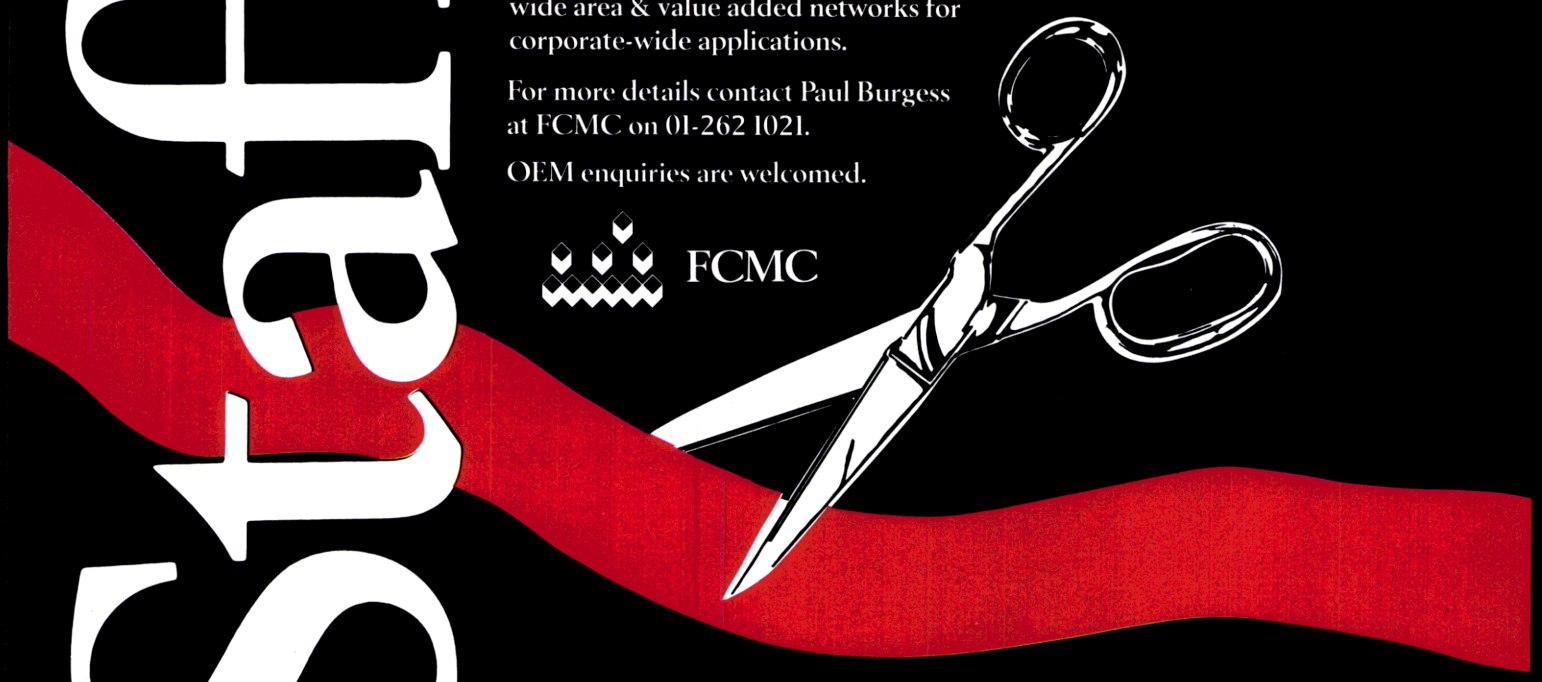

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SUPPLIER Manufacturer	PRODUCT NAME Product Description	COMPATIBLE WITH Other ...	PRICE Currency
PA Consulting Group	**onSET** Insulates the application from the operating systems and gives portability across major computer types.	**BEFG**	**£1000 - 4000**
SPHINX LIMITED AIM Technology	**AIM Benchmark Suites I & II** Set of portable benchmarks written in C		
UNIPALM South Wind Software	**Tactician** Full function spreadsheet, with graphics and interface to other software.	**ABCDEFGHIJ** VENIX	**from £550**
UNIXSYS (UK) LIMITED Softquad Inc	**Softquad Publishing Software** Professional typsetting system designed for the Unix environment.	**BCFHIJ**	**from £1000**

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SERVICES SECTION

FEATURE

UNIX Training **110**
As with UNIX hardware and software, there is a bewildering array of UNIX training available. The problem in selecting a UNIX training supplier is not in identifying who offers UNIX training, there is certainly an abundance of companies, but in choosing the most appropriate supplier and courses for your particular needs. This article suggests a series of criteria for making this selection.

TABLES

Training **109**

For further information on the companies listed in the Services Product tables complete the card at the end of the Master Suppliers Index

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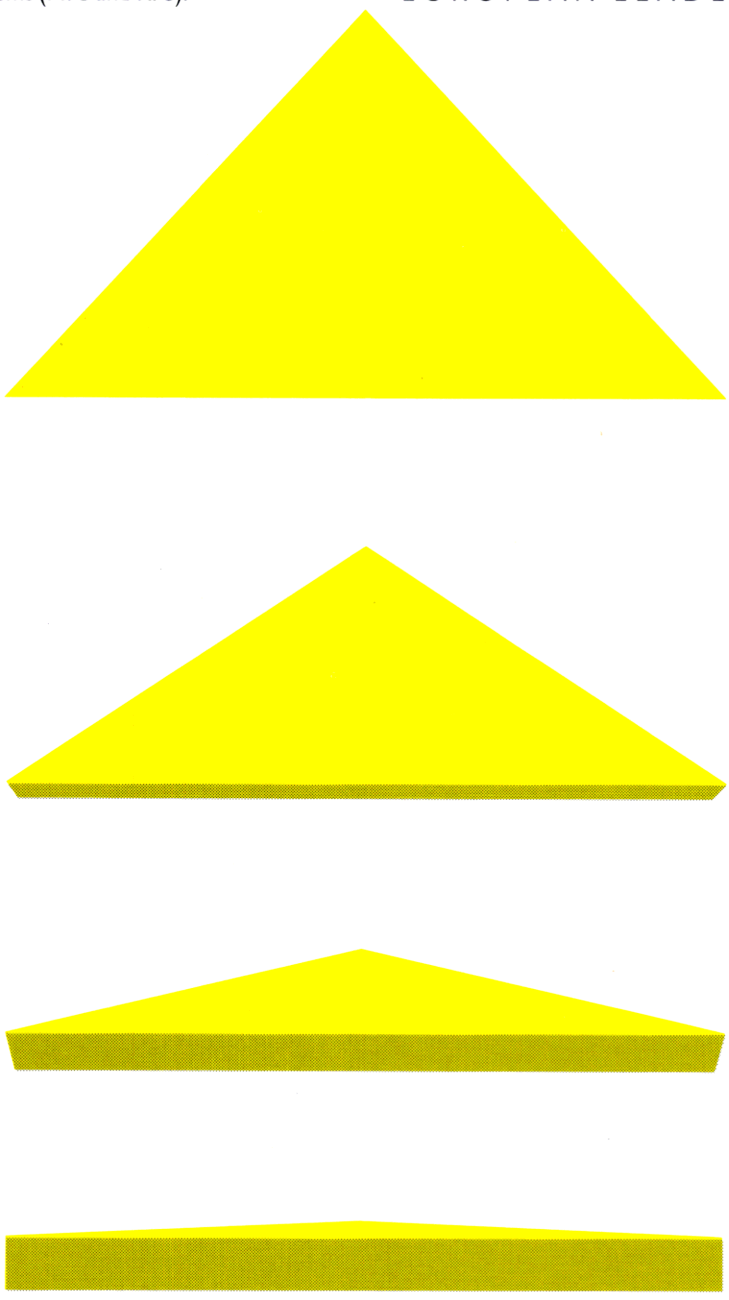

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Training

ABS COMPUTERS LTD
Courses are regularly run in system administration, C, SIMPLE, Qoffice and UNIFY Basic and Advanced. Courses are run at ABS Offices on the south coast as well as on customer sites. The accent is on customer development which means courses can be individually tailored to specific needs. Other courses run on a demand basis include Unix-Advanced and Basic, Wordstar and Datastar.

AT&T UNIX EUROPE LTD
Range of AT&T Bell Labs Training courses offered covering Unix system V. The course programme will satisfy needs of systems developers, application writers and new users.

BRAZIER SYSTEMS & CONSULTANTS
Training
Training courses offered for presentation on clients sites. Established courses are available 'Introduction to Unix', 'C programming' and 'Unix Systems Programming'. One day courses are also available covering 'Bourne Shell', 'C Shell' and 'Make & SCCS'. Presentation can be tailored to meet the customers specific requirements.

COMPUTER TECHNOLOGY GROUP
World leaders in Unix Training offers public seminars in major cities throughout the world: On-site seminars for training customised to your environment and to specific groups within your organisation. Self- instructional video-based training for consistent training that is always available at your location.

DIGICOMP AG
Computerschule Zurich/CSZ
One of the leading UNIX and C training institutes in Central Europe. Courses include: Management Overview, Introduction to Unix, Introduction to C, AIX and Advanced C Programming. Digicomp has been teaching Unix and C since 1982, both on-site and on Digicomp-owned premises. Classes are given in English and German.

INTASOFT LIMITED
Training at customers site for new users of Unix and system administrators. New Users course gives general overview of Unix. System Administrators course covers shell programming, C, Software development/ maintenance tools, etc. and shows how to extract the maximum benefit from the powerful Unix tools.

KALAMAZOO BUSINESS SYSTEMS
4-Front Training Services
Unix, C, Appgen and specific applications training for technical and end-user personnel. Training at Birmingham centre or Client sites by negotiation.

MICROTEC RESEARCH
Training Courses
The following courses are available : C Programming for microprocessor development, C programming and debugging workshops, Embedded microprocessor programming, Microprocessor programming in C, Advanced C for embedded systems, High level debugging workshop.

PENNINE COMPUTER COMPANY LIMITED
UNIX/XENIX Managers course
Training course in the management aspects of UNIX/XENIX systems. This course is designed for new users of UNIX/XENIX based systems.

REAL TIME SYSTEMS LIMITED
C Video
The C Video Workshop is a specially written and produced video training course in the C programming language. The course is intended for programmers and engineers who need to learn C as an alternative to other high level languages or assembley languages. A prerequisite for the course is experience of programming in a high level language.

STRUCTURED METHODS INC
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THOMSON COMPUTERS LTD
Sea Change Training Centre
Training offered in Unix and C.

XIRION BV
Training in UNIX and C, general history of computer development.

UNIX TRAINING

As with UNIX hardware and software, there is a bewildering array of UNIX training available. The problem in selecting a UNIX training supplier is not in identifying who offers UNIX training, there is certainly an abundance of companies, but in choosing the most appropriate supplier and courses for your particular needs. This article suggests a series of criteria for making this selection.

The criteria for selecting UNIX-based computer hardware are well understood and fairly easily measurable: price, performance, support and upward compatibility. The selection criteria for training, however, are far more numerous and significantly more qualitative. They include: price, quality, experience, subject matter expertise, range of offerings, frequency of delivery, and additional services available.

Ranking companies on the basis of the above criteria is not easy, and often requires first hand experience of their service. The first step in selection is to narrow the list based on the reputation and market position of the suppliers. The leading companies in any field have usually gained that position on merit. This is especially true of service-based companies, who really are only as good as their last contract.

This narrowed list of potential suppliers is likely to include your hardware supplier(s) and several third party training companies. It is important at this stage to evaluate the benefits of both of these types of training solutions.

Having been satisfied with the services offered by their hardware supplier when they purchased their system, many customers naturally look to their hardware vendor for training support as well. Hardware suppliers typically offer a small number of basic training courses. Very often these courses are given free, or at a very low cost. Training is typically viewed by hardware suppliers as a way of supporting their sales of hardware. As a result, they usually offer a small number of basic training courses emphasising their specific equipment. They are likely to be the only courses available which cover in detail the specifics of a particular manufacturers system, unless they have appointed a third party training company to provide it.

In evaluating your training needs, it is important to recognize that many manufacturer-based courses will only train students on the aspects of UNIX directly relevant to their system, and are less likely to go into depth about both the negative as well as positive aspects of the UNIX operating system. You are unlikely to find a manufacturer outlining all the operating system problems after he has spent six months selling you a machine. It is also important to understand that even the top computer manufacturers are not primarily in the business of training; their effort and expertise lies in hardware. It is almost unheard of for manufacturers to use the people who developed the operating system to give the courses as well. They tend to use professional instructors, not subject matter experts.

Many computer manufacturers have decided not to attempt to provide more general UNIX training, or training for specialist and advanced requirements. They instead recommend a third party training company to their customers.

The two most important general criteria in selecting a training company are quality and experience.

Consequently, the bulk of UNIX training is provided by third party training companies, as a quick glance through the course listings in the computer press or training directories will verify. However, the range of offerings and the quality of service varies widely across third party suppliers. Selecting the best for your particular needs is difficult.

The most important step in choosing a third party training company is determining your own needs – i.e. what type of people need training (experience, required level of expertise), the number of people at each level, your timetable for training.

Having identified your needs, the third party training companies can then be evaluated on their ability to meet these requirements. The two most important general criteria in selecting a training company are quality and experience. Quality in training means providing structured, consistent learning across a range of topics. Experience in achieving this is a vital factor, as the art and skill of designing and delivering training programmes develops over time with practice and exposure. It is important then in selecting a training company to ascertain whether they provide the highest quality, and whether they have significant experience in consistently providing this quality.

The next comparison should be on the basis of range of course offerings. Unlike training people in programming languages or application packages, the training requirements of an operating system such as UNIX are enormous. To ensure that a progression of skills occurs, it is critical that courses should be provided as part of a structured curriculum, not in isolation. Aside from the sheer volume of skills which need to be taught, the type of training varies significantly according to how someone is going to use UNIX. Not all third party companies offer a full enough range of courses to cover the diversity of needs a customer is likely to have. It is important to look for a training company that gives a good selection of basic, advanced and specialised courses, to assure that they will address your developing UNIX training requirements to the same standard.

The third comparison should be the level of expertise the company offers, both in UNIX and in related software such as programming languages, communications software and databases. As the number of UNIX books available shows, there are many individuals scattered around who have a knowledge of UNIX, especially in Universities. It it not too much trouble for them to 'knock-up' a basic UNIX course, but typically they have little idea of what makes a course a good learning experience or any perspective on the overall skills development. However, all but the most elementary UNIX course requires an understanding of the operating system far deeper than the scope of the course being given. Most people can learn the mechanical details of UNIX, such as how to use a certain flag on a command, from the manual. What is required from a course is an understanding of the philosophy and concepts of UNIX, how UNIX fits in with related systems software and an appreciation of where UNIX is going.

For this, the lecturer has to have not only a good understanding of UNIX, but also wide-ranging practical experience. He may be faced, for example, in a UNIX programming course with 14 attendees of not only mixed ability, but also widely ranging objectives from the training. There may be system software developers, applications programmers used to COBOL, support engineers, system administrators and project managers all on the same course.

Technical brilliance alone does not ensure a person will be an oustanding teacher, it may even ensure the opposite!

Lecturers thus should be good UNIX people who teach rather than teachers who have learned UNIX, and this a major difficulty. It is not enough to know the subject, you also have to get this information across in simple terms to inexperienced or even inexperienced students. Technical brilliance alone does not ensure a person will be an oustanding teacher, it may even ensure the opposite!

Even if the lecturer knows the subject and can get it across, there is also a problem in keeping up to date. Sometimes

burnt-out programmers move into training, and even if they enjoy the experience often find themselves out of touch very quickly. UNIX has a new major release every eighteen months, for example, not to mention the rapid development of related systems software.

The final stages of selection are based on frequency of delivery and the availability of additional services such as customising courseware. There are typically two options in the delivery of a course – to send students on a public course or to arrange to have a lecturer come on-site to your company and teach a group of students. Whether it is more appropriate to take the public or on-site route depends on both the number of people you have to train at any one time, your training timetable, and the amount of customisation you feel is necessary.

The type of course you need is largely governed by the number of people you have to train at any one time and whether you have special training requirements. If you need to train up to five people, it is probably best to send them to a public or open course, made up of delegates from many companies. The usual criteria for choosing a public course is convenience, both in timing and location, in order to save on travel and accommodation costs. A good judge of the success of a company giving public courses is the number and range of courses offered. A company successfully offering UNIX programming courses every week is more likely to provide a good service than a company offering one a month, and cancelling most of these due to low numbers. The competition is quite intense for public places, and the price typically reflects the quality. As with any service, a 10% saving on cost often reflects a 50% penalty in quality, usually manifest by poor quality and out-of-date materials, even if the lecturer knows their stuff.

For a training requirement over five people, it is cost-effective to organise an on-site presentation. This also has other advantages. The presentation can be timed to suit you, and located either at your location or close enough to your site to be convenient but where the delegates are free from being continuously disturbed by telephones and project requirements.

The competition in training is intense, and the companies who succeed often spend a great deal of time striving to further improve their services . . .

A good training company typically also offers courses for on-site delivery, and can tailor the course materials to suit particular training needs. This could be merely altering the pacing of the course to suit the knowledge and experience of the class, but could also include the writing of new articles specific to your system. This again divides the professional from the amateur training company: the ability to produce high quality tailored materials at short notice to the standard of existing text.

The competition in training is intense, and the companies who succeed often spend a great deal of time striving to further improve their services. As a leader in European UNIX and related software training,our objective is one of "transferring UNIX technology into companies". A major portion of this transfer is training, and success in the European training market is only found by focusing on the rapidly changing needs of the UNIX community and emphasising learning over merely covering a series of topics and remaining flexible to customer needs.

Two years ago the UNIX market was very much populated by system software developers. The content of UNIX training therefore tended to be subject matter orientated, such as 'a day of LEX and YACC'. As UNIX becomes much more popular in government and major applications development environments,we have begun to integrate our UNIX curriculum with the concepts, tools and methodologies of software engineering. This has initially been done as part of major in-house courseware and curriculum development for some larger customers, but will soon be reflected in public presentations.

MIKE SOUTHON is the Director – Technology Development of The Instruction Set, Europe's leading supplier of UNIX and C Language education. He has many years' experience in the design and delivery of UNIX courses, for many large companies.

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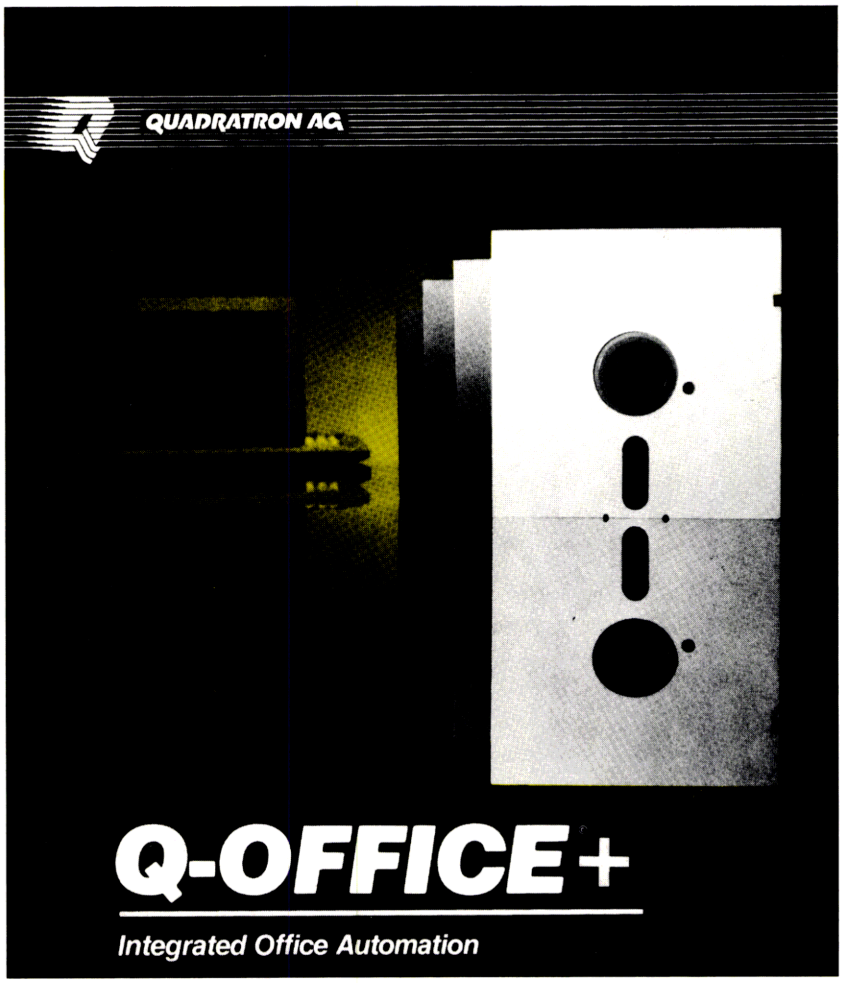

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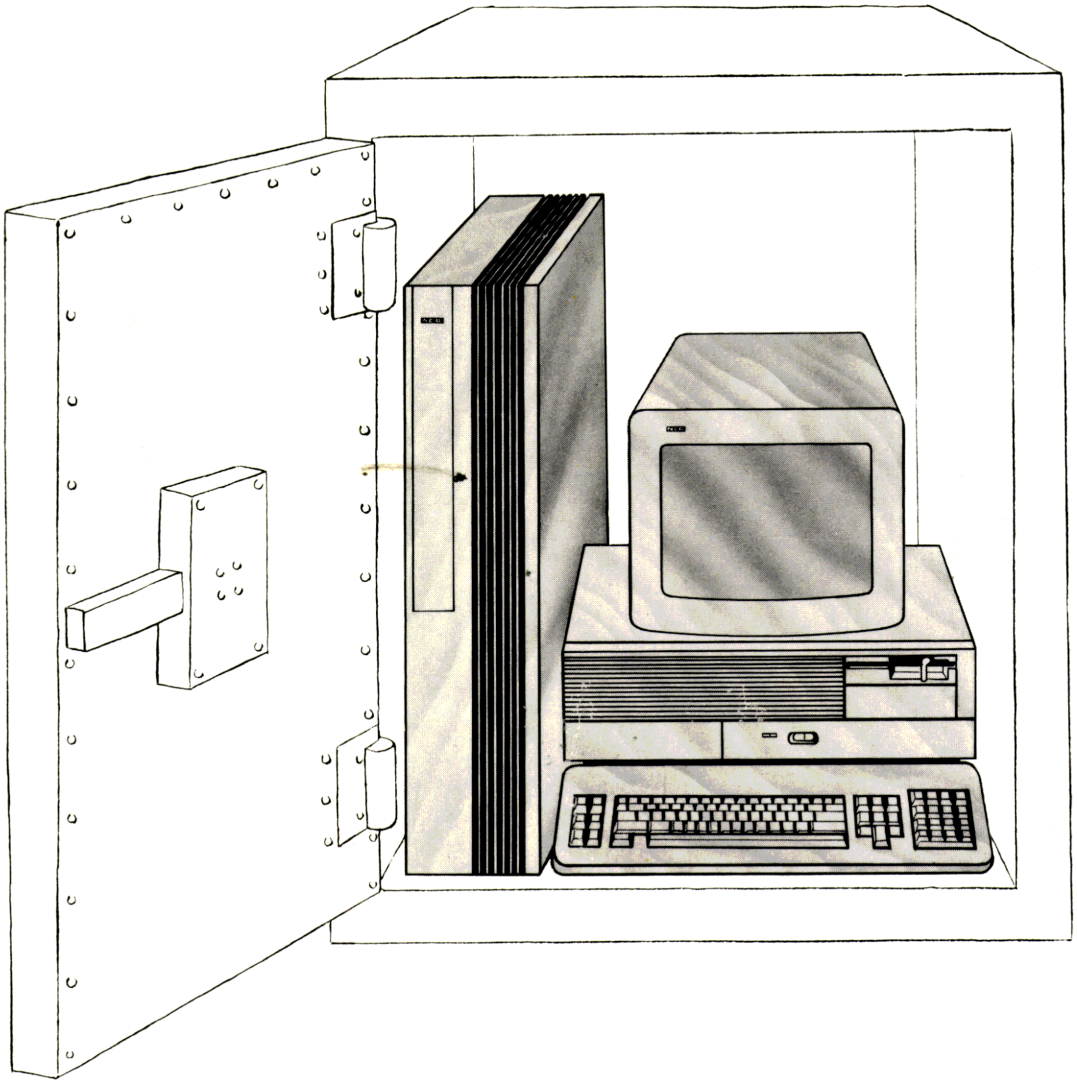

How NCR protect your investment.

Buying a computer can be a problem for any company. Will it work with existing equipment or restrict choice in the future? Can it meet both today's and tomorrow's needs? What about service and support? And once you've chosen the system you want, how can you avoid the delays that occur in developing new applications?

NCR have a unique solution to give your problems priority and help you overcome development bottlenecks.

By designing all our equipment to reflect and enhance industry standards, we protect your investment and give you the widest range possible of product and software. Both now and in the future.

But a well planned product range is only half the story. We believe we've found our perfect partners in a carefully selected number of authorised computer distributors whose special skills and expertise are complementary to NCR's.

Their specialisation can provide the answer to your development problems with their expert knowledge and ability to react quickly and flexibly to your needs. And they are backed up by the engineering, training, and maintenance support of one of the world's largest computer companies.

NCR's product range and support. A specialist's expertise and service. They combine together to give your computer problems the priority they need. It's the safest way to invest in a computer system.

As a first step in discovering just how NCR's investment protection can benefit your business, contact Helen Stamp, NCR Limited, 206 Marylebone Road, London NW1 6LY, or telephone 01-725 8451.

Perfect Partners WITH NCR

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