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***HARDCOPY* PRODUCT REVIEW:** MULTIPLEX

SYSTEMS AND SOFTWARE:
VMS FOR REALTIME?

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***NEED TO KNOW*™ SOLUTIONS FOR DEC COMPUTING**

OCTOBER 1987, VOL.7, NO.10 $3.00

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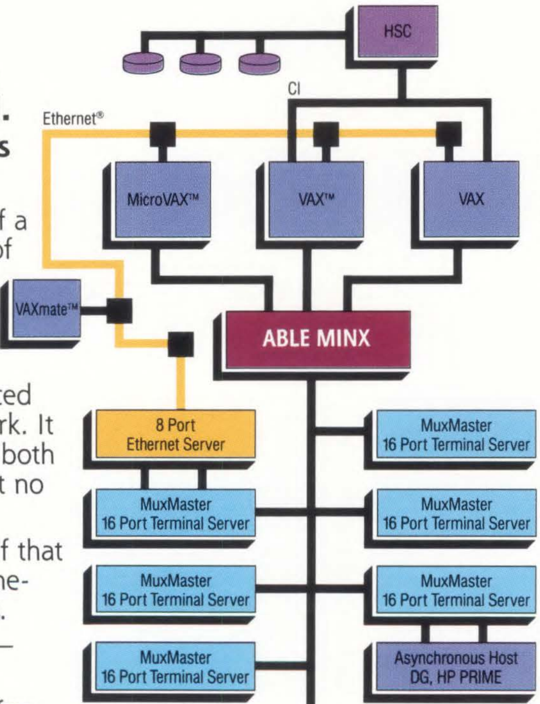

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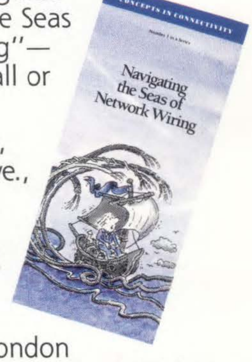

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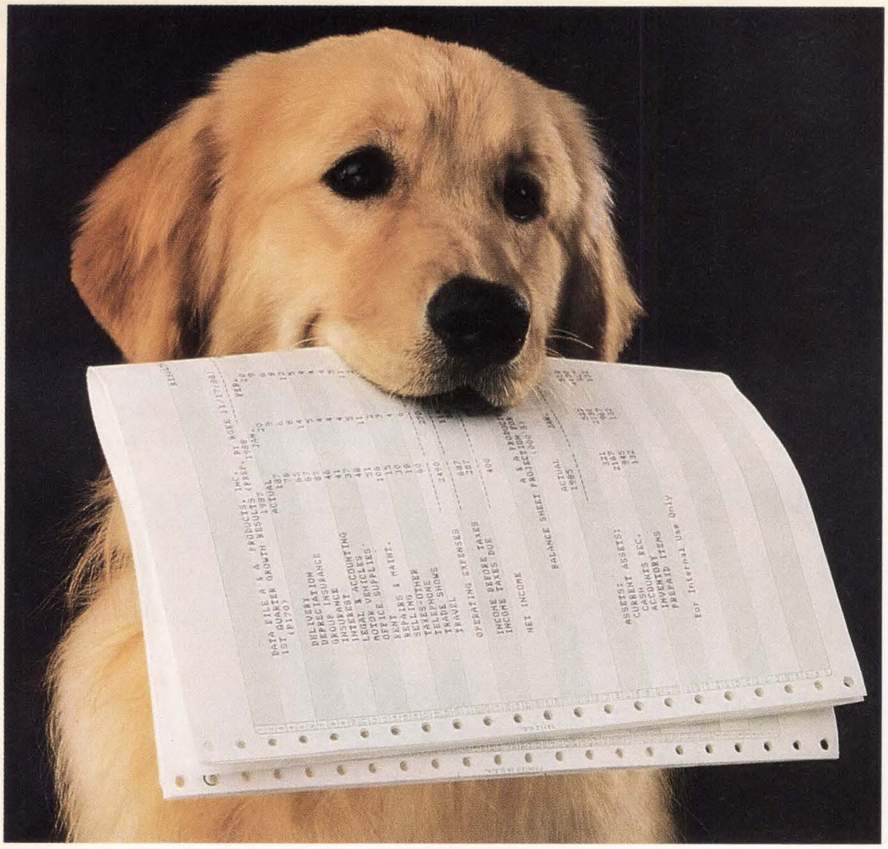


He could probably retrieve information from a database more easily than most spreadsheet users.

Which isn't surprising considering what the average spreadsheet user has had to go through to access a database.

But what if there were a way to retrieve that information without knowing a database language, without a database administrator and without leaving the spreadsheet?

Well now there *is* a way. Introducing the 20/20™ Database Connection.

Designed to work with 20/20, the leading integrated spreadsheet for multi-user computers, 20/20 Database Connection makes the promise of easy access to databases a reality.

Because the 20/20 Database Connection talks directly to your DATATRIEVE,™ DBMS or RDB databases, they actually seem like a part of 20/20.

The menus and prompts guide you every step of the way. So it's easy to build a query. Just point to the information you want. Pick the fields. Sort data. Or just select summary totals.

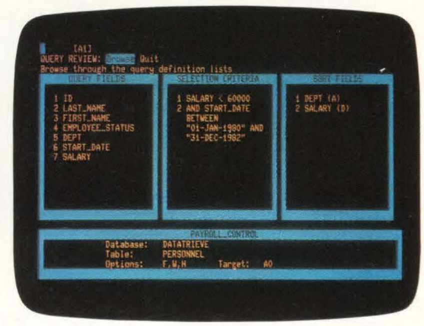
The data goes right into your spreadsheet, which automatically formats itself.

What's more, you can save your query with your model to execute later. Your spreadsheet and database can work together by having your query use results from the spreadsheet.

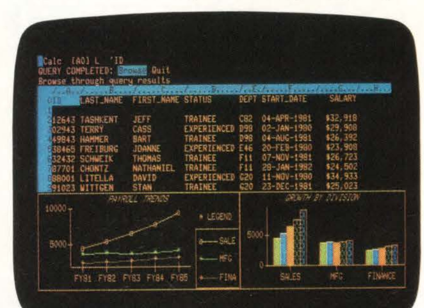
There's even built-in protection that lets systems managers control access to the database.

If you've ever been through the hassle of accessing databases, you won't believe how easy it is to use 20/20 with the new Database Connection until you actually try it. To order a special Evaluation Kit, send us the coupon.

Granted, you could look for some other way to access your DEC databases this easily. But you'd be barking up the wrong tree.



Menus tell you what information is available and help construct your query.



Your 20/20 spreadsheet is automatically formatted for the database information.

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Attached is my business card or letterhead.
Please send:

☐ Information on a 20/20 Database Connection Evaluation Kit
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☐ Information on our reseller program

Computer Model ____________

HCA107

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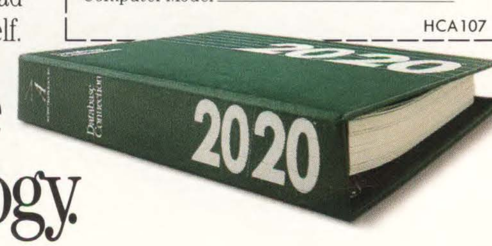

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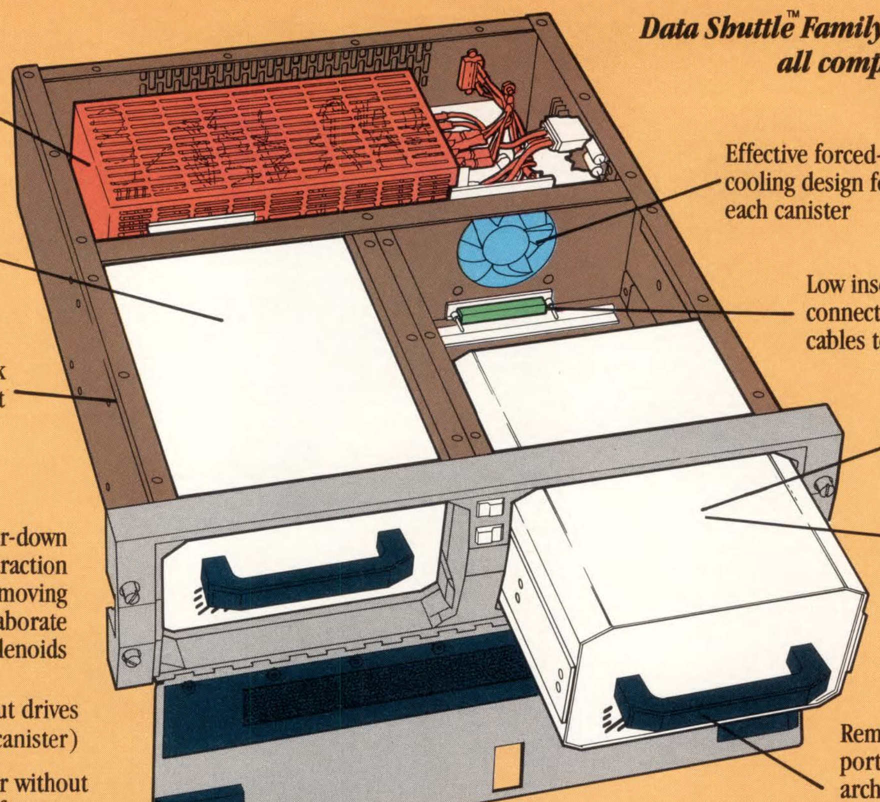
Data Shuttle™ Family for use with all computer systems



The only commercial removable-drive subsystem with shock isolation, superior design.

With failure-proof power-down feature

DATA SHUTTLE 2000™ is the latest in MDB's removable-disk subsystems. Drawing upon real experience in airborne and shipboard ruggedized, militarized installations, MDB is able to offer proprietary shock protection in this affordable and functional package.

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That's why MDB will warranty the disk drives for shock-related failures for one year - even if the manufacturer doesn't!

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The only shock-isolated, low-cost design for commercial, lab and industrial applications.

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Except for superior resolution, incredible graphics, larger screen, over 11 major improvements, and the industry's longest warranty . . . It's just another DEC VT220* Compatible

Upgrade your DEC environment with the Ditto 221XL video display terminal from Networx Data Products Co. It has all the features of the DEC VT220 plus over 11 major improvements, including superior resolution, dual host port ability and a larger screen. And with the 221GXL upgrade you can create incredible graphs, charts, plots, drawings and many other monochrome graphics . . . without disturbing any of the 221XL's alpha-numeric features.

Best of all, the Ditto 221XL is available with a four-year warranty, the longest in the industry. And all this quality, reliability and service comes with a price tag that's hard to beat.

See why thousands of users are choosing the Ditto 221XL over any other VT220 compatible. For more information and spec sheets, write or call Networx today at 1-800-531-0019 or (516) 754-2798 within New York State.

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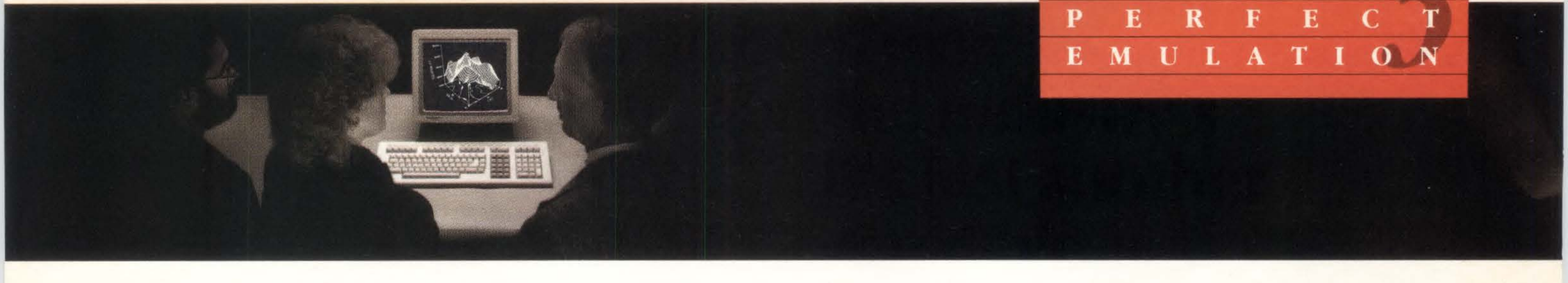
BEYOND PERFECT EMULATION 3



GraphOn. For Serious Graphics Users.

For flexible graphics and alphanumerics in a single composite terminal, no one delivers more than GraphOn. More features. More quality. More value. The GO-200 Series lets you choose the powerful graphics capabilities you need at prices you can afford.

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Emulations of Tektronix 4010-4015 graphics and VT220/100 alpha mean no workarounds or modifications. Just plug in the terminal and go to work.

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Optimized instructions running on the 16-bit 68000 microprocessor provide host communications at up to 57.6 Kb per second. Higher throughput, improved productivity.

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GraphOn's zoom provides clear, detailed images, not just pixel enlargement. You can pan and edit the image while in zoom mode.

RASTER OPERATORS.

With opportunities for pop-up menus, icons and window management, raster operators provide flexibility today, and prepare you for tomorrow's most advanced software.

LOCAL INTERACTIVITY.

Provides fast, smooth cursor movement without bogging down the host in communications.

FLEXIBLE MEMORY.

Tailor the terminal memory to your specific needs. It can support a printer buffer and provide local storage of display lists, rasters, and multiple pages of text and graphics. Reconfigure as needs change.

GRAPHON GIVES YOU MORE.

The GraphOn 200 Series provides simple upgradeability, free firmware updates and the most usable documentation in the industry. And every terminal is backed by the GraphOn warranty, responsive service and hotline support.

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If you are ready to get down to the important details, call for your free on-site demonstration or write GraphOn Corporation, 1901 South Bascom Avenue, Campbell, CA 95008. You'll see why so many users and leading software developers won't settle for less.

GraphOn sets the standard for perfect emulation in monochromatic terminals.

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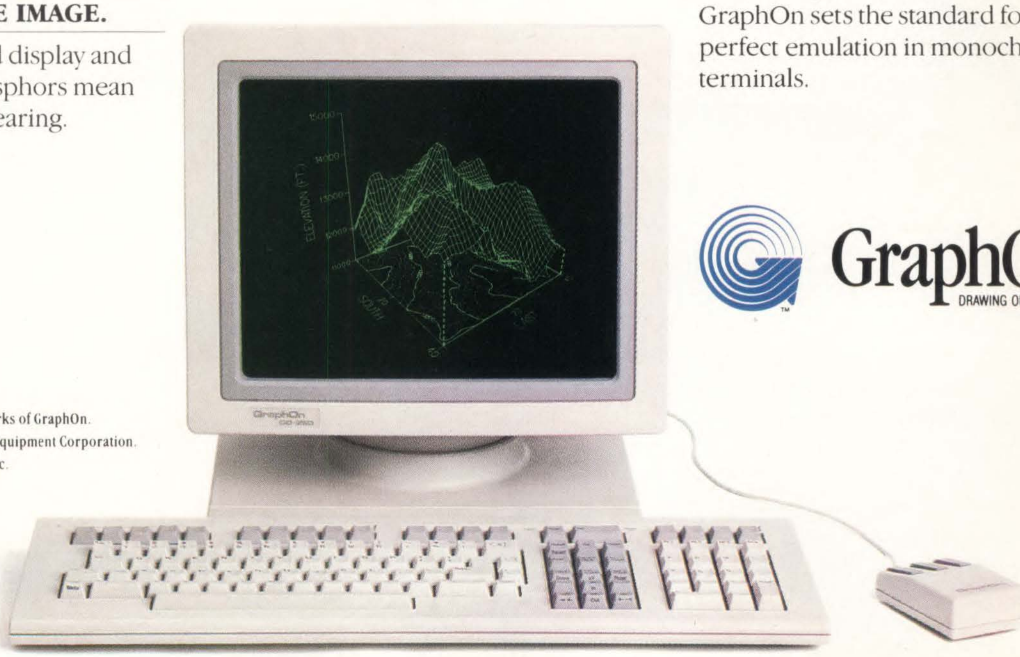

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DIRECT FROM DEC

SYSTEMS AND SOFTWARE

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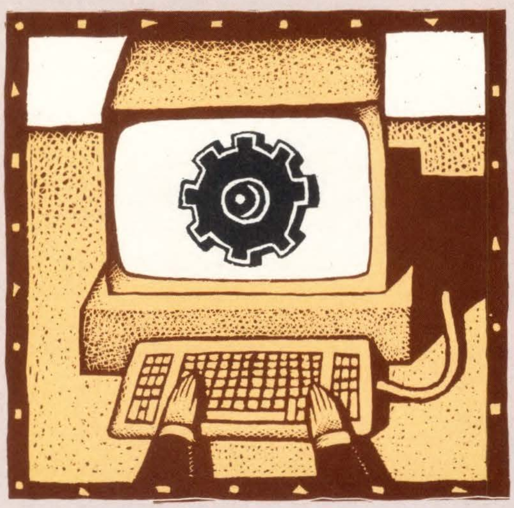

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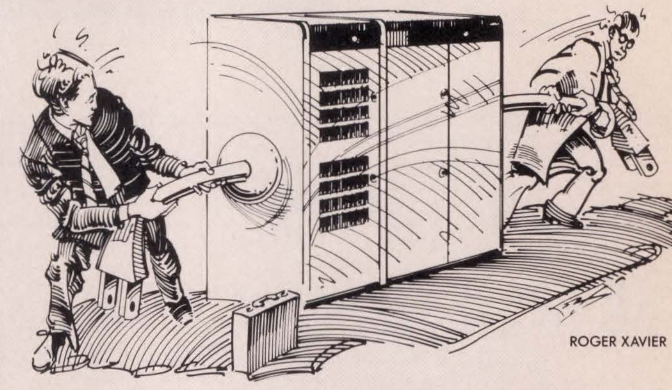
INDUSTRIAL AUTOMATION



ROGER XAVIER

VMS for realtime as well as business applications—page 76

DIGITAL ALTERNATIVES

DEPARTMENTS

COLUMNS

This month's cover, the work of Boston-based photographer Mark Thayer, illustrates Digital's targeting of the new MicroVAX at the office marketplace. Thanks to Digital for providing this photo, created exclusively for Hardcopy.

VAX™ power at PC prices.

Digital's VAXstation™ 2000 is the smallest, lowest-priced VAXstation yet.

Digital's VAXstation 2000 is a high-performance, entry-level workstation with all the benefits of Digital's VAX/VMS family of computers. And it can be configured from under $4600.00.

The VAXstation 2000 features a single-board computer with VLSI MicroVAX II™ supermicroprocessor, a floating-point unit, system memory, Winchester disk controller, tape controller, diskette controller, video controller and monitor, mouse, keyboard, printer and communication serial lines. You get the power of a VAX in a box about the size of a large dictionary.

The VAXstation 2000 is available with either a 15 or 19 inch color or monochrome monitor and it can be configured as a disk or diskless version. It comes with either the ULTRIX™ or MicroVMS™ operating system and is fully compatible with the other members of the VAXstation family—the VAXstation II and the VAXstation II/GPX.

It is ready to attach to a ThinWire Ethernet network by incorporating an Ethernet controller.

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The Network Is Ours

Digital's attempt to introduce interactive computing to the world at DECworld '87 not only showed the strategy and direction of Digital, but it put both competitors and customers on notice that, in the words of Ken Olsen, "The network is ours." He was not referring to the network in a commercial or competitive context but in a strategic capacity in which Digital intends to lead the way in helping customers of all computer manufacturers to effectively distribute and manage information. "The ability to share information anywhere in the world is what matters now . . . and 5 yrs. from now," was a statement of corporate policy and direction from Ken Olsen.

The new products and software introduced at DECworld '87 clearly enforce Digital's networking links. The strategy also includes a major emphasis on outside software partners. Not to be overlooked when analyzing this media extravaganza and the myriad of announcements, Cooperative Marketing Partners (CMPs) will provide an important strategic link in Digital's scheme to dominate interactive computing throughout the world. The software applications "lock-in" is destined to allow the company to keep and maintain its enormous lead in networking. A CMP will bring applications expertise to the network in conjunction with Digital's hardware solution. Every phase of industry and finance was represented at the show, along with several CMPs focusing on the applications involved in the various corporate disciplines. While the new product announcements overshadowed the CMP strategy, it is one that provides a firm footing for the engineering marvels introduced here and presents an enormous opportunity to the millions of individuals whose expertise can be transferred to Digital interactive networks.

Although the announcements and comments at DECworld '87 are more abundant than this column can address, I would like to share with you those that made the greatest impression on this writer.

Ken Olsen on:

PCs—"There is nothing personal about business."

Twisted-pair Ethernet cables—"It is not the best way to handle the job, but if that's what our customers want. . . . "

Apple—"We talk to them, they talk to us—they're very friendly folks."

Digital's financial statement, which was distributed at the show, was simply awesome. Aside from a 24% gain in revenue and an 84% increase in profits, the company has attained a level of profits and performance unmatched in today's high tech industry. Digital's cash position is over $2 billion and its long-term debt is an insignificant $269 million. (That's more cash than Apple has sales.)

Digital's future is brighter than it has ever been and the people and companies aligned in this industry should prosper. The securities analysts who are tasked with analyzing the significance of DECworld '87 must have given some glowing financial prediction just as I have because Digital's stock jumped more than 7 points a few days after the opening of the show.

Publisher

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CPU-Bound VAX Systems Rescued by Avalon

Attached processors are oriented towards number-crunching programs written in DEC Fortran.

Hardware and Software systems run C, Fortran, and Pascal programs with full access to VAX files, terminals, and system services.

Avalon Computer Systems recently released its second generation of attached processor systems. Founded in 1982, the company has been quietly delivering attached processor systems for UNIBUS and Q-bus VAX systems for 4 years.

Avalon's customer base has been drawn largely from the aerospace, government, and university ranks. These users were attracted by Avalon's transparent system software which executes programs (under VMS or UNIX) directly off of the VAX disk, with full access to all files, terminals, and system services. The announcement last summer of an updated Fortran compiler with VMS extensions and two new, faster attached processors has widened the user spectrum substantially. Recently, chemical, genetics, and AI companies have joined Avalon's growing customer base.

Named the AP/20 (Q-Bus) and the AP/24 (Unibus), the new coprocessors are based on the Intel 80386 microprocessor operating in the 32-bit protected mode. Both systems contain a 64K byte cache memory and an optional high-speed floating point accelerator which can multiply two single precision numbers in 437 nanoseconds. The AP/20 has 4 million bytes of real memory while the AP/24 has 4, 8, or 12 million bytes of real memory.

Either AP with an FPA is 2 times faster than a completely unloaded VAX 11/780 on floating point programs and is 3 times faster on integer programs. More important than the increased speed, however, is that the AP provides additional, *parallel* computing power.

By adding one or more AP Systems to the VAX, CPU cycles can be incrementally expanded for "power users" with compute-bound programs. The end result is the transformation of VAX Systems into parallel computers which still run the VAX/VMS operating system.

The AP software optionally includes C, Fortran, and Pascal compilers, with support for VMS, Ultrix, Berkeley UNIX and AT&T System V UNIX. Under VMS, the Avalon software automatically executes system services and I/O operations by passing messages between the coprocessor and an interface program that runs under VMS. An Avalon official explained: "The Avalon compilers put a VMS executable image in front of the Avalon program. This starts the coprocessor interface under VMS, and the Avalon image on the AP. This way, operation under the coprocessor is transparent to the program and the user after it has been recompiled." The recompiled program can then access all VMS files, terminals, and most system services, just as it did in its original form. However, the program runs entirely on the AP when not performing I/O and neither affects, nor is affected by, the computational load on the VAX.

It is believed that Avalon is the only company supplying "Blue Fortran" compatibility in its Fortran compiler. The Avalon Fortran implements virtually all of the DEC Fortran extensions and provides complete access to VMS system facilities.

Avalon provides VAX compatible, high performance systems to end users who need more power, without requiring any modifications to the original source code.

Both the AP/20 and the AP/24 are single circuit boards that range in price between $10,000 and $18,000, depending on selected options.

For more information call or write:

Sales
Avalon Computer Systems
425 E. Colorado Blvd. #710
Glendale, CA 91205
(818) 247-2216

The DECworld '87 Extravaganza: Networks At Work

With DECworld '87, Digital Equipment Corp. continued to set the pace for the computer industry. Unlike IBM, whose success has largely been founded on proprietary technology, Digital is embracing and creating industry standards, thereby ensuring not only its own growth, but the industry's in general. Nowhere has this been demonstrated more strongly than at DECworld '87.

The theme of the show, held September 8–18, was "Networks at Work." The MicroVAX 3500/3600 was introduced the second day, and a variety of other product introductions followed throughout the show. Other introductions of note were Ethernet on twisted pair and (announced in conjunction with engineers at the Massachusetts Institute of Technology) X Windows V. 11 (X.11).

Using DECnet, Digital networked all of Boston's major hotels to the show floor (located at Boston's World Trade Center) and to two full-sized cruise ships, the Queen Elizabeth II and the Star/Ship Oceanic. All attendees were issued passwords and could access the network from any location for mail input by other attendees.

The two cruise ships were used for both seminars and lodging. More than48,500 people attended this event, at a cost to Digital of somewhere between $20–$30 million. The show generated approximately $50 million revenue for the City of Boston.

On the show floor, all major Digital products were demonstrated, and the company brought in its network management control center from headquarters so that attendees could witness how Digital keeps a close tab on its own worldwide company network.

The majority of the displays, however, were of products available for a wide variety of vertical industries—health care, banking, discrete manufacturing, etc. Cooperative Marketing Program (CMP) and Systems Cooperative Marketing Program (SCMP) participants demonstrated their offerings on DEC equipment to customers working within the various vertical industries. Digital also allowed the participation of *some* third party vendors not involved in any formal agreement with the company; these companies were invited based on the uniqueness of their offerings, and they contributed significantly to the show.

To demonstrate Digital's commitment to connectivity and standards, Digital also demonstrated competitors' equipment such as IBM and Apple. A Cray was linked to the show equipment via satellite, and DECworld, in fact, began to take on the feel of Comdex, although all equipment was interconnected by Ethernet. With DECworld, Digital made it clear that it isn't threatened by the fact that opening its systems to connectivity with equipment from all manufacturers could result in the potential loss of sales—on the contrary, Digital believes that standards and interconnectivity will result in a healthier computer industry, and Digital will become the unchallenged leader.

Dan Reese

Editor

This is the screen that dreams are made of–the DEC-compatible ADDS 3220. Its unique 70Hz refresh display gives you a stunning flicker-free performance. Along with a presentation so brilliant your operators will be happy to work with it all day.

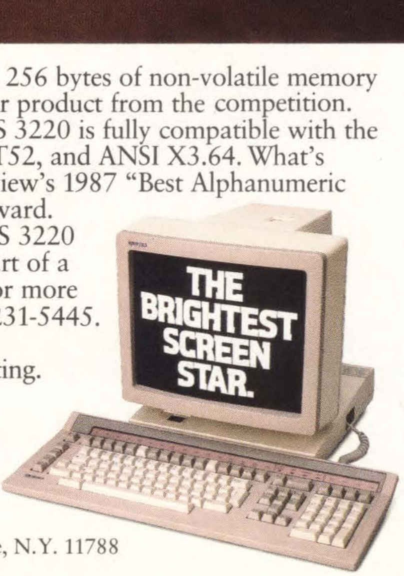
And you'll appreciate our supporting cast of bigger-than-life characters. Presented on a 14" flat green, amber or white screen, our easy-to-read double wide and double high/wide characters can be viewed in your choice of 80 or 132 column format. With operator selectable settings for brightness and contrast.

Brains and beauty.

But more than just a terminal that's great to look at, the ADDS 3220 gives you brains behind the beauty. Our DEC-style keyboard enhances the performance of your software. With value-added features like 22 fully programmable function keys and 256 bytes of non-volatile memory that help distinguish your product from the competition.

Naturally the ADDS 3220 is fully compatible with the DEC VT220, VT100, VT52, and ANSI X3.64. What's more, it won Digital Review's 1987 "Best Alphanumeric Terminal of the Year" award.

Screen test an ADDS 3220 today. It could be the start of a beautiful relationship. For more information, call 1-800-231-5445. In N.Y. 516-231-5400. Ask for Displays Marketing.



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20/20 Connects To Digital Databases

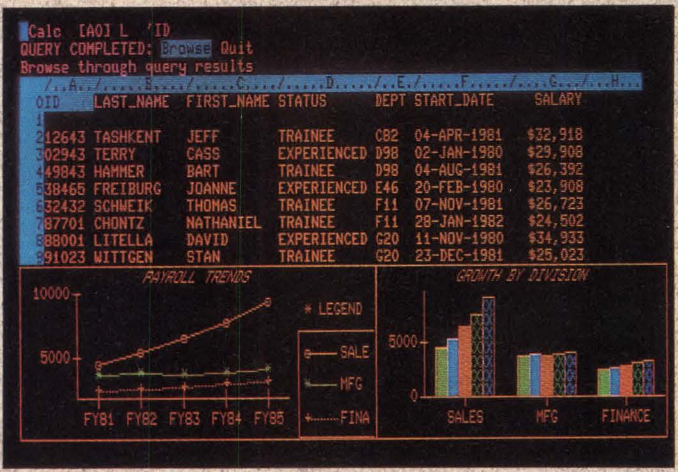
A new extension to 20/20, the widely used VAX spreadsheet from Access Technology Inc. (South Natick, Mass.), allows 20/20 users to pull information from Datatrieve, DBMS, or Rdb/VMS and place it in the spreadsheet where it can be analyzed and manipulated. RMS files can be accessed through the connection to Datatrieve.

The 20/20 Database Connection was designed for 20/20 users in a multiuser environment where databases are stored on a central computer. Unlike current spreadsheet/database solutions, it can accommodate spreadsheet professionals who have little knowledge of databases.

"It's not a front end or an interface," stresses Carl Nelson, Access' vice president. "20/20 is integrated with the database."

In fact, the product sets a precedent by tying together two popular types of data utilization that often need to be interchangeable, but historically haven't been. Although technically skilled users can interface the two using a database's query language, most data is still transferred through manual rekeying.

With the new software, users don't need to know a query language, nor is there any need for intermediate files. The connection appears as an option on the main tool's menu as /TOOLS CONNECTION. From there, DATABASE QUERY allows the user to construct three types of queries: Detail and Summary, which retrieve either detailed data or a list of the records through menu selections, and Expert, which is for users already familiar with the database language. The queries are driven by current values in the worksheet.



20/20's new extension allows users to pull information from Datatrieve, DBMS, or Rdb/VMS and insert it in a spreadsheet to be analyzed and manipulated.

Once a query path has been developed, it can be saved with the spreadsheet model. The queries can also be built into a 20/20 macro.

Users never exit 20/20, but they can browse through database files and fields and then select, sort, summarize, or retrieve data, however, security of the database is maintained. The connection doesn't permit users to alter or otherwise corrupt data, and the database administrator is capable of restricting access to certain information or can set a limit on the number of records to be selected in a single query.

REVIEW provides a full-screen look at the current status of the query and allows it to be modified; PREVIEW is an option to double-check retrieved data before accepting the query.

The spreadsheet formats cells for the incoming data, automatically determining column widths and headers.

Once inside the worksheet, the standard 20/20 comparison criteria can be applied to the data.

Access estimated 90% of the data 20/20 users need already resides in databases on their VAXes. Representatives from the company report they are currently working on similar packages for third party databases.

Incremental prices for the 20/20 Database Connection range from $600 on the MicroVAX 2000 to $5,000 on the VAX 8800. The spreadsheet costs $1,500 on the MicroVAX 2000, $12,500 on the 8800.

—Evan Birkhead

VAXBI Ethernet Controller With TCP/IP

MICOM-Interlan (Boxborough, Mass.) has announced plans to develop a new Ethernet controller with an on-board transmission control protocol/internet protocol (TCP/IP) processor for Digital Equipment Corp.'s VAX 8000 family of minicomputers. The company has been licensed by Digital to develop and sell an IEEE 802.3 Ethernet controller that is plug compatible with the VAXBI backplane interconnect bus protocol architecture.

The controller, designated the NP800, will work directly with any VAX 8000 computer without the need for a Unibus adapter. The design optimizes VAX performance by offloading the processing of TCP/IP software from the host CPU.

According to MICOM-Interlan president, Mike Barker, "The granting of this license shows that Digital views TCP/IP as a complementary protocol that can coexist with DECnet to simplify interoperability between VAX and nonDEC hosts. Also, since both MICOM-Interlan and Digital are each committed to supporting a migration to the International Standards Organization (ISO) Open Systems Interconnect (OSI) protocols, there is no risk that the user's investment in TCP/IP networking products will become obsolete in the future."

The NP800 will incorporate Digital's BIIC chip for backplane interconnect interface, and an Intel 80286 for handling the on-board processing of TCP/IP software. On-board protocol processing eliminates the host computer processing overhead that is required by VAX-resident TCP/IP software products.

The new controller will be offered as part of MICOM-Interlan's NP series of front-end TCP/IP processors. The NP family of high performance Ethernet products includes Unibus and Q-bus connections for VAX and MicroVAX systems, as well as connections for IBM PC/AT, Multibus, and VMEbus systems. Initial customer shipments are expected to begin first quarter 1988.

—Renee P. Brown

RAF. THE MAINLINE TO YOUR MAINFRAME.

RAF REMOTE ACCESS FACILITY.™ THE EASIEST, FASTEST, MOST COMPLETE WAY TO TAP DEC MAINFRAME POWER AT YOUR PC.

RAF is a PC-to-host communications system designed to integrate your PC with all the data and power of a VAX or DECSYSTEM-20. RAF does the job transparently, seamlessly and faster than any other PC-to-DEC host software. But read on, because RAF offers a lot more!

EASY ACCESS TO REMOTE DATA

RAF fools the PC into "thinking" that remote files are local. So you can utilize your regular PC software to access data stored on a remote system. It's as if the data were stored locally on your PC! Use WordPerfect, MASS-11 and other PC editors to create or edit files stored on a remote VAX. And use PC spreadsheet programs like Lotus 1-2-3 to manipulate remotely stored spreadsheets.

SHARE REMOTE SYSTEM PRINTERS

Why dedicate a printer to a PC when RAF allows PC's to share remote system printers transparently? With RAF, PC software thinks your PC is equipped with its own local printer! And RAF lets you define all remote printer options. With RAF, you decide which remote printer to use or which forms to utilize.

COMPLETE ACCESS OF REMOTE COMPUTERS

RAF delivers automatic access to remote computers through a scripting mechanism that allows you to define each step of an automatic login. Or complete VT100 and VT220 terminal emulators unlike any other software system. RAF's VT100 and VT220 support allows for instant switching between PC and VAX applications.

ASYNCHRONOUS AND ETHERNET SUPPORT

You can use RAF to communicate asynchronously or over Ethernet. A single copy supports both, so you can install RAF asynchronously now and switch to Ethernet if it's available in the future. Also, RAF allows some users to operate asynchronously while others utilize Ethernet. RAF supports asynchronous communications over modems, networks or via direct connections—at speeds from 300bps to 38kbps. Over Ethernet, RAF transfers data up to 100,000 characters per second (800 kbps)—that's about ten times faster than any other comparable communications product! And RAF allows Ethernet users to maintain multiple connections with remote systems—as if they're connected through a DEC terminal server.

TRAINING, SUPPORT AND UPDATES

In order to make sure you put every outstanding RAF capability to your fullest advantage, we have prepared a comprehensive RAF videocassette trainer. This two hour cassette—$29.95 if purchased separately—is yours *free* with the purchase of a RAF host master license.

For on-going and immediate technical support, eligible RAF users can call our special hotline, 1-800-DIAL-DSS. And as new RAF versions are made available, eligible users can update their PC software automatically through the RAF electronic distribution system. In so many ways, RAF is your main line to the DEC mainframe. Call for more information now.

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EMC Joins Optical Fray

After flexing its technological muscle with the development of a VAXBI compatible interface chip, memory producer EMC Corp. (Hopkinton, Mass.) has taken on a new challenge. This month, the company will begin shipping the Archeion, an optical disk subsystem for VAXes—EMC's first storage product for the Digital Equipment Corp. environment.

The company is currently best known as a producer of system enhancements: memory, cache, direct access storage devices (DASDs), and communications controllers. Its hardware support extends beyond Digital, covering the HP 3000, IBM minis and mainframes, Prime, and Wang VS systems. Sufficiently backed by a third consecutive year of doubled earnings, EMC decided it can afford to risk an entrance into a burgeoning, unfamiliar market with different competitors.

"Our greatest fear is stagnation," justifies Kevin Fitzgerald, EMC's VAX product manager. "We're always looking for new markets."

Backing the decision to start with a VAX product rather than an IBM or Wang venture, Fitzgerald cites research showing "in the DEC world, it [archiving] is all on magnetic tape right now." Fitzgerald predicts that the cost of optical archiving will tumble to $.5/Mbyte once the market is saturated with media and subsystem producers.

EMC's stated intention in designing the subsystem was to make it as independent of the host as possible. The host computer sees the subsystem as a TU tape drive using a Pertec standard drive interface. This way, the user doesn't have to learn new commands or procedures.

EMC also reports the subsystem will be independent of modifications made by Digital, such as new versions of VMS.

The Archeion supports up to three types of data transfers that can operate concurrently without the use of a switch: to and from the optical drive by the user; to and from tape drives by the user; and between optical and tape drives.

The Archeion, EMC's optical disk storage subsystem, provides up to 56 Gbytes of online storage for VAX users.

The subsystem implements 12-in. platters with 1.024 Gbytes/side and can support up to 56 drives. It has a burst transfer rate of 770 Kbytes/sec., and the error rate is 10^{-12} using ECC.

The subsystem has its own power supply, so a drive can be replaced or upgraded without shutting down the entire system.

EMC plans to service the subsystem from its current worldwide service facilities.

—Evan Birkhead

Optical Storage Subsystem For MicroVAX II

Current write once read many (WORM) based disk subsystems utilize different methods in an effort to solve the performance problems associated with optical technology, such as nonerasability and slow seek times. Each of these approaches has enjoyed varying degrees of success. They range from the practical (storing optical directories, bit maps, and index files on removable disks) to the bizarre (using noncompatible device drivers).

Scientific Micro Systems Inc.—SMS (Mountain View, Calif.), which claims to have produced the first commercially available controller for optical disk drives, is trying an alternate approach that integrates controller firmware design with file structure and application design, thereby taking advantage of the characteristics of WORM, rather than trying to cover them up. The SMS Optical Development Kit, designed for the MicroVAX II, is based on 5¼-in. optical media.

The kit enters the low end VAX market as a kind of testing ground for optical archiving on VMS—a first step toward full-scale optical storage for VAXes. According to Mike Liccardo, the vice president of storage systems at SMS, the kit was designed to speed the learning curve for developers evaluating software or hardware applications for optical storage.

SMS plans to sell the subsystem primarily through its established base of technical and commercial OEMs and VARs, but also to some sophisticated end users. The kit costs $10,000, while an SMS 0109 controller alone is priced at $1,150 in OEM quantities. An SMS technical staff member provides installation of the equipment as well as on-site training.

The foundation of the toolkit is an SMS 0109 multifunction controller with a small computer systems interface (SCSI) port. The Mass Storage Control Protocol (MSCP) compatible controller also supports two Winchesters, using a DU driver for the optical and Winchester drives. It can also support two floppies, addressing the Winchesters as DUA0 and DUA1 and the floppies as DUA2 and DUA3. (The optical disk is DUB0.)

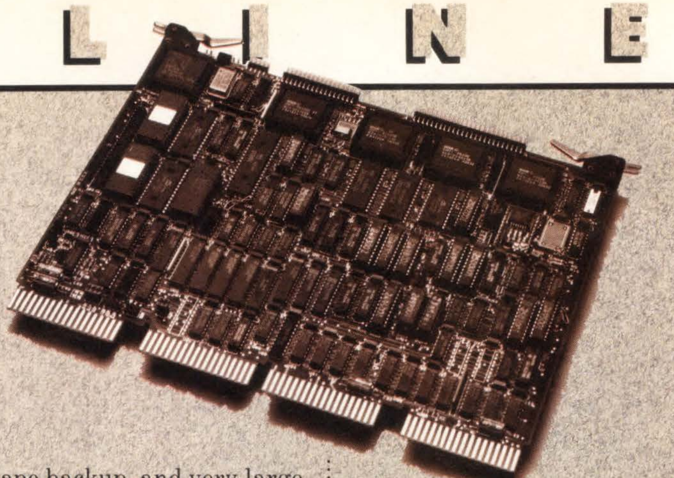
Also included are a Maxtor RXT-800S 5¼-in. drive with 800 Mbytes of storage, and SMS' proprietary Optical System Software (OSS) that manages the optical disk's file structure. The optical drive has automatic error detection and correction, and a SCSI controller to talk to the 0109.

The software, written in FORTRAN-77, is the key to the subsystem's different approach. The file structure is a subset and a superset of Digital Equipment Corp.'s OSD-2, so VMS applications can access the optical disk. (The disk home-block, file characteristics, extensions, dates, etc. are the same as any OSD-2 device.) The utility that implements the file structure is a set of subroutines that are callable from VMS.

A SCSI pass-through mode is provided for users who have additional requirements for accessing SCSI compatible disks.

Not coincidentally, SMS is also active in the storage markets for the Macintosh and IBM PC. The roots of the company, however, are in controllers, storage systems, Q-bus microcomputers, systems software, tape backup, and very large scale integration (VLSI) application-specific integrated circuits (ASICs).

—Evan Birkhead



The SMS 0109 is a single-board controller designed to interface optical disks to a MicroVAX II.

Shared Databases For Financial Institutions

In an effort to redefine the performance standards of relational database management, Britton Lee Inc. (Los Gatos, Calif.) made several potent product introductions at the National Financial Computer & Automation Conference (FinCom) in New York.

Most newsworthy was the BL8000 Shared Database System, a 32-bit machine based on both parallel processing and reduced instruction set computer (RISC) concepts. The system reportedly has transaction rates that rival those of mainframes running relational database applications. This translates to 10 times the performance capabilities of Britton Lee's current high end database.

The BL8000 is called a shared database because it's designed to allow microcomputers, minis, and mainframes to share information. While applications run on the host processor, the database management software runs on the database machine.

Besides VMS, the system supports VM/CMS, Apollo, and Sun workstations, and UNIX. Upward compatible with Britton Lee's current high end systems, the three models of the BL8000 will contain 1-120 Gbytes of disk storage, and 16-256 Mbytes of data memory. Prices start at $320,000.

V. 2 of the company's proprietary Integrated Database Manager (IDM) was also introduced to accommodate the BL8000's 32-bit architecture. Conforming to ANSI SQL and DB2 (both industry standards), V. 2 consists of the IDM host-resident software and IDM/RDBMS that resides in the Britton Lee hardware.

Both the BL8000 series and IDM V. 2 will begin beta testing at the beginning of 1988.

The BL300 Shared Database System was also introduced at FinCom. This low end database package allows IBM PC workgroups to share SQL files with VAX users. Like the BL8000, the smaller machine attaches to host systems over Ethernet or RS-232 ports and can hook-up to multiple hosts. It also supports the same operating systems.

The four models of the BL300 range in price from $17,950 to $90,950, depending on disk storage capacities and backup techniques. Sixty-three to 878 Mbytes of disk storage are offered for basic configurations, and backup is either cartridge or 9-track reel-to-reel tape.

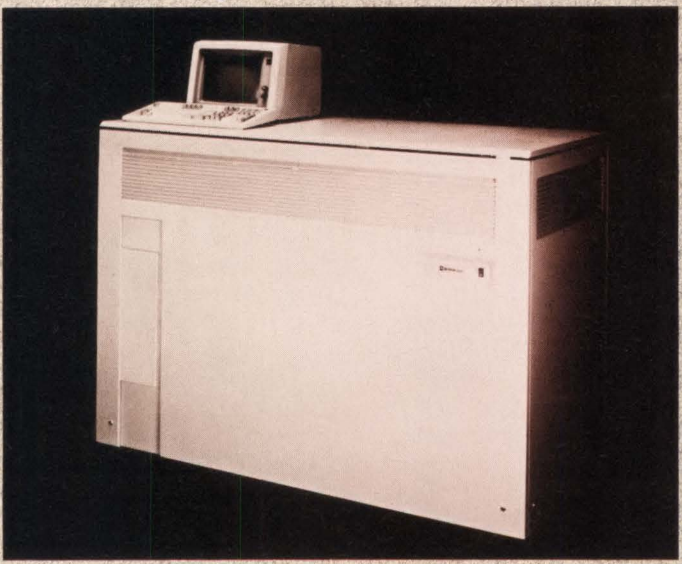
Software licenses for V. 1 of IDM on the BL300 range from $10,000 to $85,000.

Britton Lee also announced that its shared databases can now interface with Focus, the 4GL DBMS from Information Builders Inc. (New York, N.Y.). Focus users will be able to access data on Britton Lee systems and share data with the various shared database system hardware environments. To the Focus user, the Britton Lee systems look just like VM/CMS running on an IBM.

The cost of the interface, which is already available for the BL700 series, was not announced.

—Evan Birkhead

The Britton Lee BL8000 Shared Database System allows microcomputers, minis, and mainframes to share information.



UNIX And Others On Ethernet Using TCP/IP

It was only natural that the competitive new UNIX workstations from Sun, Apollo, and Prime would become popular in the DECnet/Ethernet environment. Meanwhile, transmission control protocol/internet protocol (TCP/IP), the de facto standard network communications protocol most used for UNIX, has become the primary utility for communications along dissimilar operating systems. Many UNIX-based computers already support Ethernet TCP/IP.

TCP/IP on both VAXes and PDPs has thus become an important topic for multivendor, multioperating system Ethernet networks. Process Software Corp. (Amherst, Mass.) offers TCP/IP for virtually all of Digital Equipment Corp.'s operating systems. The company offers both File Transfer Protocol (FTP) and Telnet. FTP is a file transfer networking package for VMS, RSX, RT-11, TSX, and IAS; Telnet is a virtual terminal package for VMS and RT-11.

With FTP, bidirectional transfer between any two computers on the network can take place. Both user and server file transfer protocols are supported. Computers running Telnet-VMS and Telnet-RT can access Ultrix, UNIX, and other TCP/IP systems. Most operating system versions of each program support account and password protection.

Prices for the FTP series range from $995 for FTP-TSX to $1,995 for FTP-VMS. Telnet-RT is priced at $795, while Telnet-VMS is $1,495. Using FTP or Telnet on more than one system requires an additional licensing fee.

—Evan Birkhead

ORACLE And Ingres Available From Elxsi

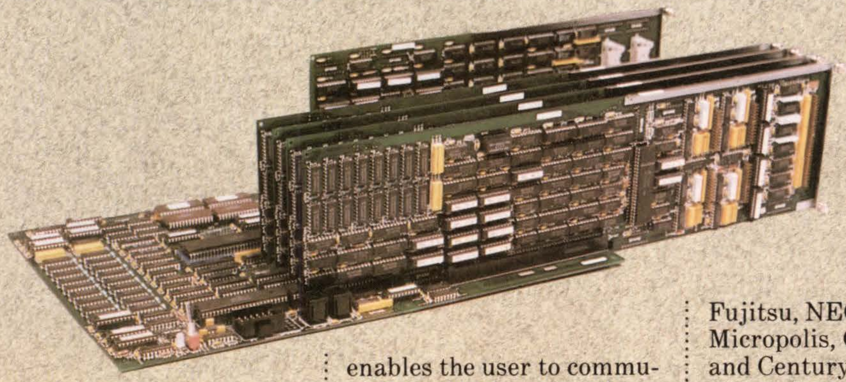
Two of the industry's leading database management system (DBMS) packages are now available from Elxsi (San Jose, Calif.). Recently signed marketing agreements with Oracle Corp. and Relational Technology Inc—made in an effort to reach the large database-user market—provide availability of ORACLE and Ingres DBMS software on the System 6400.

These new marketing agreements follow the ongoing trend in the minisupercomputer market for the system manufacturers to offer as broad a variety of software as possible for their products. "These DBMS packages will combine with the System 6400 for high performance relational database capabilities and provide the DBMS users a cost-efficient multiprocessing alternative to expensive mainframes," says Christopher Drahos, vice president of marketing for Elxsi. "ORACLE and Ingres software complement a growing list of software applications available on the System 6400."

—Renee P. Brown

Break The Bottleneck

High capacity, high performance disk storage is now more economical with the introduction of the Strategy 1 File Access Controller developed by Maximum Strategy Inc. (San Jose, Calif.). Strategy 1 is capable of significantly increasing sustained data transfer rates using standard enhanced small device interface (ESDI) and storage module drive (SMD) Winchester disk drives.



Strategy 1 increases data transfer rates using standard Winchester disk drives.

The system is designed for the high performance sector of the marketplace, where a common problem is a bottleneck in system performance due to data transfer speed. Using a newly designed architecture, Strategy 1 incorporates an array of four standard/serial disk drives to provide subsystem storage capacities from 300 Mbytes to 16 Gbytes and sustained data transfer rates from 3½ to 10 Mbyte/sec.—the kind of speeds and capacities needed for compute-intensive applications such as supercomputing, image processing, array processing, geophysical imaging, medical imaging, graphic arts, animation, and CAD/CAM.

Strategy 1 maintains a core of logical file access facilities residing in firmware. Because it is command driven, the system enables the user to communicate with the controller in terms of logical blocks within a file, rather than physical disk parameters such as cylinders, tracks, and sectors. This alleviates the need for the user to handle the routine low level access details associated with logical-to-physical block mapping, bad block management, and data error recovery.

The system provides users with the flexibility to choose from a variety of drive manufacturers including Toshiba, Hitachi, Fujitsu, NEC, Maxtor, Micropolis, Control Data, and Century Data. The use of standard disk drives and interfaces creates a reliable, cost-effective system at a price of $19,000.

"We designed the Strategy 1 to provide a cost-effective solution to the higher transfer rate demands of the rigid drive marketplace," comments Del Masters, president of Maximum Strategy. "It fills the need for reliable ultra-high performance rotating memory at a much lower cost than comparable alternatives."

—Renee P. Brown

To design our new through the eyes of

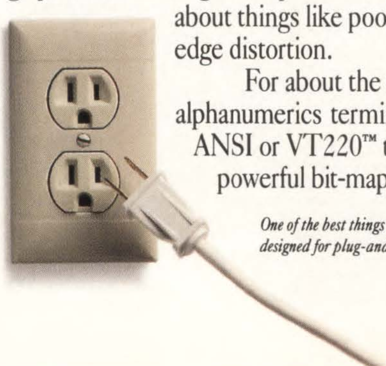
Though it's priced like an alphanumerics terminal, our 600 Series can display both bit-mapped graphics and full-featured text.

It has been said that the video quality on most alphanumerics terminals doesn't even deserve a second look. Much less a fixed gaze. Unfortunately, we have to agree.

We know what poor video quality can do to an operator's productivity. And we also know that lost productivity can cost you more than any investment you make in terminals.

But until now, it was almost impossible to find good video at a good price. You had to choose between high-performance, high-priced graphics terminals, and lower-priced, lackluster alphanumerics terminals.

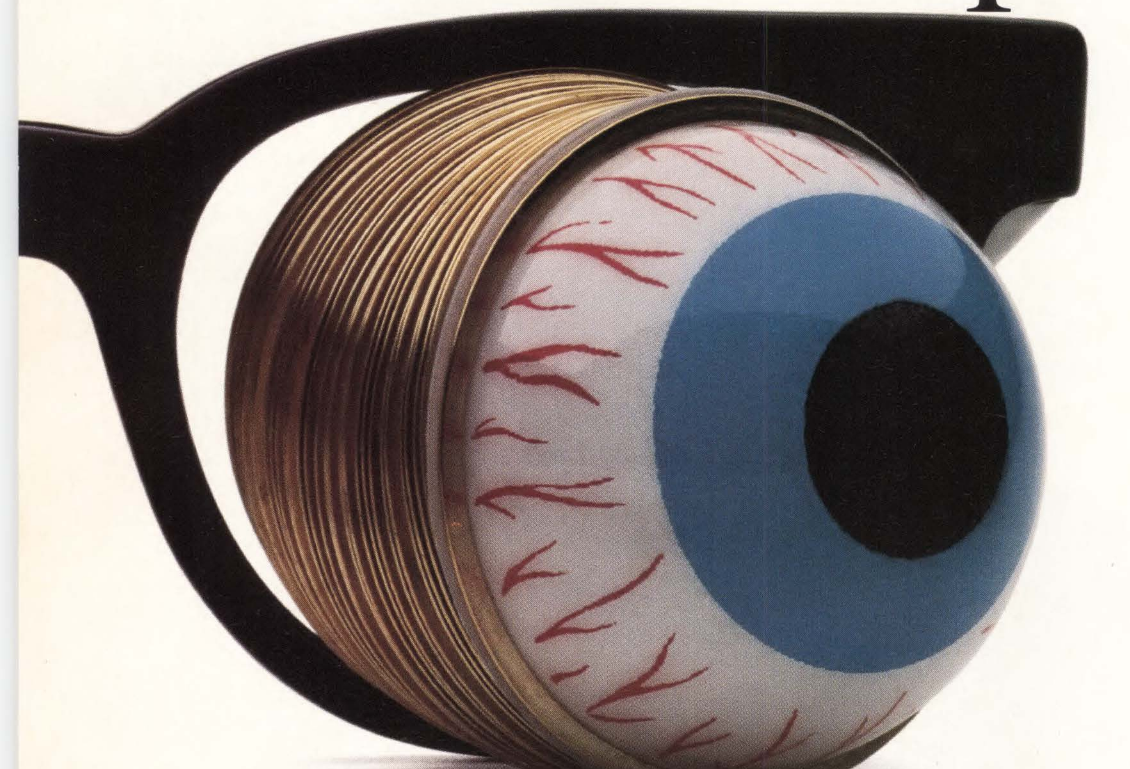
Introducing the Visual 600 Series Integrated Image Display Station.* A new kind of terminal that combines text with graphics for an image so superior that your users will forget all about things like poor resolution, flicker and edge distortion.



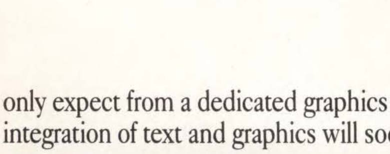
One of the best things about the 600 Series is that it is designed for plug-and-play operation.

For about the same price as a regular alphanumerics terminal, it will emulate ASCII, ANSI or VT220™ terminals, while displaying powerful bit-mapped graphics you would

terminal, we looked the terminal operator.



only expect from a dedicated graphics terminal. And we think its integration of text and graphics will soon become the standard for business computing.



A plug-in "personality module" tells the 600 Series whether to emulate a DEC, Wyse, Televideo or you-name-it.

Besides relieving terminal operators of eyestrain, our new 600 Series was designed to relieve distributors of inventory strain.

The trick is something we call a plug-in personality module that can change our basic terminal into a VT220, a Wyse 50+ or almost anything. And VARs get an open architecture so they can customize to their hearts' delight.

But don't settle for mere words. Look at our new 600 Series Integrated Image Display Station. Because nobody should look at a terminal through eyes like these.

For more information or to arrange a demonstration, call 1-800-433-0880 or write Visual Technology, P.O. Box 5505, Peoria, IL 61601.

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*Patent pending. VT220™ is a registered trademark of Digital Equipment Corp.

ENTER 697 ON READER CARD

Low Cost MicroVAX A/D Converter And Monitor

The Model 190 System Channel Monitor, from Codar Technology Inc. (Longmont, Colo.), provides MicroVAX/Q-bus users with 16 high speed, 8-bit, A/D channels along with on-board temperature and system voltage sensors for a price of $595. Designed for use where a full 10-bit resolution converter is not required, the Model 190 can be tailored to many applications.

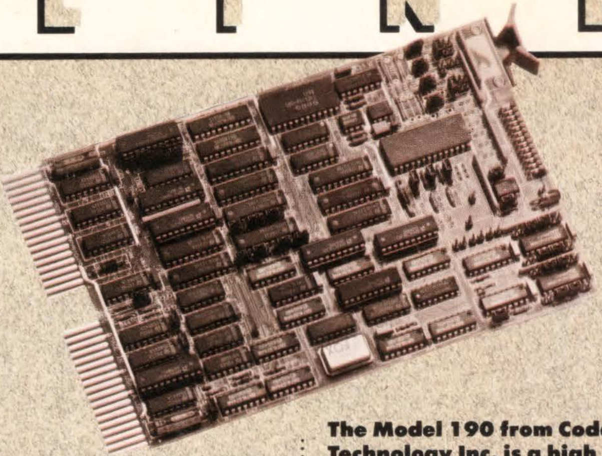
The dual-wide converter offers customer software-programmable, upper and lower thresholds stored in EPROM memory for each A/D channel. Each of the software-selected A/D channels is scanned sequentially using an on-board realtime clock. In auto scan mode, interrupts and/or an external alarm are generated only if an out-of-range condition is detected.

"You get the advantage of a high speed A/D converter running at a fast conversion rate," comments Mike Evans, Codar's president, "but without the associated interrupt overhead."

The Model 190 can also be used as a standard interrupt-driven A/D converter with auto scanning or manual channel selection. The realtime clock is programmable to either drive off-board instrumentation or generate processor interrupts at a programmable rate from 1 Hz to 25 KHz. Each of the analog inputs can also be configured to monitor TTL digital inputs.

"The Model 190's auto scan mode is ideal for low cost environmental and system monitoring," explains Wayne Farlow, executive vice president at Codar. "Interrupt overhead and timing problems associated with standard A/D converters are greatly reduced. Additionally, the requirement for a separate KWV11 realtime clock and associated backplane slot and cabling is eliminated."

—Renee P. Brown

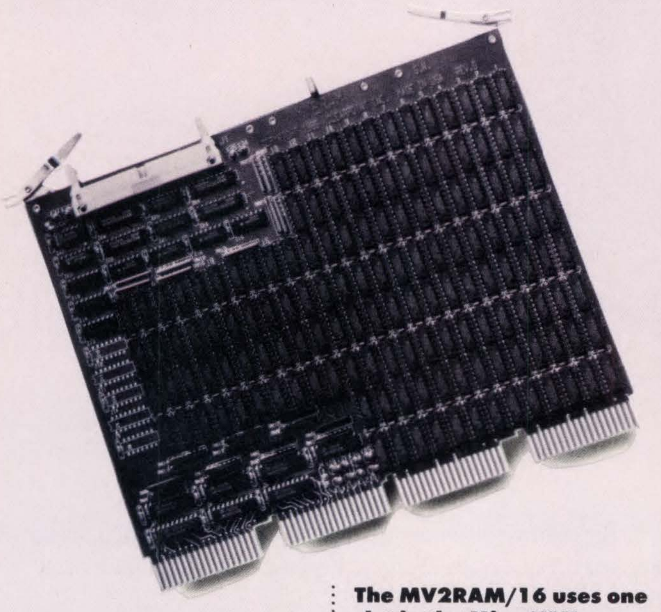


The Model 190 from Codar Technology Inc. is a high speed 8-bit A/D converter with on-board temperature and system voltage sensors.

MicroVAX II Memory

Clearpoint Inc. (Hopkinton, Mass.) has developed a 16-Mbyte memory board for the MicroVAX II and compatible systems. The board, which uses 1-Mbit DIP DRAM chips, requires one slot in the MicroVAX backplane. The company says that the one-board approach runs cooler and uses less power than two 8-Mbyte cards.

The MV2RAM/16 requires no jumpers for memory sizing or addressing. It is now available at a list price of $3,500.



The MV2RAM/16 uses one slot in the MicroVAX backplane, runs cooler, and uses less power than two 8-Mbyte cards.

Digital Is First To Develop 64-Mbyte Board

Digital Equipment Corp. recently made another price/performance adjustment across the entire VAX product line, significantly enhancing the VAX 8000 series and Local Area VAXclusters (LAVCs). The most surprising element of the announcement was the availability of two new high density memory boards for the 8000s, which will allow Digital to compete head-to-head with third party VAXBI memory manufacturers.

The two boards, a 16-Mbyte module for the 8250 and 8350 and a 64-Mbyte module for the rest of the 8000 series, utilize 1-Mbit chip technology. The 16-Mbyte board will expand the system capacity to 128 Mbytes; the 64-Mbyte array raises the ceiling to 256 Mbytes.

In addition, Digital lowered prices of the VAX 8250, 8350, and 8530 systems, while adding enhancements and adjusting prices across the rest of the 8000 line "to more accurately reflect system performance and customer value," according to a company statement. For example, 8000s can now be attached directly to LAVCs, eliminating the need for a Unibus channel.

The 8000s were also upgraded to have a maximum of four Ethernet connections for LAVCs or DECnet LANs.

Other price reductions affected the MicroVAX 2000, which was slashed from 17-20%, depending on the configuration. A final enhancement reduced the footprint size of 8530 and 8550 VAXclusters by 50% to 6 sq. ft.

High Resolution, Low Cost Graphics Display System

The 4322 is the newest member of Ramtek Corp.'s (Santa Clara, Calif.) 4300 family of high resolution graphics display systems. Comprised of a high performance color graphics processor and video display monitor featuring 1280 x 1024 screen resolution, the 4322 displays up to 256 screen colors from a palette of 4096 colors.

Based on several proprietary very large scale integration (VLSI) devices, the compact 4322 provides easy tabletop placement for small work areas. All controller hardware resides within the base of the tilt-and-swivel 15- or 19-in. color monitor and, since the 4322 uses less components, system reliability is greatly increased.

Compatible with Digital Equipment Corp.'s VAX and MicroVAX computers, Hewlett-Packard's HP21MX, Data General computers, and IBM PC/AT/XT systems, the 4322 offers intelligent graphics terminal capabilities for $8,995. The 4322 is one graphics display system in this price range that can be directly connected to Ethernet networks for communications with VAX hosts using the RAMnet device driver.

"The Ramtek 4322 provides a very low cost, high resolution graphics display system for users requiring high levels of graphic detail," explains Rick McEwan, Ramtek's manager of graphics products. "The 4322's network capability will appeal to network-oriented users wishing to add high performance graphic nodes without the expense of adding a host server device."

Geared to the high performance graphics market, the 4322 is suitable for many 2D graphics display applications such as those associated with CAD/CAM, process control, finite element analysis, mapping, C3I, and complex business graphics.

—Renee P. Brown

Ramtek's 4322 graphics display system supplies high performance graphics capabilities at a low cost.

Digital Supports Third Party Software

Service and software support from Digital Equipment Corp.'s Customer Support Centers has been extended to several third party software products. The program, called Vendor Application Services (VAS), will support customers with multi-vendor applications. Digital's support specialists will receive training directly from the software vendors.

The basic DECsupport includes installation, updates, telephone advisory support, software performance reports, and Digital's Basic Service and Self-Maintenance Service programs. The specifics of each service will be determined on a product-by-product basis, however.

According to Tim Tormey at Digital, VAS support is as close as possible to the support Digital provides for its own products. VAS is currently available only in the United States, but there are plans for European and other international programs.

Digital Automates PanAm Games For *USA Today*

The *USA Today* news bureau for this summer's PanAm Games was fully automated by an Ethernet environment designed by Digital Equipment Corp. The bureau included eight VAXmates running Xywrite word processing and typesetting software from Xyquest Inc. (Bedford, Mass.), and VAX/VMS services for MS-DOS.

Reporters at the games in Indianapolis filed their stories on the central directory of a MicroVAX server, which sent the documents via integral modem to an Atex publishing system at *USA Today's* headquarters in Virginia.

Digital claims that using the MicroVAX as a server was more cost-effective and efficient than traditional PC/mode links that require a modem attached to each PC.

For security purposes, every reporter at the remote site was issued a key diskette that was necessary to access the VAXmate and the disk on the MicroVAX.

Simplify Contact Tracking

Organizing and tracking customer contact information can be a time-consuming and cumbersome job for even the most orderly sales office. This task is now simplified with the introduction of the Computer Integrated Sales system (CIS) from Owen+Davis Systems (Costa Mesa, Calif.).

CIS allows users to track thousands of business contacts on an individual, personal level. Designed exclusively for Digital Equipment Corp.'s VAX/VMS environment, CIS installs by means of the standard VMSINSTAL program. Prices start at $900/user.

Unique features are the strong suit of CIS—such as the keyword search capability that allows contact lists to be indexed according to a variety of criteria developed by the user. For example, a group of contacts are targeted for a direct mail campaign—by including the name of a cover letter from CIS' letter module as a keyword, the logistics of the search are greatly simplified.

CIS allows users to track thousands of business contacts on an individual, personal level.

"Keywords can be anything the user chooses," says Matthew Owen, partner with the firm, "including words reflecting product interest, follow-up dates, stage in sell cycle, source of the contact name, or literature you've sent." CIS allows more than 100 keywords/contact.

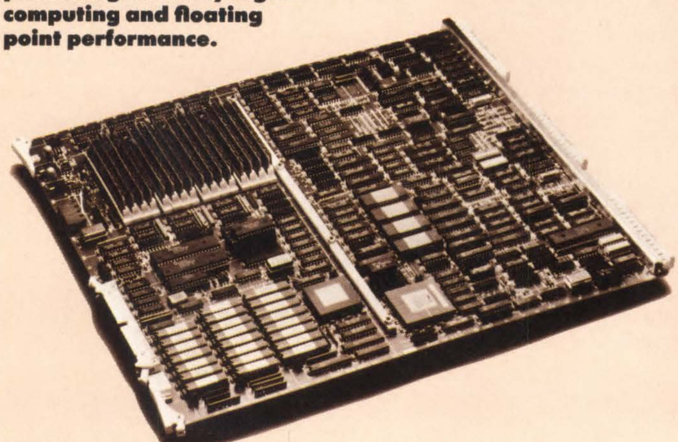
Other useful features include a free-form notepad with the capability of maintaining and reporting on an unlimited number of notes for each contact and a letter writing facility that allows standard form letters to be catalogued and maintained. The letters can be personalized to the contacts by using standard criteria or by any user-created keywords in the system.

—Renee P. Brown

Rival Workstations Increase Capabilities

The IRIS 4D/60, a 7 millions of instructions per sec. (MIPS) graphics workstation from Silicon Graphics Inc. (Mountain View, Calif.), has been benchmarked at greater than 10 MIPS running on a $7,500 upgrade called the Turbo Option. The 4D/60T is a 32-bit CPU board with a 12.5 MHz floating point coprocessor that performs 1 million floating point operations per sec. (MFLOPS)—a 300% improvement over the original CPU.

The IRIS 4D/60 Turbo Option (IRIS 4D/60T) provides IRIS 4D/60 users with a growth path to significantly higher computing and floating point performance.



The board features up to 16 Mbytes of on-board memory, and a dual cache that designates 64 Kbytes for instructions and 32 Kbytes for data.

Rosalie Buonauro at Silicon Graphics says the company anticipates the hardware will open up new applications for 4D/60 users in areas such as ray tracing for animation, finite element modeling and analysis, fluid flow dynamics, molecular models, and medical illustrations.

Apollo Computer Inc. (Chelmsford, Mass.), another Digital Equipment Corp. rival on the graphics workstation battlefield, also improved the capabilities of its flagship product. Apollo's Network Computing System (NCS) is now being marketed as a network distributor for the Trace supercomputer. The NCS can be a group of Series 3000, Series 4000, or Turbo workstations that distributes modules or parts of single application programs to the Trace where they are executed.

The joint venture between Apollo and Multiflow Computer Inc. (Branford, Conn.), producer of the Trace series, is targeting mechanical design engineers running such applications as Geomod, Supertab, Patran, and ANSYS.

—Evan Birkhead

Medical Word List Now On All-In-1

The English Spelling Corrector from Houghton Mifflin (Boston, Mass.), currently available on All-In-1, can now be enhanced with Houghton Mifflin's Medical Word List. The optional list includes biological and chemical names; compounds, generic, and trade pharmaceuticals; acronyms; surgical terms; and emerging terms associated with recent research and procedures.

Digital Equipment Corp. signed a licensing agreement for the software, which is one of Houghton Mifflin's Professional Word Series Language Aid programs.

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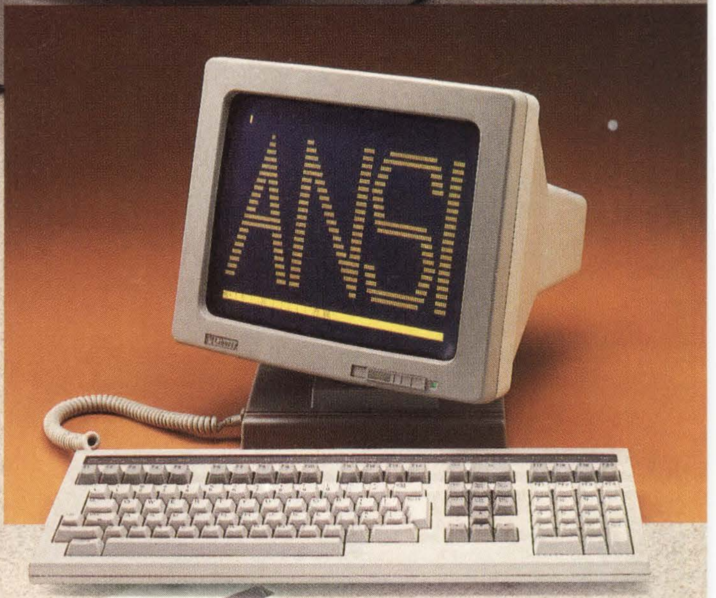

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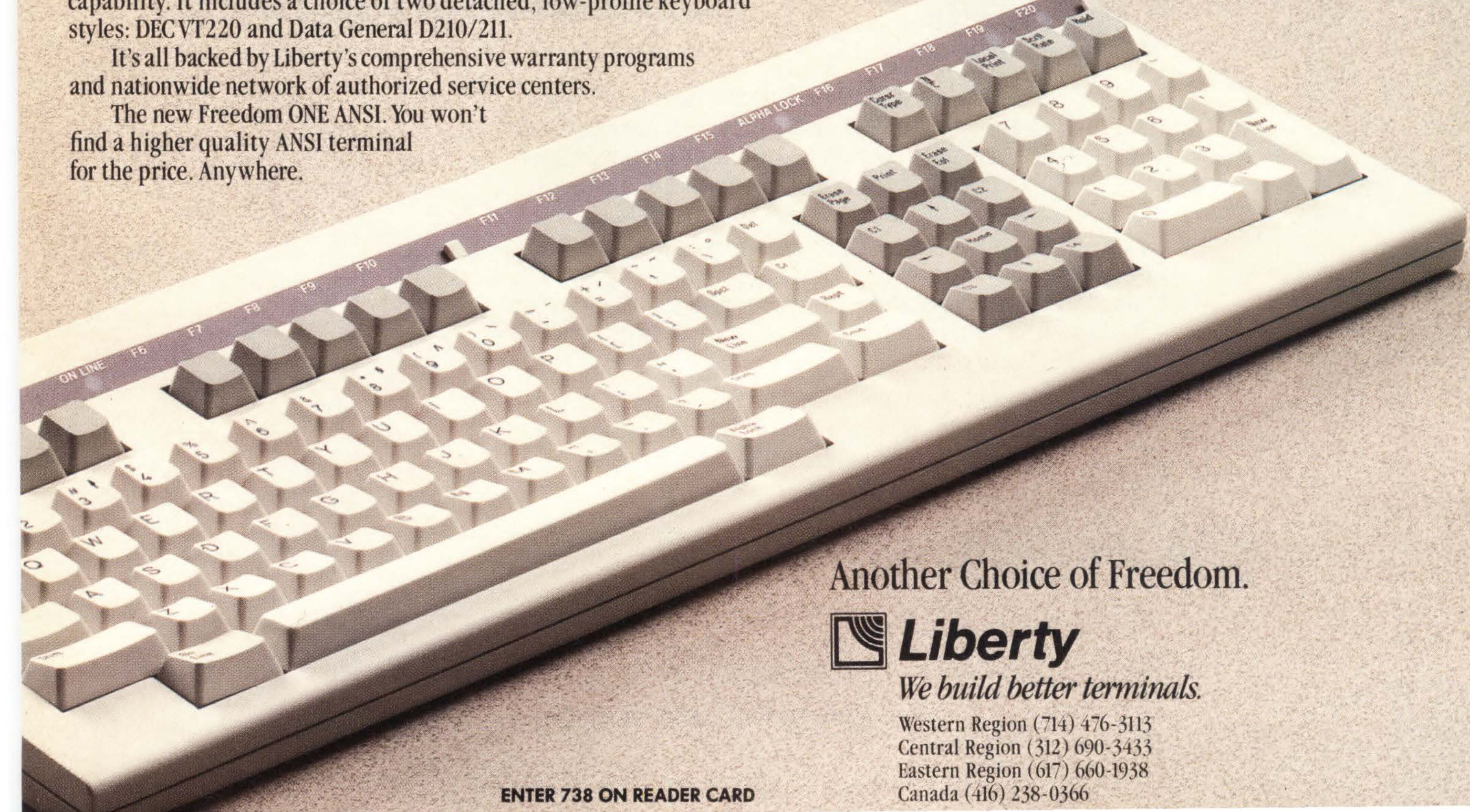

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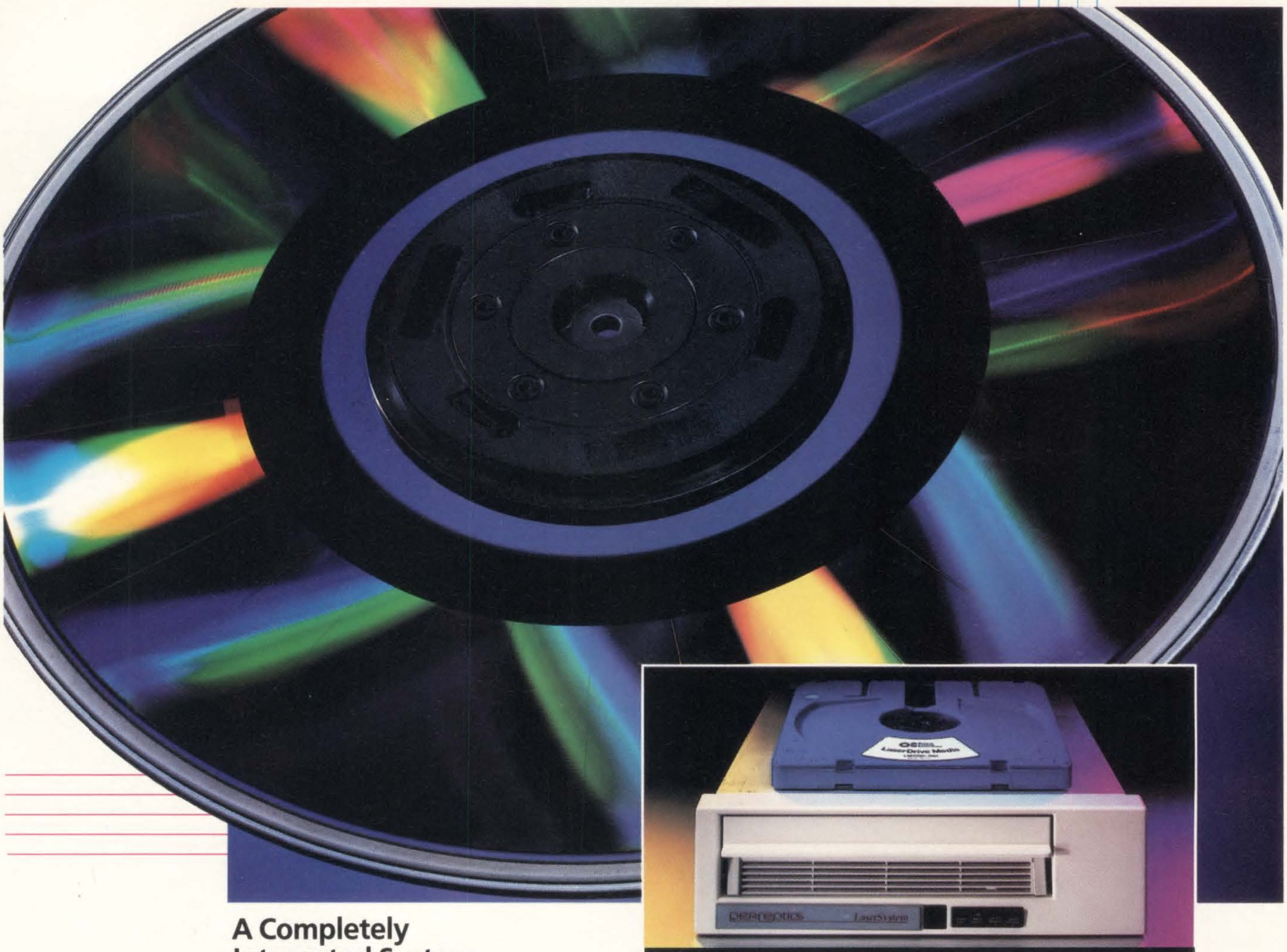

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A MINI BUT SUPER INVASION

HEAVILY ARMED MINISUPERCOMPUTER VENDORS ARE AIMING AN INVASION AT DIGITAL'S SCIENTIFIC AND ENGINEERING MARKET

BY BLAKE ERIKSEN

A new era of affordable, high performance computing is quietly being ushered in by almost two dozen young companies touting what is loosely called a minisupercomputer. While a convergence of hardware designs and integrated circuit devices makes this possible, well-conceived marketing strategies are driving these new machines to broad market acceptance.

Early supercomputers pioneered by Control Data Corp. and Cray Research offered an abundance of computing power, but ultimately didn't fulfill the needs of most scientific and engineering users. Their high price tags, batch mode operating systems, and lack of software presented too great an obstacle for the average undermanned, underfinanced research and development department.

In contrast, the latest wave of minisupercomputer vendors, Multiflow Computing Inc., Floating Point Systems (FPS), Convex Computer Corp., Elxsi, and Alliant Computer Systems Corp., is enjoying considerable success by following a strategy that marries the VAX with speed-enhancing hardware to harvest the fertile price/performance gap between a Cray supercomputer and a VAX, territory left fallow by Digital Equipment Corp. and other major computer vendors. It's not likely to stay that way, however, as Digital is reported to be nearing completion of Pegasus, its own minisupercomputer project.

The choice of hardware architecture—whether vector, parallel, matrix, or very long instruction word (VLIW)—isn't always the most critical factor in the overall scheme. The primary concern is that existing VAX software applications can be easily ported to the 64-bit hardware and made to execute much faster. Next in order of importance is an operating and software development environment closely resembling Digital's VMS operating system, which has become a veritable standard in scientific and engineering circles. Hardware design becomes an important consideration when one vendor's architecture can provide faster execution or increased versatility for a particular application.

"DEC has served scientific and engineering customers well. We want to do that too, and that means fitting into that world," says Leigh Cagan, director of marketing communications for Multiflow, a start-up that began initial minisupercomputer shipments this past summer. Multiflow, like many others, plans to spend considerable effort providing VMS compatibility in the form of a VMS shell for its UNIX operating system (an EDT-style editor) and DECnet capability.

Speed Excites, Solutions Sell

In a market where there is no such thing as too much computing power—complex computations often take hours or days to run on even the fastest supercomputers—the VAX with its general-purpose hardware can have significant disadvantages. For most scientific and engineering applications, minisupercomputers can exponentially increase the number-crunching performance of a VAX 8700 for 80% of the cost. Put another way, minisupercomputers offer 25-50% of a Cray's performance at 10% of the cost. Typical prices range from \$300,000 to \$1 million, although some high end minisupercomputers approach the \$2 million mark. A VAX 8700 sells for more than \$600,000, while

MARK SOKOL

the dual processor VAX 8800 lists at more than $900,000.

What's more, minisupercomputer vendors, following Digital's lead, are focusing on a solutions-oriented sell. "Cray got into the supercomputer business in the days when there was no software and users were willing to take raw machines. Now it's critical to have solutions software," says Jeffery Canin, an analyst who follows supercomputers for San Francisco-based Hambrecht & Quist Inc.

Alliant and Convex both offer more than 100 software packages, many of them from already-existing software ported to their systems directly from minicomputers, primarily VAXes, Canin notes. One hundred software packages is only a small percentage of the vast number of applications available for the VAX, but the point is minisupercomputer vendors have grasped the importance of providing solutions, not just systems.

"What we have always done is sell to industries that rely on applications software to get the job done," says Robert Paluck, president of Convex. "It's the software that sells the machine."

For minisupercomputer vendors like Convex, the strategy boils down to producing what are essentially cheaper, faster VAXes. The vendors that can combine VAX compatibility and applications software with the most speed and lowest price will find themselves well-positioned against other minisupercomputer suppliers and Digital. Convex's ascent to an estimated $75 million in 1987 sales in just 2 yrs. bears out the validity of that approach.

For Some, Super Sales

Although Convex is generally considered to be the hottest property in the vector minisupercomputer business today, the entire market is growing rapidly. Depending upon how a minisupercomputer is defined (and other factors), the market for minisupercomputers is currently estimated at between $250 million and $350 million, according to analysts. Hambrecht & Quist says the market has doubled in the past year and expects it to double next year, topping the $500 million mark.

Dataquest, the San Jose, Calif. market research firm, estimates the minisupercomputer market will total $1.2 billion by 1991, almost quadruple its current value. Although the minisupercomputer market is on a fast track for the next few years, nobody knows how far it will go. Cautions Canin, "It won't go on doubling forever."

According to Dataquest researcher Gregory Kosinski, a shakeout in the minisupercomputer arena is inevitable. The reason boils down to numbers. Designing, programming, marketing, and manufacturing a minisupercomputer is a highly complex, expensive process—typically requiring about $30 million for start-up. With 20+ companies each investing that kind of money and all needing comparable sales, a $300 million to $600 million market isn't large enough to support them all.

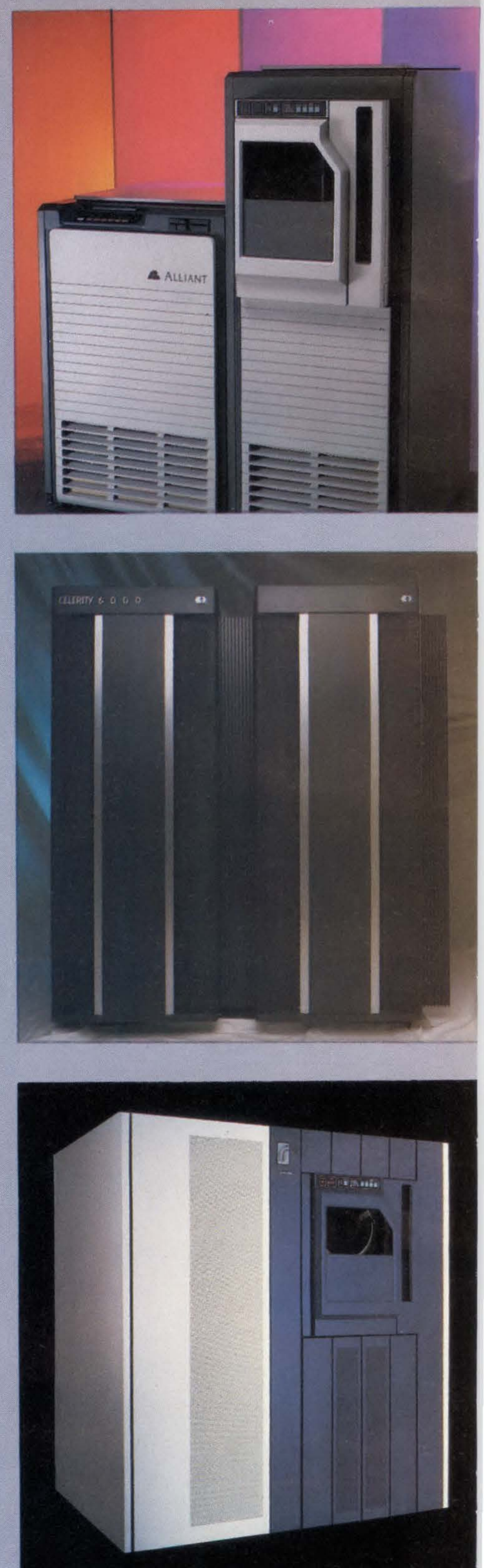
FPS, one of the first vendors to enter this market, has started to feel the effects of a changing, more competitive market. The company posted a $14.7 million loss in 1986 and was forced to trim its workforce by one-third, from 1200 to 800 employees during 1987, incurring a one-time $10 million restructuring cost in the process. Nonetheless, analysts remain optimistic about a leaner FPS' chances for long-term success. It boasts the minisupercomputer industry's largest installed base (350 systems) and recently inked a joint marketing agreement with Digital that gives it both credibility and sales. It also has a large base of applications software to run on its minisupercomputer systems and a sophisticated vectorizing FORTRAN compiler.

The emergence of the minisupercomputer is also cutting into other market segments. Array processors, in particular, are faced with a shrinking market share as minisupercomputers with increased performance, more applications, and an improved environment for applications development invade their territory.

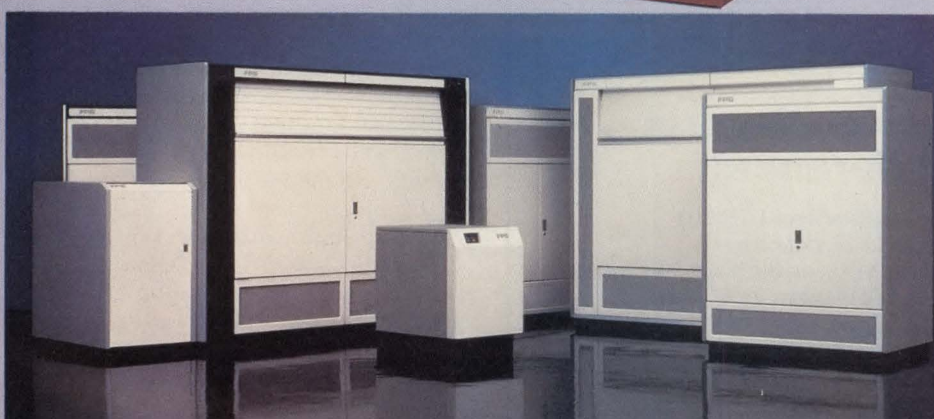
Unlike minisupercomputers, which have their own operating systems, array processors are incapable of standalone operation. They increase performance by executing subroutines from a program residing on a front-end VAX or other host. Where array processors were once the only bridge over the performance gap between a VAX and a Cray, their markets are now being limited to such areas as signal, image, and seismic processing; medical diagnostics; and realtime simulation.

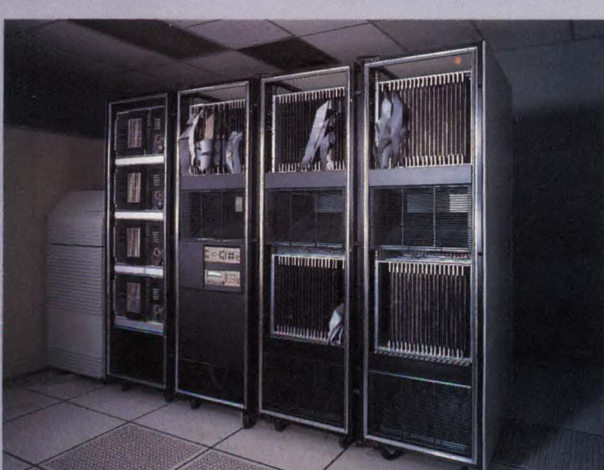
Minisupercomputers address a greater range of applications, including design automation, seismic analysis, oil reservoir simulation, computational chemistry, general scientific analysis, realtime data acquisition, graphics, and software development.

A number of systems that are classified as minisupercomputers, such as the FPS M64 series, rely on the VAX for their interface to users. The FPS M64 adds a combination of scalar and vector processing capabilities to the VAX; compiled programs can run entirely on these added processors, freeing the



Minisupercomputer systems and hardware currently marketed by Alliant Computer Systems (top), *Celerity Computing* (center), *and Multiflow Computer Inc.* (bottom).





Systems offered by Convex Computer Corp. (top), *Elxsi* (top middle), *Floating Point Systems* (bottom middle), *and Saxpy Computer Corp.* (bottom).

VAX processor for other tasks.

Who's On First?

The large number of viable competitors also creates another problem: confusion among potential minisupercomputer buyers, says Canin. "We're seeing Convex and Alliant having trouble closing sales," he says. "The demand is out there, but customers are confused as there are so many conflicting vendor claims. Customers are doing their own benchmarks and know that the longer they hold out (in closing a sale), the better prices they can get."

Selecting a minisupercomputer isn't a simple process. Selection of a system is very application dependent. Often the specialized, high speed processors in minisupercomputers are successful in lowering execution times only if the application matches the processors' architecture. For example, if only small portions of a program can be adapted to vector execution, then a machine that uses vector processing to get its speed provides only limited improvement; in this instance, a scalar machine such as a VAX might be faster. No single hardware architecture is always suitable for a specific applications environment—a fact that can make selecting a minisupercomputer a difficult, confusing process.

The best way for users to sort through performance claims is to run benchmarks on all the minisupercomputer systems under consideration. Unfortunately, this can be a very expensive, time-consuming process, typically costing \$30,000-\$100,000, according to Martin Middlewood, a spokesman for FPS. A big issue at the First World Supercomputer Conference held earlier this year in Santa Clara, Calif. was whether vendors should absorb a portion of the benchmarking cost.

In measuring minisupercomputer performance, there are four levels of benchmark categories, arranged in pyramid fashion, with actual application testing being the most revealing and the most expensive. One level down are benchmarks of third party applications, such as ANSYS, followed by nationally recognized benchmarks, such as Argonne Linpack and Livermore Loops. The most basic and least revealing benchmark is theoretical peek speed or millions of floating point operations per sec. (MFLOPS) rating as determined by running code perfectly optimized for a particular architecture.

Since minisupercomputers are used as general-purpose computers, manufacturers attempt to find ways to make their systems perform in the widest range of applications possible. This can mean sacrificing some speed to gain versatility. For example, FPS' M64 series aims for the "balance point between vector and scalar that makes the most sense," says Middlewood. It's important, therefore, to judge a minisupercomputer's overall performance, not just how it handles a single benchmark.

New Wave Speed

A number of vendors new to the supercomputer scene, including Multiflow, Saxpy Computer Corp., and Celerity Computing, are focusing their efforts on new architectures to reduce applications dependency.

Multiflow's Trace series, for example, is designed to speed up an entire program by using a VLIW architecture that overlaps the execution of a large number of operations in a single instruction word. Multiflow's real breakthrough is a trace scheduling compiler that's able to schedule operations from above and below a conditional branch, increasing the number of simultaneous operations.

The advantage of the VLIW approach to improving system performance is that speed isn't limited to the "mathematical heart code" of technical programs. It also improves execution speed of the support code required to check boundary conditions and perform I/O and memory operations. The VLIW provides performance comparable to multiprocessor parallel designs, without suffering synchronization, load balancing, and program development complexities typical of parallel systems, according to a report published by the Gartner Group, a Stamford, Conn. research house.

Saxpy is another company gaining attention, with a potentially revolutionary new design using a MicroVAX II CPU as the front end to its matrix-processing supercomputing architecture. Instead of computing sequentially, Saxpy's Matrix 1 supercomputers use a linear systolic array of processing zones with local memory to operate on many blocks of data simultaneously.

The new Celerity 6000 family of minisupercomputers uses a reduced instruction set computer (RISC) architecture that can handle scalar and vector code equally well, providing the versatility to fit into a wide range of applications.

Mainstream Vectors

The mainstream of minisupercomputing, however, revolves around vector processing themes. The Convex C-1 uses an architecture based on Cray supercomputer design principles. This architecture features integrated 64-bit scalar and vector processors that, through extensive pipelining and the use of independent functional units, provide simultaneous execution.

The Alliant FX/8 series uses a variation on that theme, running up to 12 vector processors in parallel. Elxsi, which recently signed an agreement with Sky Computer to integrate that company's board-level vector processors into the Elxsi System 6400 parallel scalar-architecture computer, is also moving toward more vector processing. But, depending upon the application, a multiprocessor scalar-architecture Elxsi 6400 can outperform vector machines.

Vector architecture minisupercomputers offer proven performance, broad applications in scientific and engineering applications, and plenty of software support. Says Paluck, "The Cray architecture is the standard for supercomputing. It was a fundamentally brilliant idea to build an affordable, miniature Cray."

It also appears that Digital is planning vector extensions to the VAX architecture, under a project code-named

Pegasus. The new system will debut in 18-24 mths., according to industry sources.

Paluck, for one, welcomes the competition. "Digital's entry into minisupercomputing legitimizes the market, making it grow even faster," he says. "Competition is healthy."

Another reason for Paluck's confidence is that he believes Digital is at an inherent design disadvantage. "DEC's strength is the VAX architecture and the VMS operating system. Adding vector and parallel capability to the VAX is possible, but not as elegant and efficient as a system designed for parallel-vector processing."

Paluck also contends that it may take Digital 4 yrs. to reach the point where Convex is now, because once the hardware architecture is complete, there still remains the formidable task of writing a compiler to take advantage of the system.

"One of Convex's most valuable assets is our optimizing, vectorizing FORTRAN and C compilers," says Paluck. "There is a tremendous amount of work involved in writing a compiler that DEC has yet to complete."

In the meantime, minisupercomputer vendors have encroached mightily on Digital's territory. Convex, Alliant, and Elxsi all provide high levels of VMS and DECnet compatibility. Convex's Convue and Alliant's VCL provide VMS-like operating environments on top of the UNIX operating system.

Elxsi, which allows up to four operating systems to run concurrently, provides a complete VMS compatible operating system called EMS. "We sell to people who have VAXes or are evaluating them," says Christopher Drahos, vice president of marketing for Elxsi. "We say 'take the code you use on the VAX and continue to use it on our systems under EMS, and you can run UNIX at the same time.' If people need more performance than the VAX, they buy our system." ■

Blake Eriksen is a Newport Beach, Calif. freelance writer specializing in the computer and electronics industries.

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Control Data Corp.
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Convex Computer Corp.
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Richardson, TX 75081
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612-333-5889

Elxsi
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Floating Point Systems Inc.
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503-641-3151

Multiflow Computer Inc.
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203-488-6090

Saxpy Computer Corp.
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Sunnyvale, CA 94086
408-732-6700

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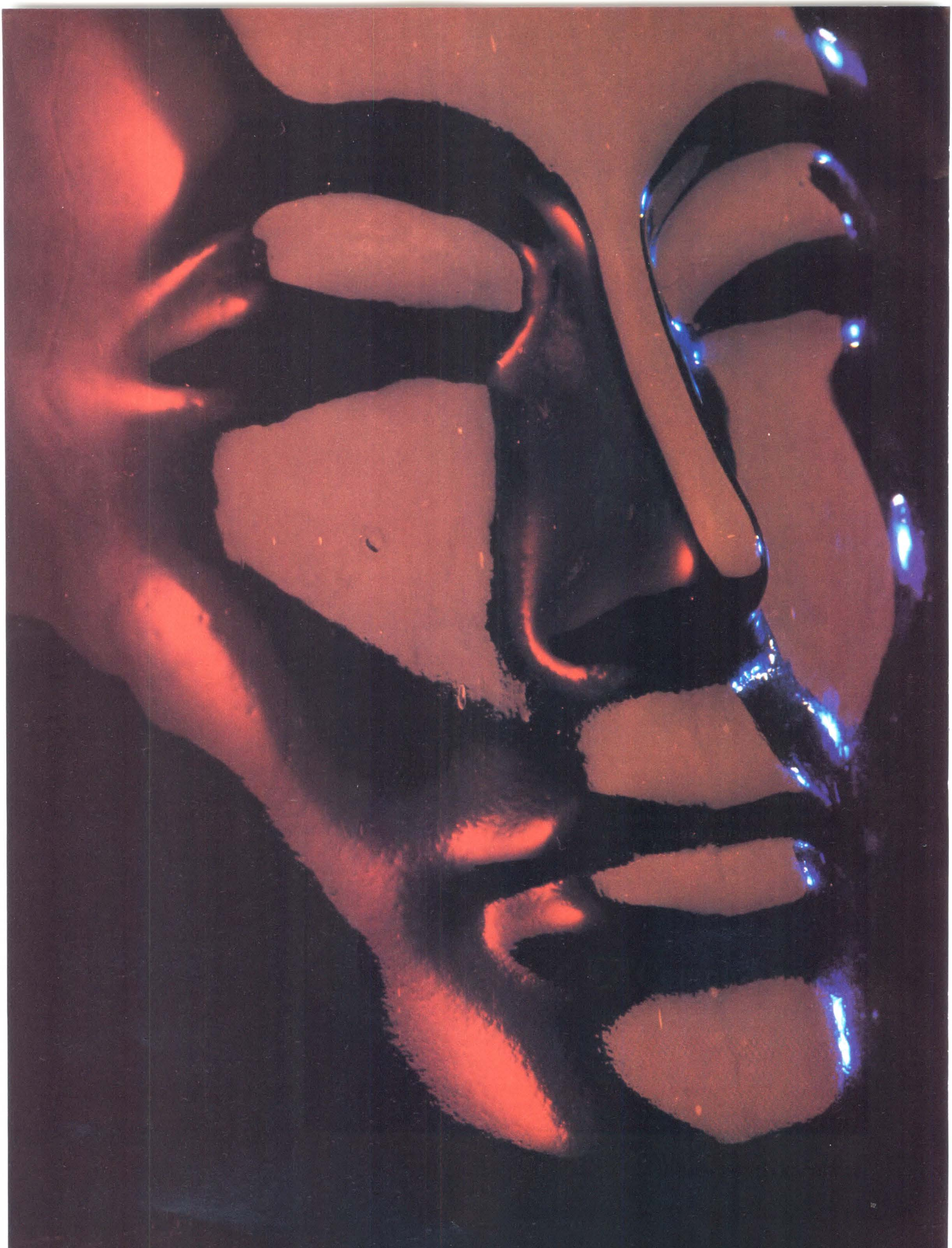

PARALLEL PROCESSING SYSTEMS:

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NOW AN OPTION FOR VMS INSTALLATIONS

BY CLAUD TEETER
ELXSI

CRADOC BAGSHAW

Until quite recently, machines with parallel and vector processing architectures haven't been an option for VMS installations. These machines, sometimes called minisupercomputers, are usually geared to running applications under UNIX or proprietary operating systems.

This is changing, however, as some minisupercomputer manufacturers are providing VMS emulation in addition to their standard operating system offerings. It's now possible to link these machines to existing VAX computers using DECnet, thereby adding an enormous amount of processing power in comparatively little floorspace.

Is parallel processing in your future? Some of the best candidates are installations where throughput is an issue—the speed at which a job runs is directly related to productivity and, hence, to profits.

Consider, for example, an aerospace firm with 30 VAXes connected via DECnet throughout the state. When the company expands the network, it habitually thinks in terms of adding VAXclusters. It might first purchase a VAX 8700 for documentation control on a new project, then cluster additional machines for bill of materials tracking, circuit simulations, and other related applications.

Although this cluster enables the network to accommodate more users and applications, it doesn't solve the fundamental problem of throughput for the engineering team, whose productivity is directly related to the number of simulations it runs in one day. This group needs more MIPS (millions of instructions per sec.) than a VAX can provide without losing VMS compatibility. Here, a minisupercomputer may prove a better choice than a cluster.

It's essential, though, that this machine be able to emulate VMS. Most Digital Equipment Corp. shops have made an enormous investment in their VMS applications, enlisting generations of programmers to improve the code's performance. Not only are these applications written under VMS, but they may use VMS command files and directory structures, as well as assume Digital's filename conventions.

The challenge here is to bring in a nonDigital minisupercomputer to increase throughput with minimal disruption and not break the budget. And the best way to do that is to stay as compatible as possible with VMS and DECnet.

Some History

Minisupercomputers make use of parallel processing, a technique used for adding MIPS by allocating portions of the application code to multiple processors that work simultaneously but independently (Figure 1).

Hardware manufacturers use this technique to increase the performance of a given chip technology—be it complementary metal oxide semiconductor (CMOS), emitter coupled logic (ECL), or gallium arsenide—when that technology is already performing cost-effectively. Parallel processing is especially appealing because it permits a vendor to further capitalize on the research and development costs of a proprietary architecture.

Multiprocessor machines designed for parallel processing are not new, but have grown more popular in recent years. One of the first designs was the Illiac IV, a one-of-a-kind system developed in the early 1970s. One of the first commercial parallel processing computers was unveiled by Elxsi (San Jose, Calif.) in 1983.

Since then, a number of vendors have entered the market—including Concurrent Computer Corp. (Oceanport, N.J.) with a 12-processor machine and Sequent Computer Systems Inc. (Beaverton, Ore.) with a 32-processor system using off-the-shelf CPUs. The Cray Research (Minneapolis, Minn.) XMP is a four-processor unit and the forthcoming Cray YMP is rumored to contain 16 CPUs.

Digital gingerly entered the parallel processing market with the 8800 and VAX-11/782—both shared-memory dual-processor machines—and the VAX-11/784—a four-processor system—but none of these really took off as a parallel processing computer.

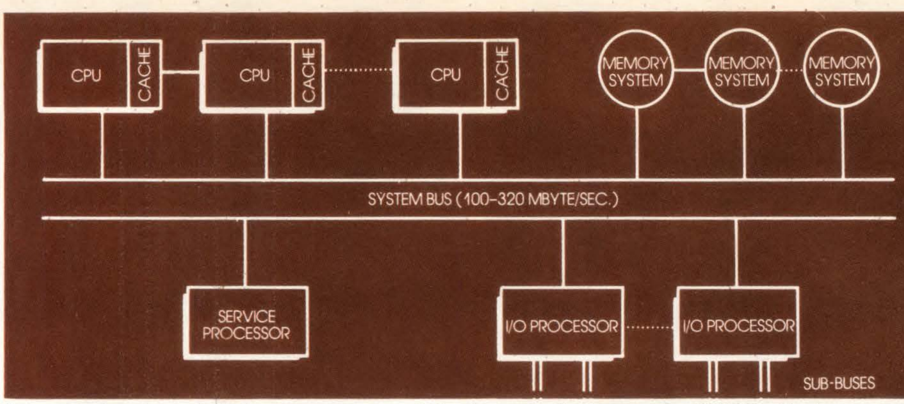

Figure 1—*A parallel processing architecture includes a set of CPUs that access common memory and subsystems over a high speed system bus. A service processor is sometimes added to provide diagnostics.*

Minisupers And VAXes

The most obvious difference between a minisupercomputer and a uniprocessor VAX is processing speed. Absolute benchmarks are hard to come by, but in one test Elxsi's model 6420, equipped with three CPUs, tested 60% faster than a VAX 8700—the fastest Digital uniprocessor. Generally, the speed difference between the two architectures depends on the machines and how much code is running in parallel.

This is not to say that a VAXcluster is incapable of handling parallel processing applications—only that it is an imperfect environment to do so. The best architecture for parallel processing is a "dense" one—where the CPUs share the same memory, talk on the same bus, and address the same storage media and terminals.

The VAXcluster resembles a parallel approach in the sense that there are multiple CPUs handling various tasks, but communication delays can cause problems when partitioning a single task across multiple processors.

CPUs on parallel processing machines communicate at speeds ranging from 100 to 320 Mbyte/sec. In contrast, the cluster bus speed is less than 9 Mbyte/sec.—insufficient to keep up with the numerical results produced by the processors, hence the cluster bus is a bottleneck. The processors themselves are relatively powerful, but are handicapped in a parallel application because of the low data interchange rate between them.

Also, although main memory may be made accessible to all processors, this requires programmer intervention. The process is slow because data must be deliberately copied from one computer to another.

The lack of load balancing on the VAX is also a disadvantage. On a cluster, once a task starts on a CPU, it must stay there until it's completed. Although the operating system can allocate which CPU will start the task, this approach isn't as flexible as one in which a job can be shifted during the run.

Downtime

Another distinction between a VAXcluster and a parallel system is how users are affected by downtime. Here, the cluster has the upper hand in that if a VAX halts, the rest of the cluster continues to run. If the minisupercomputer halts, everyone on the node halts with it.

Minisupercomputer vendors have compensated by building redundancy into their machines. Dual power supplies are often used. On some machines, a malfunctioning processor can be deconfigured, enabling the machine to run without it. This is possible because no one user is specifically assigned to any given processor. Of course, the machine won't run at full performance; but, unlike the cluster, all users will still have use of the system.

Multiple Operating Systems

Another advantage of some minisupercomputers versus a VAXcluster is the ability to run multiple operating systems in parallel. The choice between VMS and Ultrix has become a dilemma in the VAX environment. Ordinarily, a VMS user attempting to implement UNIX would have to run interactive programs under UNIX during the day, and large production programs under VMS at night. The alternative is to purchase a second computer dedicated to UNIX.

A minisupercomputer may allow an installation to "vote with its feet" by running both operating systems concurrently on the same machine—watching to see which operating system eventually dominates. Moreover, a parallel environment can make the transition smooth. Users can alternate between operating systems with a few key strokes, and with only one set of disk drives and other subsystems required. Moreover, the coexistence of two operating systems allows programs to be converted at leisure, rather than as a rush project.

Evaluating Minisupercomputers

In evaluating minisupercomputers, several factors must be taken into account, including the type of architecture, the number of processors needed, and how VMS is emulated.

It's important to recognize the two different architectures in which parallelism is achieved—each of them ap-

CPUs	Time to execute	Code running in serial	Code running in parallel
1	140	140	—
2	80	20	60-60
3	60	20	40-40-40
4	50	20	30-30-30-30
5	44	20	24-24-24-24-24
6	40	20	20-20-20-20-20-20

(a)

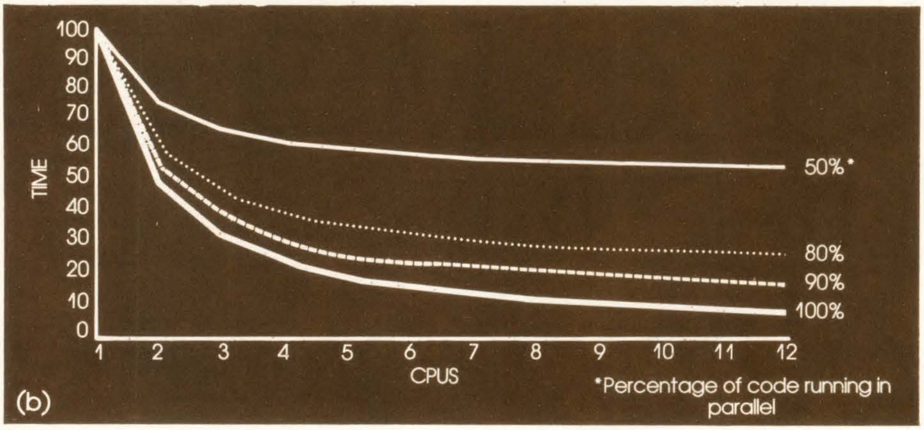

Figure 2—(a) *Additional processors bring diminishing returns for a given 140-min. task.* (b) *The fall-off point varies, depending on what percentage of the code is running in parallel.*

propriate for different applications.

The first is vector processing, which uses a set of chips to run a single type of operation in lock-step. For example, multiple adders might be used to execute add instructions four-at-a-time instead of one-at-a-time. Vector processing is usually applied to arithmetic operations. It's always used to attack a single type of operation within the code, rather than large chunks of code.

As a result, vector processing is especially effective for solving orderly problems in which number crunching is extensive and predictable: the simulation of air flow in a room, for example. It isn't as effective for solving scalar-type problems, in which an intermediate result is needed to determine which operation to perform next.

The alternative to vector processing is parallel processing. This architecture uses a paired set of CPUs capable of executing any portion of the code. This approach is more expensive than vector processing, but has the advantage of running independent streams of instructions. You may also allocate each CPU to a separate application or, on some machines, to an entirely different operating system.

You should note that both vector

and parallel processing require modification of the application code. This is necessary to direct which instructions are to be performed by which processor.

It's several orders of magnitude more difficult to vectorize an application than to parallelize it. Vectorization takes place at a very low level within the code. To be successful, the technique must be used everywhere it can—and this may ultimately require the modification of thousands of lines of code. Not surprisingly, vendors have developed vectorization software tools to help automate the process.

With parallel processing, the modification takes place at a much higher iterative level within the application—you work at the subroutine level, not the instruction level. Consequently, you can achieve substantial parallel processing with comparatively little work. Unlike vectorization, however, the most effective parallelization is performed manually.

To decide the type of architecture to adopt, you should consider whether your applications will be primarily vector or scalar. If the answer is not obvious at the outset, you might consider a computer equipped to handle both.

Number Of Processors

Virtually all parallel computers enable you to start with a small number of CPUs and expand as necessary. But more CPUs are not necessarily better.

First of all, in order to use all the computing resources of your machine, you must be able to allocate your code so that each CPU gets a share. This inevitably means additional programming to devise ever-more-inspired algorithms.

But beyond that, the greatest gains in execution speed take place when the first two or three CPUs are brought online (Figure 2). Consider, for example, a program that takes 140 min. to run on a single processor. If 120 min. worth of the code were to run on two processors, the runtime would be reduced to about 80 min. (assuming no additional overhead). If the same portion of code is run over three processors, the runtime would be 60 min. A fourth processor would reduce the time to 50 min., and so on.

VMS Language Extensions

Besides converting your existing applications, you will have to adapt them for a third party compiler. The effort required varies extensively from one installation to the next.

Digital is reasonable about observing standards in its VMS compilers, but like most vendors, it offers numerous extensions as well. Many developers who believe they will be using VMS forever will take full advantage of these extensions, thereby locking themselves into the Digital environment.

FORTRAN applications are the least troublesome to convert, usually. Because FORTRAN is the most dominant language for engineering/scientific applications, most minisupercomputer vendors have implemented as many VMS FORTRAN extensions as possible.

Other languages may pose more of a problem. For example, although there is an ANSI C standard, C implementations vary more widely than FORTRAN implementations. Furthermore, C programmers seem more likely to write machine-specific code—developers who know, for example, the width of VAX registers are likely to use that knowledge in writing efficient, machine-specific code.

Of course, machine-specific code can be written in any language. For example, many developers write exception handlers in FORTRAN—code that deals with floating point and address-

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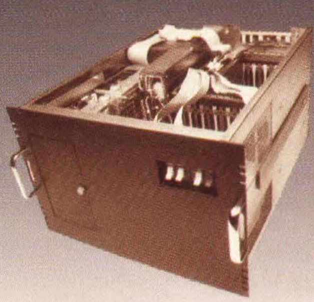

SA-H149

SA-H152

ing violations. These routines, in effect, disassemble an instruction to see what went wrong. Obviously, if a different instruction set is resident on the computer, that module will be useless.

The worst conversion problems are those applications written in one of Digital's proprietary languages—such as BLISS, an operating system language, or Macro, Digital's assembly language. Here, third party compilers are scarce or nonexistent. The same holds true for applications based on Digital's layered products, including its proprietary database package. Applications using these development products should remain on VMS.

When bringing any third party system into a Digital environment, you should consider how extensively you are locked into the VAX; you must decide how important your nonFORTRAN applications are to your normal operation, and whether you can port enough of your bread-and-butter applications to the new machine to justify its cost.

Emulating VMS

You should also consider how a given minisupercomputer emulates VMS. There are two general approaches: run an emulation module over UNIX or add VMS extensions to a proprietary operating system—preferably one that already resembles VMS.

Placing a VMS emulator over UNIX is expensive in terms of compute cycles. The problem is that VMS and UNIX are very different operating systems. For example, the UNIX file system is very spare, whereas the VMS file system is baroque in its syntax—making use of dots, semicolons, and version IDs.

UNIX has relatively poor recovery features compared to VMS, hence a VMS recovery facility must be added on top. Another big difference: VMS is built to handle streams of records while UNIX handles streams of bytes, allowing the application to determine what constitutes a record.

You should also look at the depth of a VMS emulation. For example, a third party system should provide an emulation of the Digital Command Language (DCL). DCL is a programming language that uses other programs as macros to create a large functioning application. It controls such things as the names of the data files an application handles and the way information is passed from one program to another. A good DCL emulation should support symbols and expressions, logical names, command syntax, filenames, and version IDs.

A robust implementation of VMS system services and the runtime library is one of the most important factors for integrating a third party minisupercomputer into the Digital environment. These systems should be especially welcome where VAX-based applications are large, compute-intensive, and heavily used. For such installations, the cost advantages of parallel processing are too great to ignore. ■

Was the information in this article helpful to you in the performance of your assigned responsibilities?

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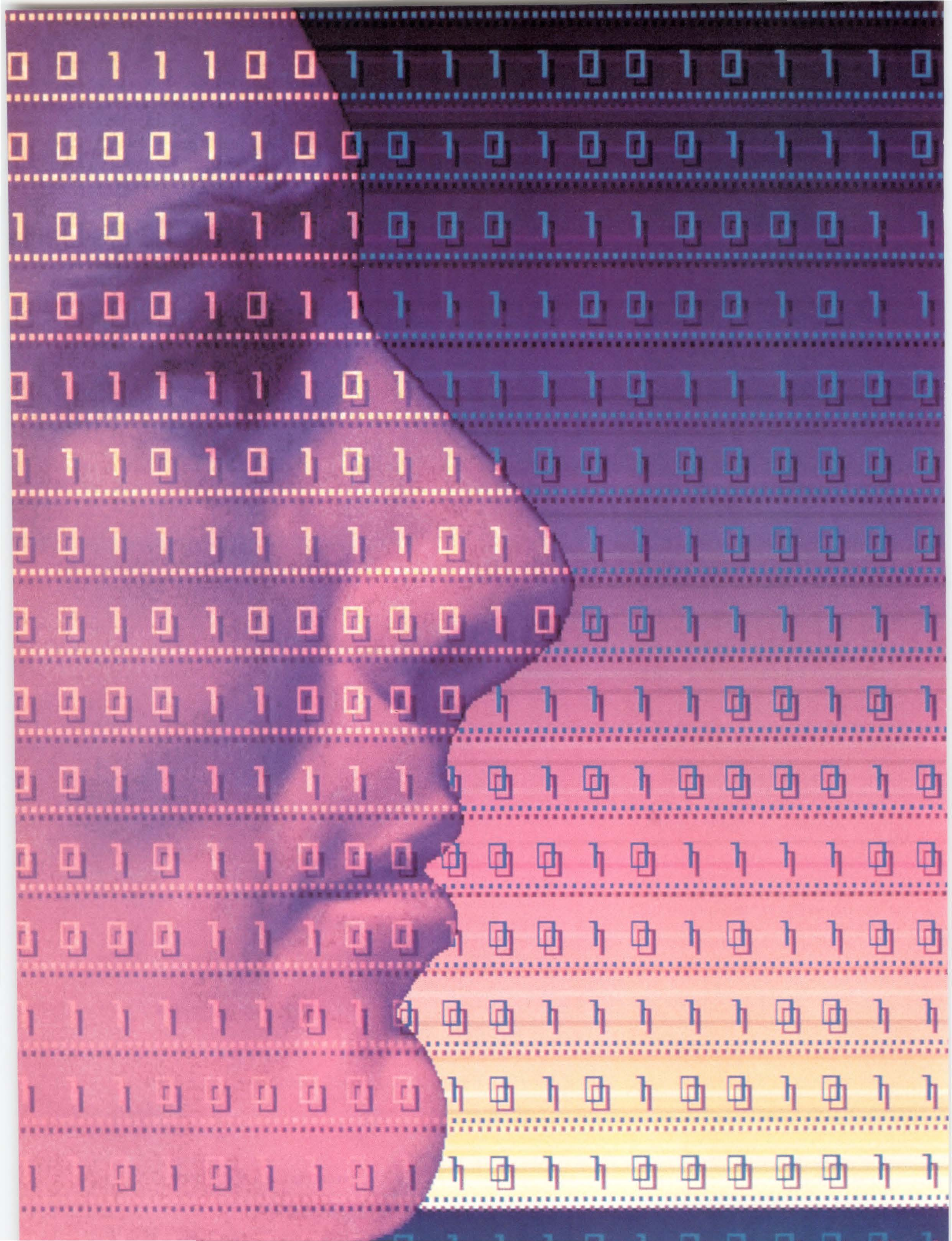
Claud Teeter, manager of software development for Elxsi (San Jose, Calif.), holds a B.S. in computer science and an M.S. in computer engineering from North Carolina State University. He was the engineering manager on the development of EMS, the company's VMS implementation.



HOW TO ADD MORE MIPS TO YOUR VAX

SUPERVAX:

SUPERCOMPUTING IN THE DIGITAL ENVIRONMENT

It's a decision that more companies are now facing—which is better for scientific and engineering processing, a superminicomputer or one of the minisupercomputers that exist on the market today? A common response has been to replace the superminicomputer environment with the more powerful standalone minisupercomputer. However, there is another response that many users are considering—don't replace that VAX superminicomputer; instead, upgrade it to minisupercomputer performance.

Which of the three—superminicomputer, minisupercomputer, or a combination of both—is the best choice? The answer to that question is becoming more apparent: It depends on what the system will be used for. With highly interactive applications, as well as small scientific jobs, the general-purpose superminicomputer continues to provide an adequate and cost-effective solution. For high performance processing of large problems, such as computational physics and finite element analysis, scientific minisupercomputers provide a better and faster solution—solving in hours problems that can take days or weeks on superminicomputers. If both high performance scientific computing and maintaining an interactive Digital Equipment Corp. applications environment are important, then the combination of an interactive VAX superminicomputer front-ending a minisupercomputer is the most viable option.

by George O'Leary, Ph.D.
Floating Point Systems Inc.

The selection process for a superminicomputer is relatively straightforward. For more than 10 yrs., Digital has set the pace in terms of performance, functionality, and, more recently, compatibility throughout the industry. Today, as a result of its successful efforts, the Digital environment permeates the scientific workplace and is the de facto standard for a significant portion of all scientific processing. For the superminicomputer route, then, the choice is clear—Digital.

Scientific minisupercomputing, on the other hand, grew out of a different tradition, one requiring the processing of computationally intense, large-scale programs. It wasn't until the mid-70s, when the first commercial array processor was introduced, that many of these computationally intense scientific applications could be economically addressed. By the end of that decade, Seymour Cray had applied the "attached" processor concept to produce the world's most powerful computer, the Cray I supercomputer. In many cases, users selected a general-purpose computer, the VAX, as the interactive front end to their systems.

It is this need for scientists to access huge amounts of processing power and memory to economically run large-scale programs that continues to drive scientific minisupercomputing. The move toward the supercomputing concept focused on programs whose demand for processing power outstripped the most powerful mainframes of the day (i.e., IBM 308x and CDC Cyber), and whose processing and memory demands continue to outstrip the most powerful computers used today, such as the IBM 3090.

Minisupercomputers now offer affordable performance and memory capacity on a scale that's sufficient for many scientific applications—typically minisupercomputers represent one-fourth of the performance of a Cray at one-tenth the price. But the user needs to consider the pros and cons of a standalone processor such as those provided by Convex Computer Corp. (Richardson, Texas), Elxsi (San Jose, Calif.), and Alliant Computer Systems Corp. (Littleton, Mass.), or an attached minisupercomputer such as those offered by Floating Point Systems—FPS (Portland, Ore.) or Scientific Computer Systems Corp.—SCS (Wilsonville, Ore.). Attached minisupercomputers are high performance, optimized number crunchers driven by an interactive front end. At the minisupercomputer level, vendors like FPS and SCS employ this architectural approach. At the supercomputer level, Cray does.

In most cases, the typical scientific or technical minisupercomputer purchaser isn't a computer specialist, but a physicist, chemist, or engineer looking

DIGITAL ART/WEST LIGHT

for the best tool(s) to solve large-scale mathematical problems. Increasingly, the problems that this demanding set of users is asking to be solved are moving from static to dynamic modeling, from 2D to 3D, from linear to nonlinear, and combinations of these, in many instances. The degree of accuracy required is increasing to the point where 64-bit precision is mandatory, and the amount of compute effort increases exponentially as the complexity of these scientific problems expands. The purpose, then, for buying these machines is performance, accuracy, and the ability to solve large, complex problems.

The environment where superminicomputers are sufficient for small-scale scientific processing has already been defined—by Digital. What we have, then, is a basic user decision whether to extend and increase the performance of his existing Digital investment or to replace it.

The standalone minisupercomputing approach offered by Convex and Alliant provides certain "DEC-like" features, but, in general, represents a departure from a true Digital environment. Users wishing to have a more independent approach to their scientific processing will find the Alliant and Convex machines offer certain advantages. Other users who have substantial investments, both tangible and intangible, in their Digital shops find that expanding their existing VAX by attaching a minisupercomputer provides all the benefits of the familiar Digital environment, while offering the significant performance increases required of an optimized scientific processor. In assessing these two approaches to supercomputing, there are three specific areas that a user needs to thoroughly understand: economics, technical issues, and compatibility.

Economic Considerations

The VAX has significantly affected the scientific, technical, and engineering computing environments. There are more than 100,000 VAXes currently installed. And there are hundreds of applications written for them, covering everything from finite element analysis and computational fluid dynamics to arbitrage modeling. Billions of program lines have been written for these applications. Training, documentation, and service for VAXes are well-established, competent, and thorough. More than half of all VAXes are dedicated to engineering and scientific usage. In short, Digital has set the computing standard for science and engineering.

With the range of investment in a VAX running up to $400,000, one of the economic issues purchasers must consider is retaining that investment—not just in the hardware, but in the code they've developed, their training investment, and the security of a large service base.

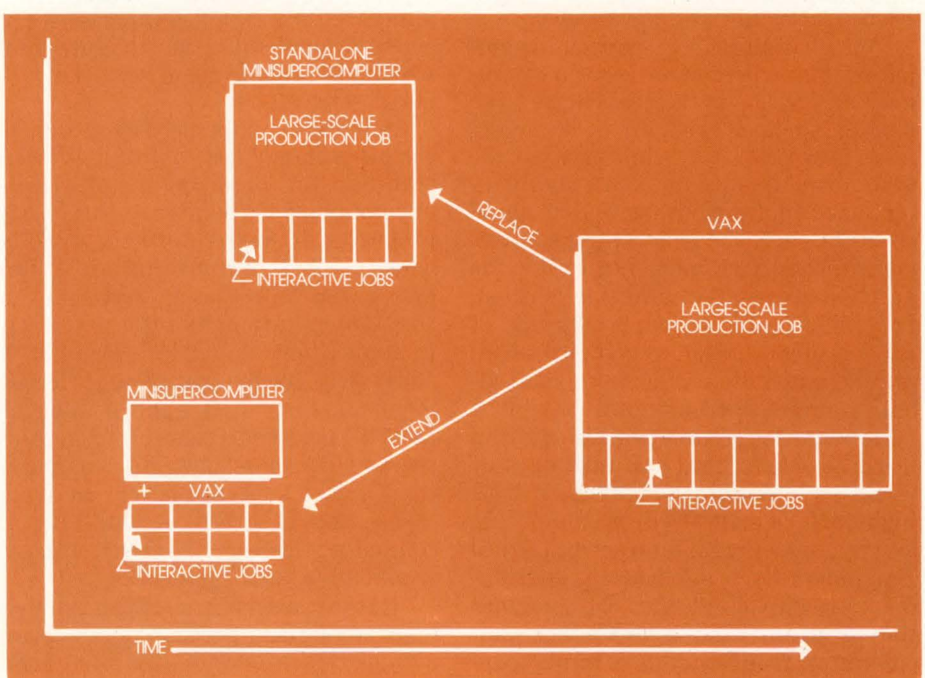
Where users need more computing power than their existing system can supply, they are faced with a dilemma: Can they give up their existing computer and the job it's doing? Because computers aren't typically taken out of service until their maintenance costs exceed their replacement costs, this means that they add another computer. When users realize this, they have two choices: either add another standalone computer or add a compute-intensive processor to their existing VAX.

VAX users looking at the two higher performance alternatives—standalone or attached—must carefully determine the specific area requiring increased performance. While many commercial applications require the capacity to support more users, most scientific and engineering applications need faster single-job performance and turnaround. In the latter case, interactive user support is often adequate on the VAX, so there's technically no need to expand or replace it with another high performance standalone system. What is typically required, however, is a boost in the performance of large compute-bound production jobs and the elimination of any degraded interactive performance on the VAX caused by a large production job. In this instance, it's desirable to supplement the performance of only the number-crunching side of the VAX.

Standalone minisupercomputers must spend resources to complete both the interactive and large-scale functions, while a VAX that's front-ending a minisupercomputer separates the interactive and compute-intensive tasks. The latter approach allows the full resources of the attached minisupercomputer to be applied to maximize its machines for large-scale production jobs, including I/O optimization, improving CPU utilization, and developing application expertise. A performance improvement factor of 10 or better can be fully realized in this mode since the attached processor is dedicated to, and optimized for, number crunching. If the entire VAX system, by contrast, is replaced with a single standalone processor of 10 times the compute performance, such a system could not achieve the same throughput—its performance will be impeded by the need to support the interactive users and the overhead of switching between large-scale production and interactive processing.

Technical Issues

Scalar processes are frequently used by general-purpose systems that process computations one at a time.



Bringing supercomputer power into the VAX environment—*There are two paths to supercomputer performance beyond that available for a VAX. One approach is to replace the VAX with a general-purpose, standalone minisupercomputer that attempts to handle both the interactive and large-scale production jobs. The second is to let the VAX continue to handle the interactive part of the workload while front-ending a minisupercomputer for large-scale production jobs.*

While this is the simplest approach to program execution, it's the least efficient. Scalar processes are evident in virtually all scientific and engineering applications and, in fact, are dominant. Scalar computations are usually random and unpredictable, and, therefore, performed sequentially. The most notable scalar machines include the VAX and IBM's 43xx and 3080 Series.

Vector processing utilizes a repetitive process, or "formula," on an entire sequence of numbers (a vector), making programs execute quickly and efficiently. Many scientific calculations consist of mathematical operations on ordered sets of data, often vectors and matrices. Typically, vector processing is important for applications found in mechanical engineering, computational chemistry, and physics. Unlike the scalar processes, vector computations are repetitive and their performance can be improved by the use of specialized hardware.

Minisupercomputers are primarily vector processors. Unfortunately, to use a vector architecture efficiently, the programmer must create vector structure in the code so that the compiler can find it. This task, called vectorization, is tedious, error-prone, and requires advanced programming skills. The programmer needs to know efficient vector algorithms for the problems at hand and must understand the target vector architecture in detail. Debugging on a vector processor presents further challenges for the programmer. Vectorizing compilers are currently becoming available, but suffer from limitations in their ability to recognize vector constructs and introduce significant compilation overhead.

Scalar machines like the VAX can best handle vector processing by front-ending minisupercomputers. Vector-oriented machines handle scalar processing within their vector architecture, but at a reduced level of performance.

Unfortunately, real world computations aren't purely vector or scalar, and the requirement for vector/scalar balance has been recognized since 1967, when G.M. Amdahl postulated a mathematical relation commonly known as Amdahl's Law that limits the payoff from vectorizations (see sidebar, "Scalar/Vector Processing And Amdahl's Law"). Amdahl's Law computes the effective speed of a vector processor as defined by three parameters: the computer's scalar speed, its vector speed, and the percentage of the program that is vectorized.

Multiuser And Multitasking Needs

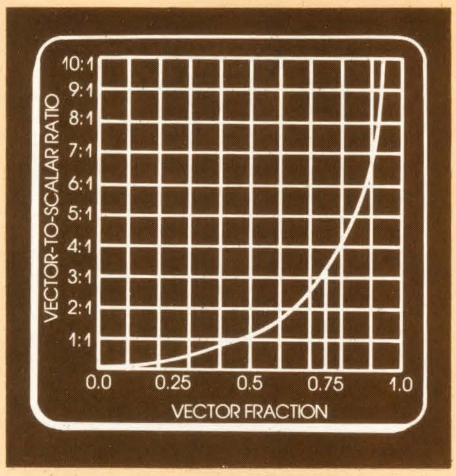
When considering the replacement of a compute-bound machine, many users assume that they simply need the next higher level of performance to run more of the same types of programs, to run the same number of programs faster, or to run the same programs with larger data sets. They also assume that a more powerful machine will accommodate more users doing the same jobs and still provide room for extremely large programs. These users must contend with the trade-offs between interactive user response time and the throughput of large production jobs. The dilemma here is that one always impacts the other. If the system is tuned for interactive response time, production jobs suffer. Conversely, if the system is tuned for the throughput of large production jobs, response time for interactive users is impacted.

This isn't a dilemma for those users who have configured a system in which a separate, interactive front-end processor such as the VAX is coupled with a dedicated processor, such as a minisupercomputer, optimized for large-scale production jobs. In this environment, the user gets the best of both worlds,

Scalar/Vector Processing And Amdahl's Law

Scalar processing has dominated engineering and scientific computing. A scalar machine has few parallel features, and scalar programs have little or no structure. Addressing is random across the real or virtual address space, and the runtime mix of floating point, integer, Boolean, I/O, and branching operations cannot be predicted at compile time. Scalar processing is dominant for a variety of reasons:

- Most applications are written in FORTRAN, a scalar language with no capability to express vector constructs.
- Scalar machines are the least expensive to design, manufacture, and maintain.
- Compilers for scalar machines are the easiest to write and run the fastest.
- Scalar application codes are the most efficient on scalar machines.
- Scalar application codes are the easiest to write and debug.



The optimal vector-to-scalar ratio—*Because the payoff of vectorized architectures is limited by Amdahl's Law, it's appropriate to consider a mixed vector/scalar architecture for optimal minisupercomputer performance. Amdahl implied that vector/scalar performance should be 3:1.*

- The bulk of computer science theory applies to designing efficient algorithms for scalar machines.

Although scalar processing dominates, scientific or engineering codes often contain operations on arrays of data, such as vectors and matrices. In contrast to scalar processing, a number of approaches, broadly referred to as parallel processing, can be built into a machine for efficient vector processing. Vector processing features highly structured program codes. Addressing is regular, not random, and a compiler can usually predict the runtime behavior of the program well enough to create optimum code for a parallel architecture.

The principal parallel approaches to vector processing used in minisupercomputers are:

- parallel pipelined microcoded scalar architecture (FPS M64)
- vector processors (the Convex C-1), and
- parallel vector processors (the Alliant FX/8). *—G.O.*

optimum interactive response time out of a machine designed specifically for that function, and maximum performance on large-scale production jobs from another machine specifically designed for large-scale production jobs.

Under multiuser and multitasking conditions, standalone machine configurations may outperform sequential batch processing for some applications; for this to be true, all multiple jobs must be small enough to stay within the machine's physical memory. Once a virtual memory machine must page to memory in order to accommodate a large program, the batch processing approach offers faster results. In scientific and engineering applications very large programs are generally the rule, not the exception.

Compatibility

As previously noted, the majority of small-scale scientific/engineering computing is performed on VAXes. Consequently, prospective buyers of a minisupercomputer consider VAX compatibility to be a major concern. Incompatibility can have significant implications in terms of installation/support costs and user productivity. In the standalone environment, existing VAX FORTRAN programs, in most cases created originally in VMS environments, must be ported to a different FORTRAN compiler running a different operating system, usually UNIX.

The process of program conversion is expensive (typically $1/10 lines of code), not to mention the learning-curve costs incurred by users as they adapt to a new system. User productivity is reduced and project schedules may slip as users learn to work with a different computer system and familiarize themselves with different documentation, procedures, compiler, and command language. Some vendors have attempted to minimize the impact of their computer's incompatibility with the VAX by developing some VMS-like commands and compiler extensions. Alternatively, the existing VAX owner can select a processor to attach to his VAX in a manner that is transparent to the users and, thereby, access a large body of applications software already ported to the Digital environment. Thus, users can continue to operate in their familiar VMS environment, but experience the benefits of dramatically higher performance on the attached minisupercomputer. This is the ultimate in compatibility, short of executing on the VAX itself.

When considering the next level of computing performance beyond superminicomputing, the answer at first may seem obvious—replace the VAX with a more powerful, standalone minisupercomputer. That's at least until one considers the economic, technical, and compatibility dimensions of the decision. When these issues are considered, the decision process becomes more complicated. But a thorough understanding of the applications is the critical issue for making the right choice. And in many instances, that choice can preserve the Digital environment and provide minisupercomputing power. ■

Was the information in this article helpful to you in the performance of your assigned responsibilities?

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George O'Leary, Ph.D., president and chief operating officer for Floating Point Systems Inc. (Portland, Ore.), holds a Ph.D. from Yale University. O'Leary designed the company's array processor.

COMPUTER INTEGRATED MANUFACTURING: WILL IT EVER REALIZE ITS POTENTIAL?

ONE ASPECT OF CIM INTEGRATION IS SELECTING SYSTEM COMPONENTS USING A LONG-TERM STRATEGY

BY JIM MEADE

JOE CRABTREE ILLUSTRATIONS

"I don't know of anybody tying CAD systems into manufacturing really well," says a blunt Mark Wise, president of Alpha II Systems. Tying computer aided design (CAD) to computer aided manufacturing (CAM) is the latest trend in computer integrated manufacturing (CIM). And CIM alone is a big trend in the computer marketplace. Though experts debate the meaning of CIM, it is, in simplest terms, a single network and uniform information system connecting the engineering workstation with the manufacturing floor and, ultimately, with the numerically controlled machines themselves (Figure 1).

In fact, depending on who is defining it, CIM may integrate almost everything in manufacturing, production, design, operations, and—as Digital Equipment Corp. and others see it—sales and marketing on one end and distribution on the other.

Potential rewards from CIM are almost unlimited. Experts say that CIM can change the way the world does business. A Digital white paper theorizes that Digital may have risen from its 1984 slump to become the darling of Wall Street, in large part, thanks to CIM—not the CIM it has marketed, but the CIM it has implemented internally.

There are even grander possibilities for CIM. Japanese manufacturers are not utilizing CIM; at least not using the computer, points out Jay Hay, vice president of Structural Dynamics Research Corp. (SDRC), computer aided engineering (CAE) specialists. True *computer* integrated manufacturing could be the basis for an American resurgence against the Japanese and the Europeans. It could even be, in what seems a highly unlikely dream at the moment, the basis for General Motors once again taking the lead against Toyota.

Another measure of the nationwide effects of CIM, Wise of Alpha II believes, is that the computer slump of 1985 may have been the result of department heads insisting that CIM purchases be cost-justified. The slump ended as equipment buyers could, in fact, cost-justify CIM acquisitions.

ADMINISTRATIVE

The promise and potential of CIM, then, are almost unlimited. Analysts believe it could change the economy of a company, a nation, or the world. It could. But, for the most part, it hasn't. Not yet.

The Problem With CIM

What is the problem? Overall, the difficulty with CIM is the sheer magnitude of the undertaking. "If CIM hasn't realized its promise yet, to a large degree it's probably because CIM is a daunting task," explains Dennis Freeman of MCBA Inc., producers of modular software for manufacturing.

"The task is too big for any one company," concurs Ron Hank of Cincom Systems, a Digital marketing partner. "It's too big even for IBM or Digital." Nor does Digital dispute the conclusion. Says Jack Conaway, manager of CIM planning and architecture at Digital, "We don't believe that any one company can deliver CIM in the sense that we mean it; namely, total enterprise integration. It has to be very much a partnership integration. Digital can take a major role, but we have to subcontract out pieces to our partners."

Implementers are not altogether certain they have the entire picture with CIM. Says longtime manufacturing consultant Daniel Murray of R. Michael Donovan Inc. (Natick, Mass.), "Each year as we have become smarter, we have found that we always left something out the year before. Therefore, MRP [material requirements planning] became MRP II, which became JIT [just in time], which evolved into CIM, which is becoming TQC [total quality control]. And we may not be at the end yet."

SDRC's Hay points out that CIM is not only a massive undertaking, it re-

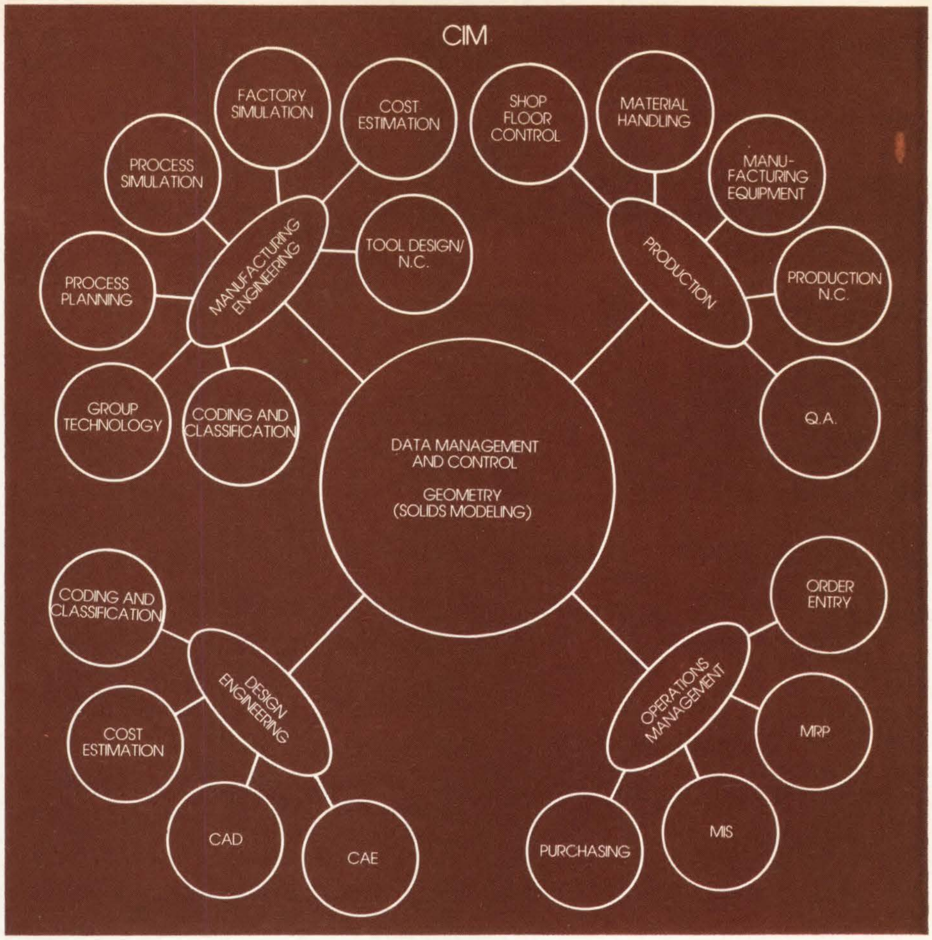
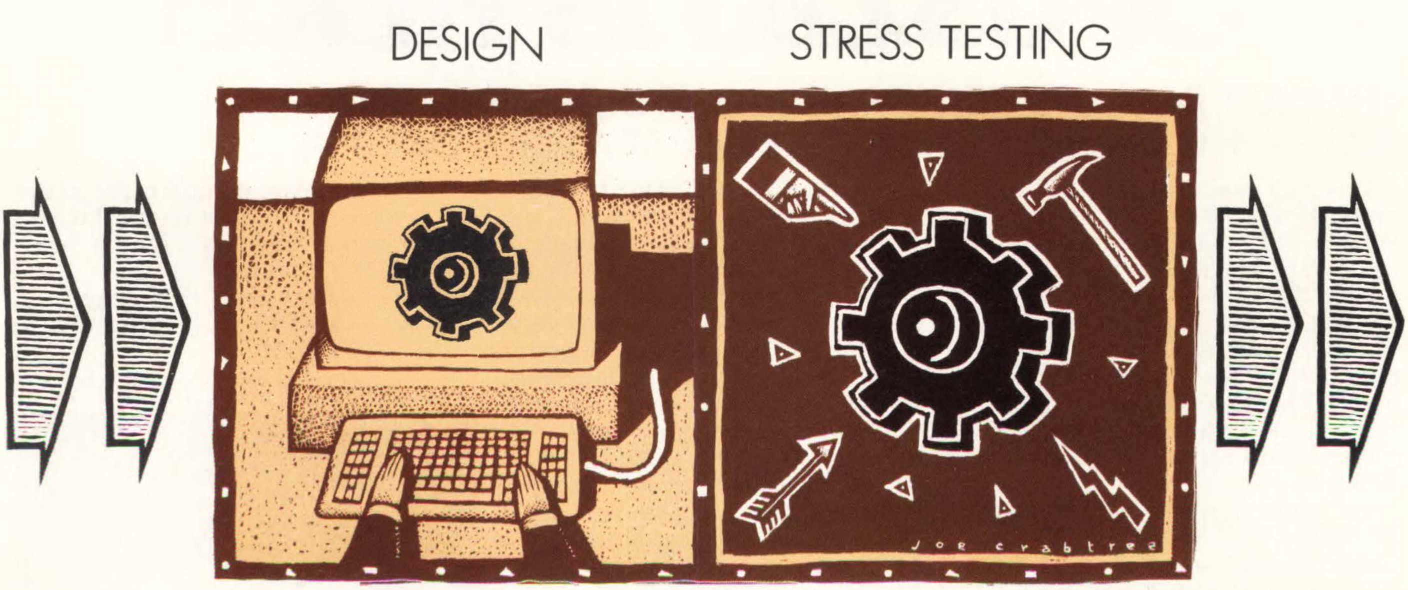


Figure 1—*Depending on who is defining it, CIM may integrate almost everything in manufacturing, production, design, and operations.*

quires massive business reorganization to carry it out. "It's hard to reorganize something if you don't understand what you've got," he adds. "And it's not very well understood how all this fits together."

Consider, for instance, the need for design engineering and manufacturing engineering to integrate their two functions. "Engineering and manufacturing have, in the past, remained fairly separated," Hay notes. "The standing joke has been that engineering will take 2-3 yrs. to develop a design, then throw it over the wall to manufacturing, who will then redesign it so they can make it."

It's one thing, then, to talk about tying CAD systems to manufacturing, quite another actually to do it. Alpha



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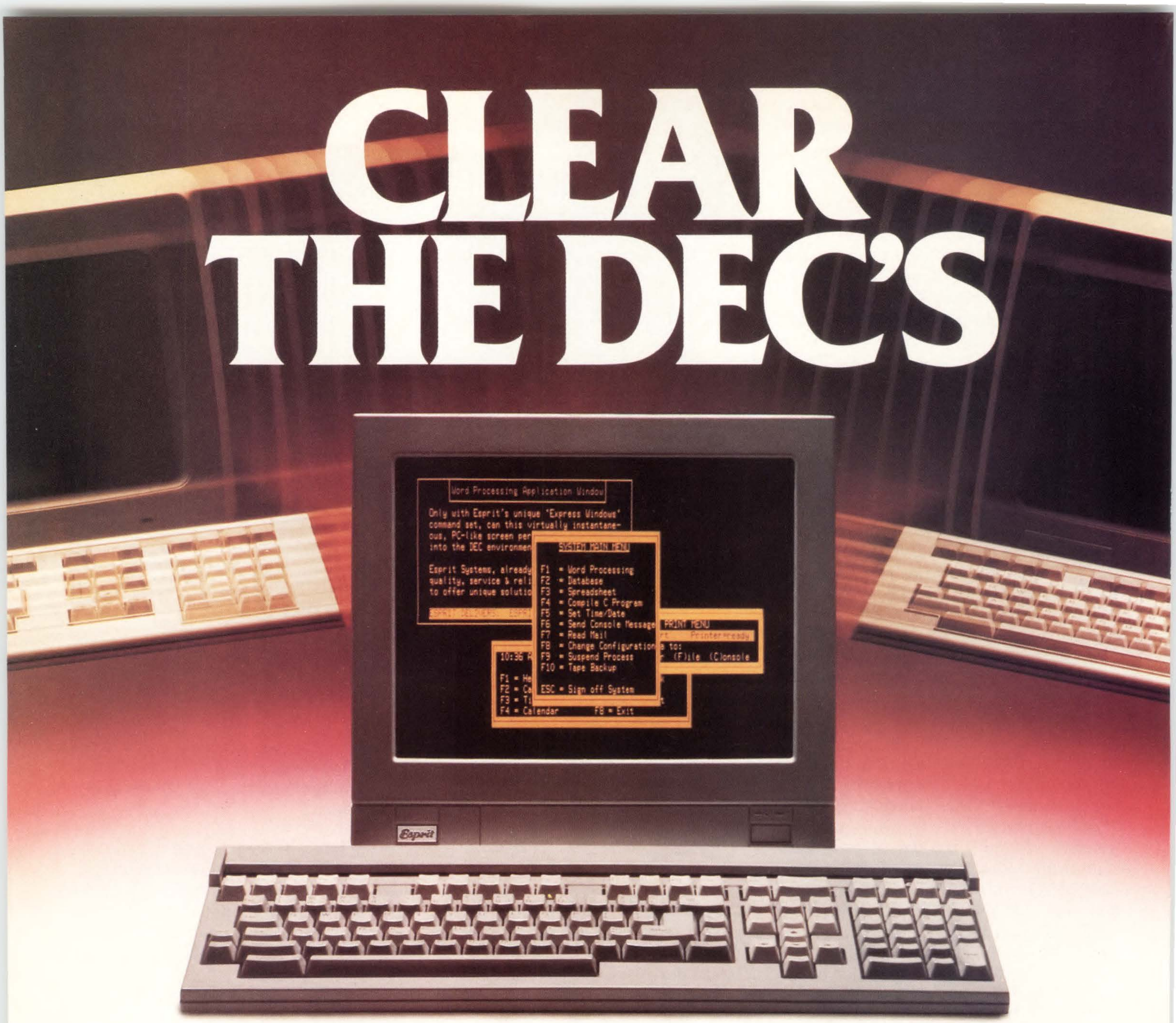

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Esprit Systems, Inc., 100 Marcus Dr., Melville, NY 11747

II's Wise, who has yet to see anyone achieve the blend successfully, explains why the appearance of successful CIM is rarely the reality.

"I was at the AMF show in Chicago in June. On display at one booth was an impressive example of CIM—circuit boards being designed on a CAD workstation, then manufactured directly from those designs without human intervention." If you were not, like Wise, a player in the CIM game yourself, you might have thought that the future had arrived.

"The fact was, they had a limited product line that they were building—one circuit board, with one option. If you take a job shop that has to completely engineer something from scratch, it's not likely to be able to tie into production directly."

A robot arm can move only in certain ways, for instance. The robot arm may not be able to do what the design engineers specify. In the words of Wise, "Programming a flexible work center to create any product is not here yet."

Integrating CAD/CAM into overall CIM is technically difficult—one of those problems on the order of the talking typewriter, erasable optical disk, or space-based missile defense program. Drawing a neat configuration on paper is, if not easy, at least possible; implementing the plan down to the final detail, some maintain, is close to impossible.

Companies With Solutions

Is the magnitude of the problem discouraging people from getting started? In many cases, yes. Companies opt for small "islands of automation." They automate manufacturing, engineering, the office, or distribution, but do not integrate them with each other.

However, when the potential rewards are as impressive as they are for CIM, there are bound to be companies ready to rise to the challenge. And there are.

A.S. Thomas Inc., for instance, builds complex antennas used by the Air Force. Thomas initially began to integrate CAD/CAM in 1955, says its president, A.S. Thomas, "as protection—to be sure that the antennas we designed would be properly produced."

Conventional manufacturing techniques limited the geometric configurations designers could use. To overcome limitations, and be sure designs would not be degraded in manufacturing, Thomas linked design with the numerically controlled machines on the shop floor. The results were its Nuform system for numerical control and graphics, which it now markets to a list of major companies that includes General Electric (GE), Lockheed, Polaroid, and Raytheon. Nuform runs on any of the Digital computers, from the PDP-11 through the VAX 8800 family.

Nuform, Thomas concedes, is "still not off-the-shelf CIM." For each installation, A.S. Thomas has to adapt the product to fit the company's own requirements, methods, and various special considerations.

Thomas has been able to meet those special requirements repeatedly—well enough to have installed CIM for elaborate flexible manufacturing systems in two major companies. "We are heading into virtually automatic manufacturing," says Thomas. "You limit the amount of people required. You have to have a manager of the facility and a number of engineers. But you can cut the number of people required to one-fourth or one-fifth of the previous number." At one Nuform installation, he says, the number of people required to operate a plant decreased from 120 to 26.

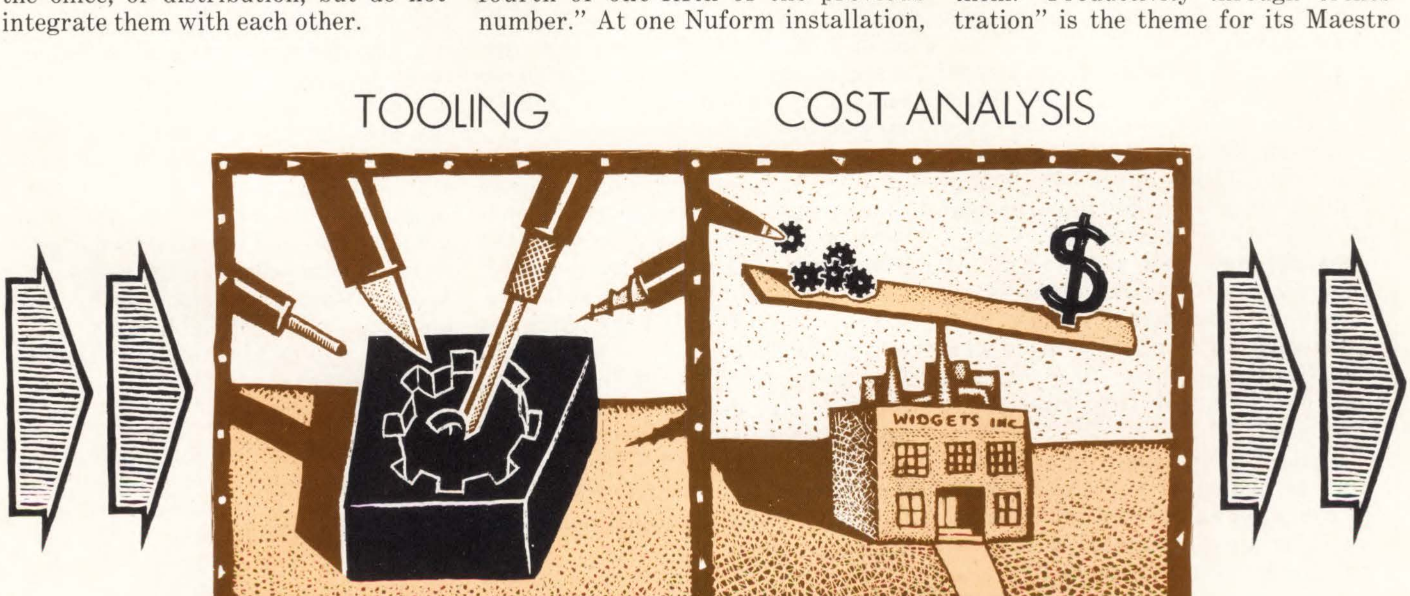
SDRC, like A.S. Thomas, extends sophisticated CAE technology into that "traditionally separate" function—manufacturing. By not involving itself directly in MRP, SDRC is rather "staying upstream from that," according to Hay.

The intent of CIM, says Hay, is to do a better job of designing the manufacturing process. Using "concurrent" or "simultaneous" engineering, SDRC aims to combine the design of the product and the manufacturing process early in product development, so that both continue simultaneously.

SDRC, which performs all internal development in VMS and then ports it to UNIX or MVS, initially worked with individual beta customers. The company is now beginning to offer its I-deas (mechanical CAE system) off the shelf.

Customers like NCR, GE, and Beckton-Dickinson are realizing dramatic benefits. Hay explains why. The Air Force concluded in a study that 7% of the cost of manufacturing products purchased could be attributed to "direct touch labor" (the assembly line). But, 63% was materials cost! In that 63% were hidden costs attributed to purchasing parts that had to be re-machined, and, in general, redesigned in manufacturing. While most of the attempts to enhance productivity are aimed at the assembly line, SDRC pursues the design engineering process that directly accounts for 63% of the materials cost.

Manufacturing Data Exchange Corp. (MDX) also looks beyond traditional CAD/CAM to the link between them. "Productivity through orchestration" is the theme for its Maestro



MANUFACTURING: AN INDUSTRY IN TRANSITION

BY THOMAS WOMELDORFF
CINCOM SYSTEMS INC.

It's a well-known fact that to be successful in today's manufacturing world, you have to gain and keep a competitive advantage. If everything remained constant, and it doesn't, that goal would be easily achieved.

In the past decade, manufacturers have had to deal with, and adapt to, new demands and changes that are occurring within individual industry segments (their own peers) that are being dictated by the specific industry. What has happened is a self-imposed competition that has resulted in new products, rate wars, new channels of distribution, etc. This places the players of the industry in one of two roles—proactive or reactive. The manufacturer that can capture and maintain leadership in this tactical area will clearly have a competitive edge.

Not only does a manufacturer have to contend with what historically has been competitive, but also with an influx of new competition. A big influence in this particular area is in the international segment. With the regulatory changes in the past decade, the way American manufacturers look at their businesses is changing dramatically.

Also, with the new trends toward diversification and acquisition of corporations, smaller companies have had to shuffle to maintain their positions. The direct effect of economic factors and inflation have become highlighted and must be dealt with on both the long and short term. All these types of outside influences are variables manufacturers have little control over. The manufacturers must be able to adapt to these changes without a major interruption to business.

With the onslaught of relational data management and the evolution of computer integrated manufacturing (CIM), just in time (JIT), material requirements planning (MRP), etc., it's no wonder that what once was a simple gathering of data has emerged into complete information centers, with the manufacturer trying to stay one step ahead of the competition. Technological forces of change are the most difficult to comprehend and almost impossible to predict.

The best way a company can expect to compete is by understanding where it is heading, and developing this concept to the fullest. Trying to "keep up" could be detrimental—look to functions, not bells and whistles. If integration of a purchased software package and an in-house system is what you're looking for, look for the vendor who does just that—most likely anything more will not be fully utilized or appreciated until the initial conquest of integration has occurred. It will probably save much time and money to do things one step at a time.

Since these segments are not autonomous, the difficulty of putting a "harness" on these internal/external effects is a constant struggle. It becomes a delicate balance for the manufacturer; to be competitive, he must be in tune with every aspect of the operation—from improving productivity and quality to reducing inventory and operating costs. The best way to meet competition head-on and ultimately "win" is to get a handle on the one factor a manufacturer should be able to control: company data.

Accomplishing this requires an innovative strategy that delivers immediate results while supporting long-term goals. Fortunately, as the manufacturing industry has matured, computer hardware and software have emerged to fulfill the needs not only of the programmers, but the people who use and need the information the most, the end users. As changes occur within industries and the end user becomes "computer literate," the need to retrieve data and format it effectively and efficiently becomes increasingly important.

The tools to achieve these results are available now. By improving information management and by facilitating the use of manufacturing management techniques, the manufacturer can gain control over not only the company's valuable resources, but an edge in the marketplace.

The difference between a mediocre company and a company with direction is in the utilization of the data from the tools available.

Implementation of any or all of these tools extends from basic to sophisticated. As the company grows and the demand for information increases, the ability to choose the tools that will be able to handle the influx becomes essential. Choosing the correct combination of the software that is available in the beginning allows for a better understanding of future growth.

Separately, each of the above tools gives a powerful insight into the data within the corporation. Together, integrating the various technologies would comprise a total solution that is greater than the sum of its parts. With that, control of the data becomes simpler.

Conversely, all the wonderful functionality becomes limited (or useless) if the hardware is unable to support the demands being placed upon it. By detailing all the needs of the organization—the concrete as well as the abstract—to the hardware and software vendors, the manufacturer will benefit from the state-of-the-art products that will address his individual situation and the combined experience and knowledge of the hardware and software professional. Also, by knowing what is available, the manufacturer will be able to maximize his investment to the fullest.

Thomas Womeldorff, senior product manager for application software for Cincom Systems Inc. (Cincinnati, Ohio), holds a B.S. degree in systems analysis from the University of Miami (Ohio).

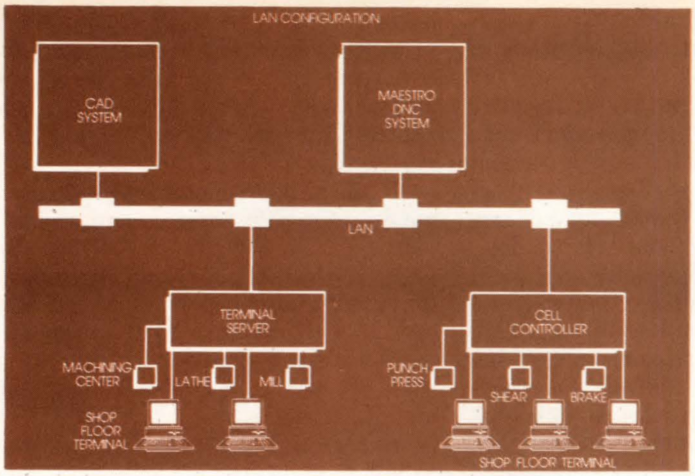


Figure 2—*The Maestro system by Manufacturing Data Exchange Corp. integrates two of the more basic CIM elements, CAD and the shop floor.*

Figure 3—*Digital took the industry by surprise when it announced the Color VAXstation 2000, the first 32-bit color workstation for less than $8,000.*

factory integration system, which its Sales and Marketing Manager Charles Buckley describes as "the next step after CAD" (Figure 2).

Factory managers recognize the need to eliminate the paper tape on numerically controlled machines, but there are risks associated with change. "The challenge is getting 500 companies to take that next step into factory automation," says Buckley.

"We continually stress that, as they make a decision to buy this product, we're really providing them with a factory communication system, and not just a point solution for numerical control or for picking up bar code information."

MRP And Workstation Companies

Recognizing the value of integrating CAD/CAM, then, companies have moved to solve the problem of linking two functions that have been traditionally separate. While some companies are addressing the link directly, others that have developed products for the separate "CAM" and "CAD" are now looking for ways to forge this link.

MCBA, developers of MRP II software, is increasingly encouraging companies to work with the big picture in mind. "We're trying to tell people, 'Start with your MRP II system. Don't buy little islands of automation. Get your MRP II and build outwards,' " says Freeman.

By implementing modules such as accounting, order entry, inventory control, and shop floor control, companies achieve immediate boosts in productivity. When they have the management information and control they need, Freeman says, they should incorporate additional links with CAD/CAM.

Cincom, according to Ron Hank, "has established strategic alliances with companies providing a well-rounded, complete solution." One of the companies Cincom works with is Digital; another is workstation manufacturer Intergraph Corp.—which, according to a company spokesman, is the world's largest turnkey CAD/CAM vendor.

If workstations are becoming more important to MRP vendors, MRP is likewise becoming important for workstation manufacturers. "More and more, especially in a CIM environment, people are coming to appreciate that capturing data from conceptual design to manufacturing is really an asset," says Senior Intergraph Technical Manager Jerry Adams.

It is well known that competition among workstation manufacturers is fierce, matching the growing demand for CAD workstations. Digital startled the marketplace in June by announcing "the industry's first color 32-bit workstation for less than $8,000"—the Color VAXstation 2000 (Figure 3). Another announcement was the price decrease

ROBOTICS ASSEMBLY

of the monochrome VAXstation 2000 from $10,500 to $5,400.

Competitors Sun Microsystems Inc. and Apollo Computer Inc. are not surrendering market share passively, as they, too, have announced price cuts and performance enhancements. Other players offer further alternatives for workstation buyers. Opus Systems, for example, offers a high performance, 32-bit processor that converts an IBM PC into a high performance UNIX workstation (Figure 4).

Single-Vendor Solution

Less obvious during all the din and clatter of this *features* race is that implementers are beginning to evaluate the more important considerations of the workstation.

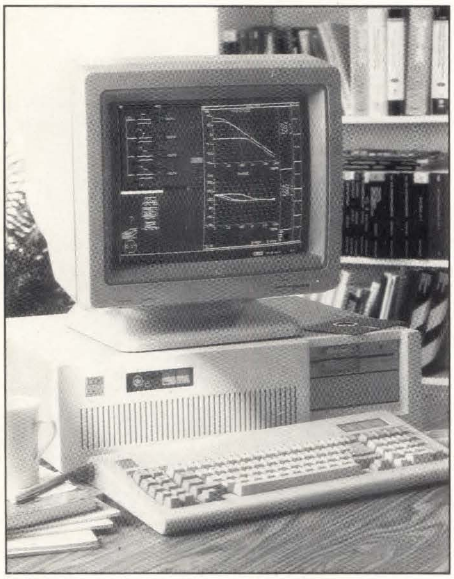


Figure 4—*Opus Systems offers a 32-bit processor that converts an IBM PC into a UNIX workstation.*

For an implementation as large and complex as CIM, companies tend to ask, is it best to go with a single vendor whose products all work together? Digital itself would, of course, tend to recommend a single vendor, and it does. Digital's Conaway concedes that most of its CIM customers say they prefer a two-vendor solution: Digital and IBM. Digital isn't the only vendor advocating a single-vendor solution; almost everyone in the CIM marketplace acknowledges that, for problems so complex, users have to find stability somewhere, and one source of stability is a single vendor.

System integrator Wise says, "I tend to try to stay with a single vendor as much as I can, because I feel there will be long-term advantages for us." The installation is more likely to run smoothly, with a minimum of finger pointing. (Sometimes, though, he just cannot go with the single vendor. When Digital bar code readers were selling for $2,400 and third party offerings for $600, for example, he felt he had to go with the alternative.)

Conaway, too, explains why the single-vendor solution may be more important for CIM than for more localized problems. "When you look at the integration problem in detail, it's very technical," says Conaway. "It's just not sufficient to have a technical network. For a departmental system, you want to be able to make query connections at the database level, have the programs understand the formats output from one application to the next, as well as have the physical networking in place."

Going with a single vendor like Digital, in fact, can help resolve one of the biggest obstacles to CIM— the multivendor environment on the shop floor. "Those that short-listed their vendors and went with just a few have an advantage later when it comes to CIM," says Conaway.

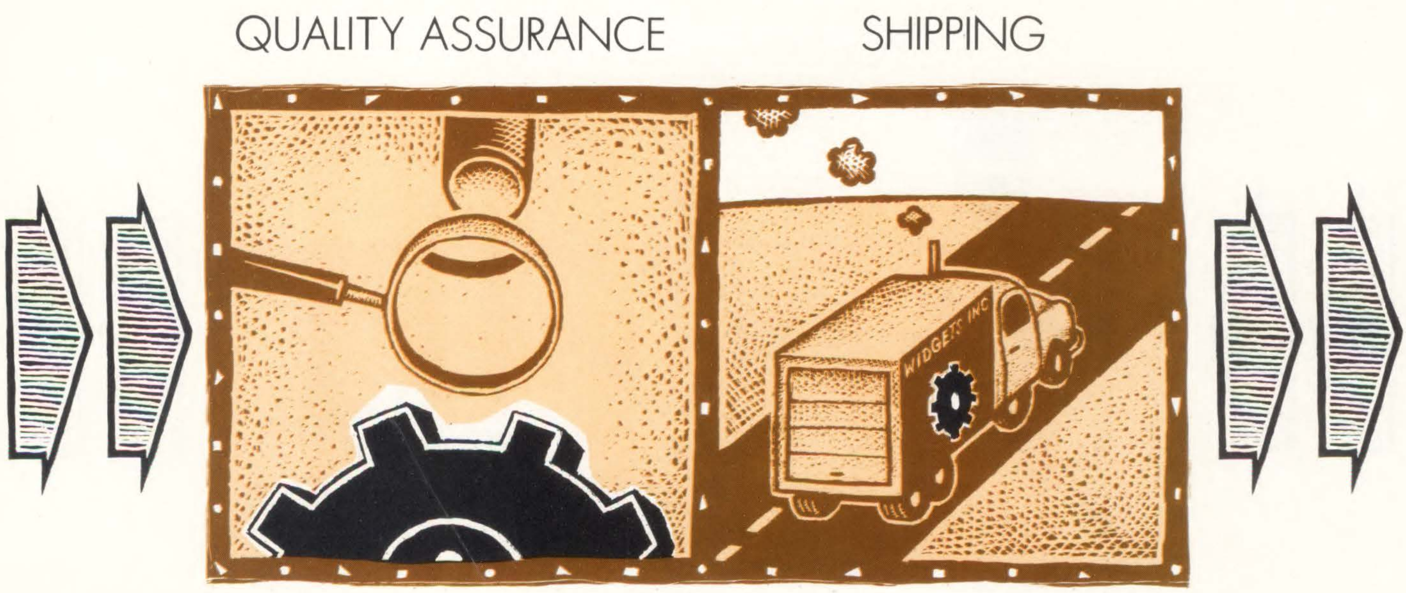
If the single vendor is Digital, say many in the CIM environment, the advantages may be numerous. With its VAXELN operating system optimized for realtime conditions in manufacturing, and the ruggedized IVAX suited to the shop floor, Digital has become a leader in software and hardware for manufacturing.

But Digital's advantages on the technical front are not only VAX and VMS, adds Conaway, but "our whole offering—our storage systems architecture, our single networking architecture. It's not just a matter of having the hardware and operating systems, but of offering a set of integrated products at the database level. We offer an information technology that's uniform from the hardware up to database level."

Human And Organizational Issues

Digital's biggest advantage in implementing CIM may not be technical at all, but cultural. Concludes Conaway, "One trend we've seen emerge very strongly in the past year is that people list human and organizational issues at the top of their lists—over and above information technologies as the most important issues to resolve in CIM."

Digital itself has what Conaway terms a "networked organization and culture, beyond matrix management," that have adapted well to CIM. Recognizing that the biggest problems in CIM are probably not technical, but organizational, Digital is drawing upon its own culture to pass along the right



The following vendors were mentioned in this article

Alpha II Systems
5330 E. Main St.
Columbus, OH 43213
614-868-5011

A.S. Thomas Inc.
355 Providence Hwy.
Westwood, MA 02090
617-329-9200

Apollo Computer Inc.
330 Billerica Rd.
Chelmsford, MA 01824
617-256-6600

Cincom Systems
2300 Montana Ave.
Cincinnati, OH 45211
513-662-2300

Intergraph Corp.
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M/S IW1510
Huntsville, AL 35807
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Manufacturing Data Exchange Corp.
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Minneapolis, MN 55435
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MCBA
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Glendale, CA 91204-1269
818-242-9600

Opus Systems
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Cupertino, CA 95014
408-446-2110

Structural Dynamics Research Corp.
2000 Eastman Dr.
Milford, OH 45150
513-576-2400

Sun Microsystems Inc.
2550 Garcia Ave.
Mountain View,
CA 94043
415-960-1300

human resources programs to other companies.

Now the marketplace is outgrowing the old disputes over which MRP II program to select or which workstation vendor to go with. CIM is forcing businesses to transcend technical discussion altogether, to face larger issues.

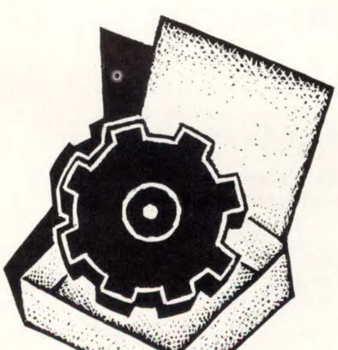
"The issue today is not the technology, it's the cultural changes we have to go through," assents SDRC's Hay. Adds Intergraph's Adams, "What I encourage people to do more and more is sit down and put together a good implementation plan, a strategy. CIM is no longer a technical question; it's a strategic question. Companies must recognize they may have to sacrifice to get all the benefits."

System integrator Wise concurs as well. "It's an absolute requirement that people evaluate business objectives before attempting changes in their information systems. They don't have to spend the money and integrate everything all at once, but they do have to have a strategy."

Cautions MCBA's Freeman, "CIM just takes time, and people don't want to talk about something for 2 yrs. before starting it. With CIM, though, they may have to do that."

For those who chose to begin, though, the incentives are there. As Digital's Conaway puts it, "Yes, there are problems with CIM. But the companies that stayed with it are getting phenomenal returns."

Jim Meade is a Hardcopy *contributing author.*



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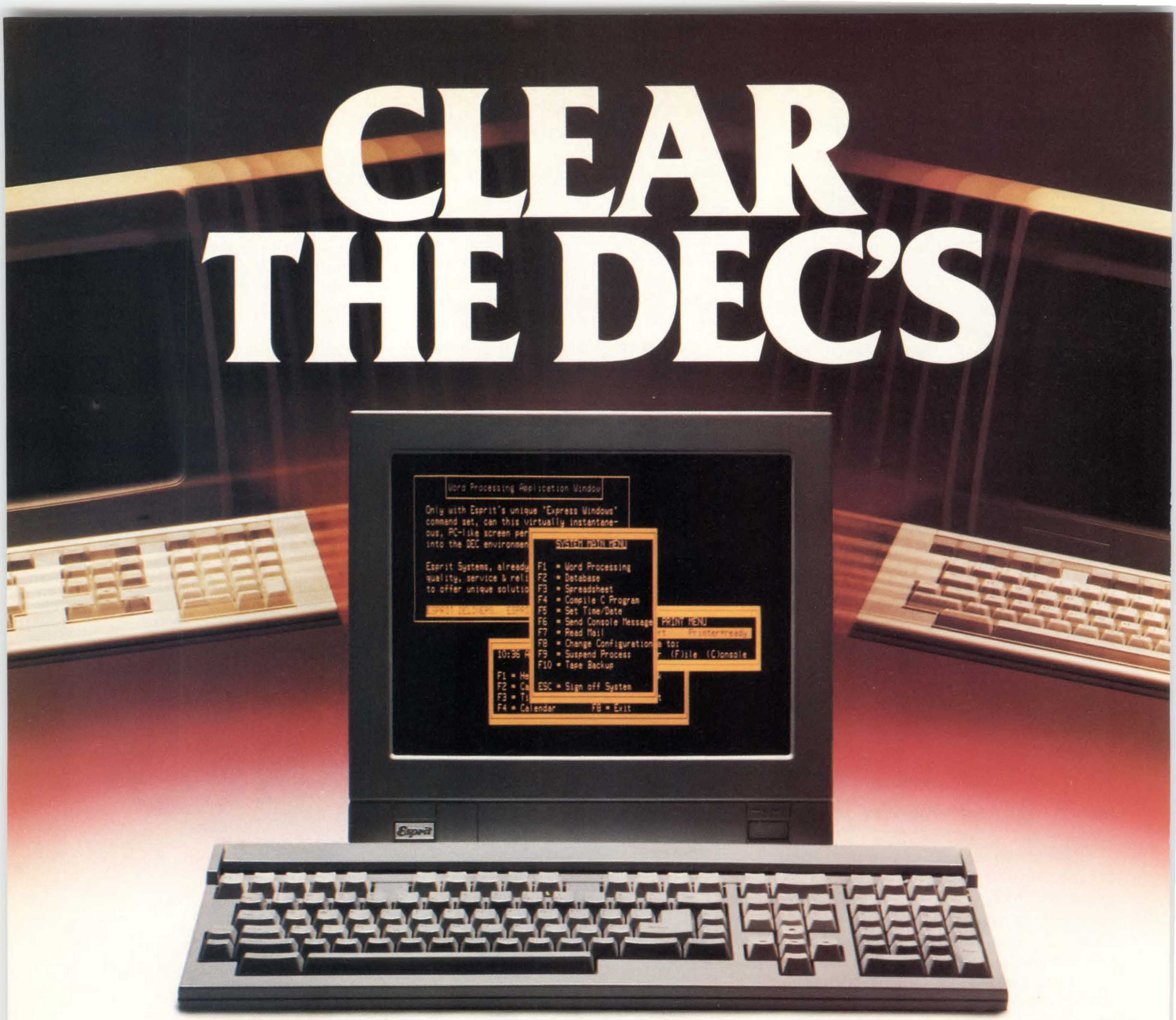

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CIM SOFTWARE

Company	Operating System(s)	Modeling/Design Capabilities (CAD)	Model Simulation/Test Capability	CAM/Numerical Control (NC)	Process Control/Monitoring	Forecasting	Materials Requirements Planning (MRP)	Just In Time (JIT)	Full Accounting Functions	Levels Of Integration
ALDEN COMPUTER SYSTEMS CORP. One Salem Green, Ste. 420 Salem, MA 01970 617-744-1314 **Enter No. 153**	VMS, RT-11, RSX			•						Data from coordinate measuring machine or digitizer generates minimum number of linked CNCs that match specified accuracy; linked CNCs then post-processed to obtain CNC program
ANATEC, ANACONDA ADVANCED TECHNOLOGY 5160 Blazer Memorial Pkwy. Dublin, OH 43017 614-764-4277 **Enter No. 154**	VMS, RSX		•		•					Allows complete access to all plant floor information utilizing standard DEC layered application software tools
APPLIED DECISION SYSTEMS-DIV. OF TBS INC. 33 Hayden Ave. Lexington, MA 02173 617-861-7580 **Enter No. 155**	VMS, MS-DOS					•	•			Sales forecasting integrated with sales reporting system and MRP/distribution requirements planning system
A.S. THOMAS INC. 355 Providence Hwy. Westwood, MA 02090 617-329-9200 **Enter No. 156**	VMS	Nuform CAD for mechanical engineering and design; wire frame and surface modeling of sculptured surface		•	•		•	•	•	Modular design completely integrated by flexible database; sales orders entered, designed, and verified; all manufacturing data is generated and shop floor automated manufacturing system (AMS) controlled with full data capture; integration with third party packages
ASK COMPUTER SYSTEMS INC. 730 Distel Dr. Los Altos, CA 94022 415-969-4442 **Enter No. 157**	VMS						•	•	•	Any CAD, CAE, or other engineering system capable of creating an ASCII file can pass attribute data to the engineering database to be reviewed, modified, and merged
AUTO-TROL TECHNOLOGY CORP. 12500 N. Washington St. Denver, CO 80233 303-452-4919 **Enter No. 158**	VMS	Wire frame, surface, and solids modeling, view manipulation, attribute management functions; graphic representations of individual components from a user-defined library of symbols	•	•						Geometric modeling system for 2D or 3D product models; can be used for design studies, documentation, or NC programs; complete CAD/CAM product fabrication; wire frame, surface, and solids modeling
AUTODESK INC. 2320 Marinship Way Sausalito, CA 94965 415-332-2344 **Enter No. 159**	VMS, MS-DOS	3D wire frame; open architecture allows third party developers to design add-ons for specific environments		•						Completely solution-oriented; allows product concept/design through finished product manufacturing; over 400 add-on software products available
CADMATICS 21941 Ybarra Rd. Woodland Hills, CA 91364-4237 818-884-8957 **Enter No. 160**	RSX	Symbolic drawing; circuit design using wirewrap; physical modeling	•							Designs are fully testable; tested designs can be directly interfaced to hardboard artwork
CALCULUS QUEBEC 2954 Boul. Laurier, Ste. 360 Ste-Foy, Quebec Canada G1V 2M4 418-659-3530 **Enter No. 161**	VMS, RT-11, TSX					•	•		•	All production information integrated with other software involved—inventory, industrial accounting, production management, calculation of standard costs, pay, order entry, invoicing purchasing, general ledger
CASTELLO COMPUTER SYSTEMS 103 W. Lancaster Ave. Reading, PA 19603 215-374-4110 **Enter No. 162**	VMS, RT-11, TSX						•		•	Integrated from a business information viewpoint
CIMTELLIGENCE CORP. One Forbes Rd. Lexington, MA 02173 617-861-1996 **Enter No. 163**	VMS									Fully integrated software productivity tools to standardize and optimize the design and manufacturing database for electronic and mechanical components and assemblies
CINCOM SYSTEMS 2300 Montana Ave. Cincinnati, OH 45211 513-662-2300 **Enter No. 164**	VMS						•	•	•	Provides the interfaces to bridge design and engineering systems (Intergraph, Litton) with other manufacturing functions

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CIS MEDUSA INC. 201 Burlington Rd. Bedford, MA 01730 617-276-1288 **Enter No. 165**	VMS	Solids, wire frame, assembly, and surface modeling		•						Single database—design to detailing to production; open system easily passed to finite element analysis, and MRP
COMPUTER COGNITION 6696 Mesa Ridge Rd. San Diego, CA 92121 619-453-6660 **Enter No. 166**	VMS, UNIX/Ultrix, MS-DOS					•	•		•	Materials cost/control; material requirements based on a master plan; can export data to other systems
COMPUTER CONVENANT CORP. 309 Farmington Ave. #A211 Farmington, CT 06032 203-677-6563 **Enter No. 167**	VMS, UNIX/Ultrix, RSX, MS-DOS				•		•	•	•	Integrated manufacturing and financial system; manufacturing can be directly from raw material to finished product
COMPUTER STRATEGIES INC.- SUBSIDIARY OF CULLINET SOFTWARE 3940 Pennisular Dr. S.E. Grand Rapids, MI 49506 616-957-4444 **Enter No. 168**	VMS, Pick					•	•	•	•	Does not integrate directly with CAD; however, serves as repository for engineering data
COMPUTER SYSTEMS DEVELOPMENT INC. Wayside Professional Bldg. 910 Boston Post Rd. Marlborough, MA 01752 617-460-0330 **Enter No. 169**	VMS						•	•		Integrated/financial MRP II system(s) can be integrated with CAD system(s)
COMPUTING TECHNICIANS CORP. 13896 Harbor Blvd. #5-C Garden Grove, CA 92643 714-554-1551 **Enter No. 170**	VMS					•	•	•	•	Total integration of all modules forms a complete forecasting, MRP, distribution management solution
CONSILIUM INC. 1945 Charleston Rd. Mountain View, CA 94043 415-940-1400 **Enter No. 171**	VMS		•		•			•		CAM-oriented for shop floor control, engineering and quality management, equipment and facilities management; integrates with equipment for full automation
CREARE INC. Etna Rd. P.O. Box 71 Hanover, NH 03755 603-643-3800 **Enter No. 172**	VMS, UNIX/Ultrix	Models diverse 2D and 3D laminar and turbulent flows with inert or reacting particles or droplets	•							Handles a wide variety of design applications—from analyzing complex flows in chemical processes and combustion equipment to solving computer chassis cooling problems
CREATIVE VISUAL SOFTWARE P.O. Box 20638 San Jose, CA 95160 408-997-1621 **Enter No. 173**	VMS, UNIX/Ultrix	Surface modeling and wire frame for conceptual design, simulation, motion scripting, 3D mapping, and flow analysis	•							Software can be used for conceptual design, motion simulation, and robotic simulation
DB/ACCESS INC. 20111 Stevens Creek Blvd. Ste. 200 Cupertino, CA 95014 408-255-2920 **Enter No. 174**	VMS		•		•	•				Process monitoring and statistical process control; process optimization using Taguchi methods is supported; process and product engineering applications available
DECUS INTERNATIONAL SOFTWARE LIBRARY 219 Boston Post Rd. BPO2 Marlboro, MA 01752 617-480-3521 **Enter No. 175**	VMS	General-purpose circuit simulation program for nonlinear dc, nonlinear transient, and linear AC analysis	•							
DIGITAL EQUIPMENT CORP. 146 Main St. Maynard, MA 01754-2571 617-897-5111 **Enter No. 176**	VMS, RT-11, UNIX/Ultrix, VAXELN, TSX, RSX, RSTS, CP/M, MS-DOS	The combination of software developed by Digital itself plus that available under CMP and SCMP agreements	•	•	•	•	•	•	•	Using a simplify, organize, automate, then integrate strategy, Digital's customers have a comprehensive hardware/software product line to choose from when implementing CIM solutions
DRILLING RESOURCES DEVELOPMENT CORP. 611 E. Skelly Dr. #415 Tulsa, OK 74135 918-664-9010 **Enter No. 177**	VMS	Wire frame, surface, solids, and finite element modeling; stress, heat transfer, and vibration analysis	•							Translates data from 15 CAD and solids modeling products; reads IGES and autoCAD DXF format; outputs IGES files and writes neutral files (written in ASCII)

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DSD CORP. 10632 N.E. 37th Cir. Kirkland, WA 98083-2669 206-822-2252 **Enter No. 178**	VMS, UNIX/Ultrix		•			•				Links to other software to aid in analysis and reporting of design and manufacturing information
DTRO SOFTWARE 1229 7th Ave. San Francisco, CA 94122 415-861-5454 **Enter No. 179**	VMS, RT-11, UNIX/Ultrix, VAXELN, TSX, RSX, Pick, RSTS, MS-DOS					•				Simulation of alternative forecasting methods; advanced forecasting methods; standard and advanced statistical quality control methods
ECAD INC. 2455 Augustine Dr. Santa Clara, CA 95054-3082 408-727-0264 **Enter No. 180**	VMS, UNIX/Ultrix	All aspects of layout including verification and fracturing are supported								One family of layout tools allows user to implement physically realizable version of the logic/circuit design; a second family verifies design
ENGINEERING/ANALYSIS CORP. 24050 Madison St. #211 Torrance, CA 90505 213-373-1234 **Enter No. 181**	VMS, UNIX/Ultrix	Linear elastic static and dynamic finite element analysis; eigenvalue extraction and dynamic response analysis including random, harmonic, and time history								General interfaces available to popular finite element modelers
EXTENDED TECHNOLOGIES CORP. 1023 Blvd. E Weehawken, NJ 07087 201-348-6688 **Enter No. 182**	VMS, RSX				•		•	•		Factory automation system monitors production requirements, job flow within the factory, and data to host system for job status and completion
GE CALMA 501 Sycamore Dr. Milpitas, CA 95035 408-434-4056 **Enter No. 183**	VMS	Wire frame, surface, and solids modeling; robot-simulation, sheet metal, and plastics applications	•	•						One common database throughout all applications
HOUTZEEL MANUFACTURING SYSTEMS 318 Bear Hill Rd. Waltham, MA 02154 617-890-2811 **Enter No. 184**	VMS, UNIX/Ultrix, MS-DOS			•						NC system utilizes feature information from graphics package to generate NC instructions automatically
INDUSTRIAL SYSTEMS 18720 142nd Ave. N.E. Woodinville, WA 98072 206-481-6325 **Enter No. 185**	VMS	Realtime or interactive graphics display package for control room or modeling applications	•		•					
INFORMATION AUTOMATION INC. 925 Westchester Ave. White Plains, NY 10604 914-948-4300 **Enter No. 186**	VMS, RT-11, VAXELN, MS-DOS				•					Turnkey production monitoring systems include technical studies, design, implementation, and all software and system installation
INTEGRATED COMPUTER INC. P.O. Box 212 4417 Old William Penn Hwy. Pittsburg, PA 15146 412-856-5770 **Enter No. 187**	VAXELN, MS-DOS				•					4GL application shell runs on board-level MicroVAX; connects directly to process control sensors
INTERACTIVE INFORMATION SYSTEMS INC. 4541 S. Butterfield, Ste. 405 Tucson, AZ 85714 602-790-4214 **Enter No. 188**	VMS, UNIX/Ultrix				•		•	•	•	LAT/batch traceability; job costing; actual/standard costing; interface for labor/data collection; can handle multiple warehouses, companies, divisions, and budgets
JENNEY SYSTEMS ASSOC. LTD. 2618 Union Rd. Buffalo, NY 14227 716-668-1606 **Enter No. 189**	VMS, UNIX/Ultrix, RSX, RSTS			•	•		•			System(s) integration using DEC Baseway, PC Link, and Ethernet
JOHN A. KEANE & ASSOC. 575 Ewing St. Princeton, NJ 08540 609-924-7904 **Enter No. 190**	VMS, RSX		•		•	•		•		Bridges quality control information between industrial/laboratory collection, manufacturing, CAD/CAM design, purchasing, inventory control, and accounting
KASTLE SOFTWARE ASSOC. 1501 Wilson Blvd. Arlington, VA 22209 703-528-8800 **Enter No. 191**	VMS				•		•	•		4GL allows monitoring of PLCs from various vendors via standard LANs simultaneously using a MicroVAX II

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Company	Operating System(s)	Modeling/Design Capabilities (CAD)	Model Simulation/Test Capability	CAM/Numerical Control (NC)	Process Control/Monitoring	Forecasting	Materials Requirements Planning (MRP)	Just In Time (JIT)	Full Accounting Functions	Levels Of Integration
KINETIC SYSTEMS CORP. 11 Maryknoll Dr. Lockport, IL 60441 815-838-0005 **Enter No. 192**	VMS, RSX		•	•	•					Includes scanning of I/O points, alarm limit checking, data storage and display, control of PID loops, and capability of devising complex control strategies using regular and sequential control
MANAGEMENT SCIENCES INC. 6022 Constitution N.E. Albuquerque, NM 87110 505-255-8611 **Enter No. 193**	VMS, MS-DOS	Automatic stress analysis, circuit simulation, reliability, maintainability, availability, logistics, safety, and hazard analyses	•			•		•		Accepts data input from CAD, DBMS, or other commercial software recorded in an ASCII file
MANUFACTURING AND CONSULTING SERVICES INC. 9500 Toledo Way Irvine, CA 92718 714-951-8858 **Enter No. 194**	VMS	Mechanical design and drafting; wire frame, surface, and solids modeling; finite-element mesh		•						Drawing, modeling (wire frame, surface, solids), finite-element mesh generation, and NC machining programs all done from one database
MANUFACTURING DATA EXCHANGE 7644 W. 78th St. Minneapolis, MN 55435 612-829-7022 **Enter No. 195**	VMS, RSX			•	•					Full factory data communications allowing transfer of NC files, set-up instructions, monitored statistics, and mail, from NC production machine to host computer
MCBA INC. 425 W. Broadway Glendale, CA 91204-1269 818-242-9600 **Enter No. 196**	VMS, RT-11, TSX, RSTS						•		•	Complete MRP II system; accepts data from shop floor control systems (bar code readers, magnetic stripe terminals)
MCCORMACK & DODGE 400 Las Colinas Blvd. Ste. 550 Irving, TX 75039 214-869-2060 **Enter No. 197**	VMS		•			•	•	•	•	Interfaces with designs of CAD system; parts can be passed onto Bill of Materials module, Master Planning, and Accounting functions
MCDONNELL DOUGLAS MANUFACTURING & ENGINEERING SYSTEMS CO. 325 McDonald Blvd. Hazelwood, MO 63042 314-232-3890 **Enter No. 198**	VMS	Solids modeling, printed circuit board design, finite element modeling, mechanism linkage design, machine element design, and graphics machining	•	•	•					Design database is focal point in CAE, CAM (including robotics software), factory production with distributed numerical control (DNC) capabilities, and information management
MICROPROD. TECH. SOFTWARE INC. 16 Blackhorse Dr. Acton, MA 01720 617-263-3408 **Enter No. 199**	VMS, RSX				•	•	•			Combines production control with engineering data collection and analyses
MODULAR DATA SYSTEMS INC. 2525 Bay Area Blvd., Third Fl. Houston, TX 77058 713-486-1712 **Enter No. 200**	VMS, RSX				•					Monitors and controls industrial processes in realtime to: read and convert signals to engineering units; display engineering units for management personnel; and compute and implement control actions
NORTHEAST DATA SYSTEMS INC. 20 A St. Burlington, MA 01803 617-273-2920 **Enter No. 201**	Pick					•	•	•	•	Supports CAD interfaces, lot control, and options bill of materials; single or multilocation environments; inventories multiple warehouses; provides multicompany financial modules
NUMERICAL CONTROL COMPUTER SCIENCES 17321 Murphy Rd. Irvine, CA 92714 714-474-7444 **Enter No. 202**	VMS	Wire frame, surface (complex 3–5 axis)		•						Fully integrated CAD/CAM system
OCTAL INC. 28280 Franklin Rd. Southfield, MI 48034-1659 313-356-8080 **Enter No. 203**	VMS, UNIX/Ultrix, MS-DOS									Company develops and markets host-independent direct CAD database conversion software and services
OPTIMATION INC. 2801 E. Missouri, Ste. 17 Las Cruces, NM 88001 505-522-3303 **Enter No. 204**	VMS, UNIX/Ultrix, MS-DOS			•	•			•		Packages are integrated with various CAD systems via geometry, APT, or NC interfaces for generating NC instructions of nested parts; total integration with CAD and MRP packages, and machine tools

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PDA ENGINEERING 2975 Red Hill Ave. Costa Mesa, CA 92626 714-540-8900 **Enter No. 205**	VMS, UNIX/Ultrix	Solids modeling, multiple-light-source shaded imaging, finite element modeling, and analysis results evaluation								Provides interface to graphics devices, peripherals, and user-written programs; optionally interfaces wide range of analysis, CAD, and CAM software tools; links and enhances incompatible external codes into a single MCAE environment
PIXAR P.O. Box 13719 San Rafael, CA 94913 415-499-3600 **Enter No. 206**	UNIX/Ultrix	3D surface rendering display system	•							Accepts geometric models as input in a variety of image description formats
PRECISION VISUALS 6260 Lookout Rd. Boulder, CO 80301 303-530-9000 **Enter No. 207**	VMS, UNIX/Ultrix	Hierarchical modeling capabilities for 2D and 3D structures; name set filtering; structure editing; hidden line removal; and an extended primitive set	•	•	•	•				Building, manipulating, and editing 2D and 3D spatial models; product design and testing; developing charts of test results; statistical quality control; manufacturing simulation; mapping; CGM compatible metafile system
PROMIS SYSTEMS CORP. 4699 Old Ironsides Dr. #300 Santa Clara, CA 95054 408-748-9822 **Enter No. 208**	VMS	Modeling and simulation of production facility (i.e., factory floor) as a planning tool		•	•		•	•		All production functions are integrated with a common database; the manufacturing model is the core that drives all other modules
RELEVANT BUSINESS SYSTEMS INC. 2682 Bishop Dr., Ste. 225 San Ramon, CA 94583 415-867-3830 **Enter No. 209**	VMS, MS-DOS, AMOS					•	•	•	•	All modules access common, central database; actions taken in one module (e.g., Engineering Change Order) are immediately reflected in other modules (e.g., open WIP affected by ECO)
RWT CORP. 1601 Feehanville Dr., Ste. 500 Mt. Prospect, IL 60056 312-390-0200 **Enter No. 210**	VMS, RT-11, MS-DOS			•						Distributed numerical control (DNC) to a network of machine tools with NC or CNC controls; existing CAD/CAM or programming system provides NC tape files, setup data, part drawings, etc. distributed throughout the network
SAFE COMPUTING CANADA LTD. 2000 Argentia Rd., Plaza 4 #200 Mississauga, Ontario Canada L5N 1W1 416-826-5352 **Enter No. 211**	VMS, BOS			•			•		•	
STAFF COMPUTER TECH. CORP. 440 San Lucas Dr. Solana Beach, CA 92075 619-259-1313 **Enter No. 212**	Custom				•					User monitors and controls processes while producing any required process reports
STRUCTURAL DYNAMICS RESEARCH CORP. 2000 Eastman Dr. Milford, OH 45150 513-576-2400 **Enter No. 213**	VMS	Solids modeling; finite element analysis; drafting; mechanical test analysis	•	•						MCAE applications that share common database, menus, and graphics displays; unbundled software available on all major computer hardware platforms
STRUCTURAL RESEARCH & ANALYSIS CORP. 1661 Lincoln Blvd. #100 Santa Monica, CA 90404 213-452-2158 **Enter No. 214**	VMS, MS-DOS	Wire frame, surface, and/or solids modeling	•							Integrated with several CAD programs, such as AutoCAD, CV Personal-Designe, and CADKEY to form a complete engineering analysis system
SYSTEM DYNAMICS CORP. 151 Esna Park Dr. Markham, Ontario Canada L3R 3B1 416-475-5155 **Enter No. 215**	VMS, UNIX/Ultrix					•	•	•	•	A full MRP II system with integration between accounting and distribution modules; also integrates payroll/production costing
SYSTEMS CONTROL TECHNOLOGY INC. 1801 Page Mill Rd. Palo Alto, CA 94303 415-494-2233 **Enter No. 216**	VMS, UNIX/Ultrix	Computer-aided control engineering and nonlinear dynamic system simulation in an interactive environment	•							Easy access to data files, operating system commands, and external programs permits control system design, analysis, and simulations in the same interactive software environment
TEC COMPUTER SYSTEMS INC. 30 Tower Rd. Newton, MA 02164 617-964-3890 **Enter No. 217**	VMS						•	•	•	Interface to CAD/CAM and shop floor data collection systems

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Company	Operating System(s)	Modeling/Design Capabilities (CAD)	Model Simulation/Test Capability	CAM/Numerical Control (NC)	Process Control/Monitoring	Forecasting	Materials Requirements Planning (MRP)	Just In Time (JIT)	Full Accounting Functions	Levels Of Integration
TECHWARE COMPUTING CO. 4912 Creekside Dr. Clearwater, FL 33520 813-576-3734 **Enter No. 218**	VMS, RT-11, RSX	2D plots from 3D drawings		•						Sheet metal geometry used to create NC program that can be inspected prior to sending to punch press
TEKTRONIX INC. Wilsonville Industrial Pk. P.O. Box 1000, M/S 63-635 Wilsonville, OR 97070 800-225-5434 or 503-235-7202 **Enter No. 219**	VMS	2D drafting application tailored for low CPU utilization and integration with CAD/CIM functions; IGES, SIF, Patran, AutoCAD DXF, Compact II, and APT Translators available	•	•						Drafting information is passed to other design and manufacturing software through industry standard file formats on custom bill of material reports; drawing geometry can also be translated into APT or Compact II languages
USERWARE INTERNATIONAL 2235 Meyers Ave. Escondido, CA 92025 619-745-6006 **Enter No. 220**	VMS, RSTS					•	•	•	•	Totally integrated manufacturing/distribution/accounting system
WCI MACHINE TOOLS & SYSTEMS CO. 3615 Newburg Rd. Belvidere, IL 61008 815-547-5321 **Enter No. 221**	VMS			•	•					Integrated shop floor control system including user-configurable menus, distributed numerical control, tool management, production data collection and reporting, and preventive maintenance scheduling

New MicroVAX 3500/3600 Triples MicroVAX II Performance

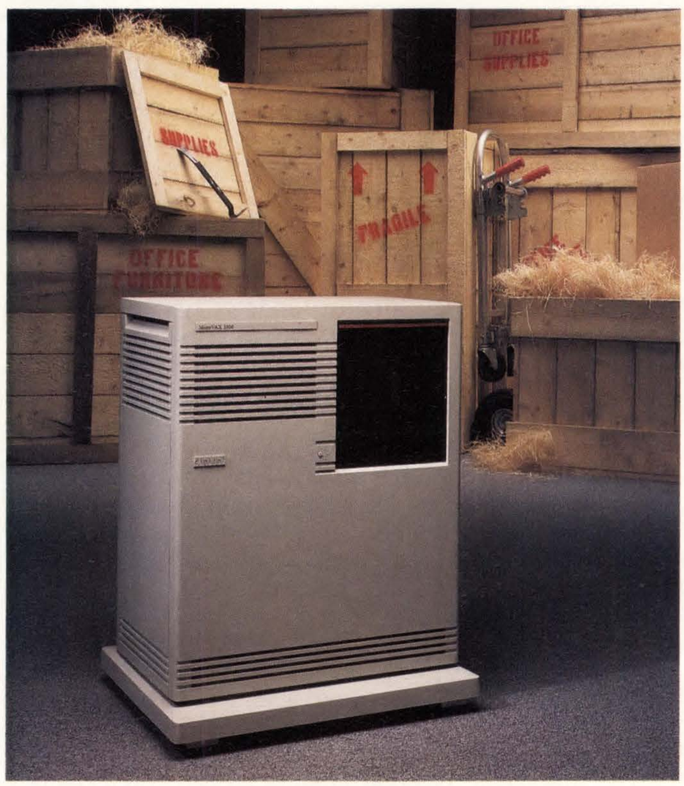
Digital provides an exclusive description of its newest machine and the engineering process required to bring it to market/by Charles J. DeVane and Gary P. Lidington [Digital Equipment Corp.]

There is usually both opportunity and challenge for engineers when designing a more powerful member of a computer family. The opportunity is to make the most of a faster microprocessor chip in maximizing system performance; the challenge is to provide full compatibility with the new system's predecessors, without limiting the engineers' options in achieving their goals.

The principal goal in designing Digital Equipment Corp.'s recently announced MicroVAX 3500/3600 32-bit microsystem, now the fastest member of the MicroVAX family, was to triple the performance of the MicroVAX II. At the same time, the MicroVAX 3500/3600 had to be compatible with the MicroVAX II in module and system packaging, I/O bus, and peripheral devices. (See "DEC Explains The Design Of The MicroVAX II 32-bit Single-Module CPU," *Hardcopy*, p. 76, June 1986).

Two-thirds of the MicroVAX 3500/

Charles J. DeVane, senior hardware engineer in microsystems development for Digital Equipment Corp., holds a B.S.E.E. from North Carolina State University. Gary P. Lidington, principal engineer, also in microsystems development, holds a B.S.E.E. from Tufts University and an M.S.E.E. from the University of Massachusetts.



Fastest member of MicroVAX family—*The principal goal in designing the MicroVAX 3500/3600 was to triple MicroVAX II performance, yet remain compatible with the MicroVAX II in module and system packaging, I/O bus, and peripheral devices.*

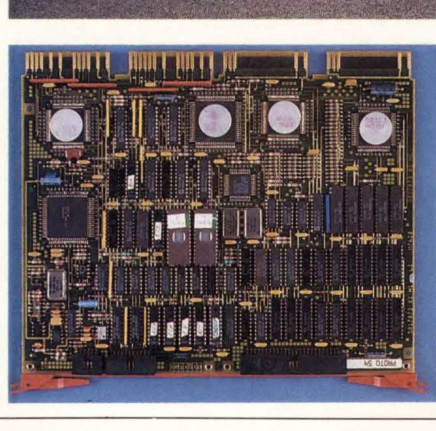


Figure 1—*The MicroVAX 3500/3600 CPU is fully contained on one quad-size (8½ x 10½ in.) module. About 80% of the CPU's functionality has been implemented in six custom 2-μ double metal CMOS surface-mounted cerquad chips.*

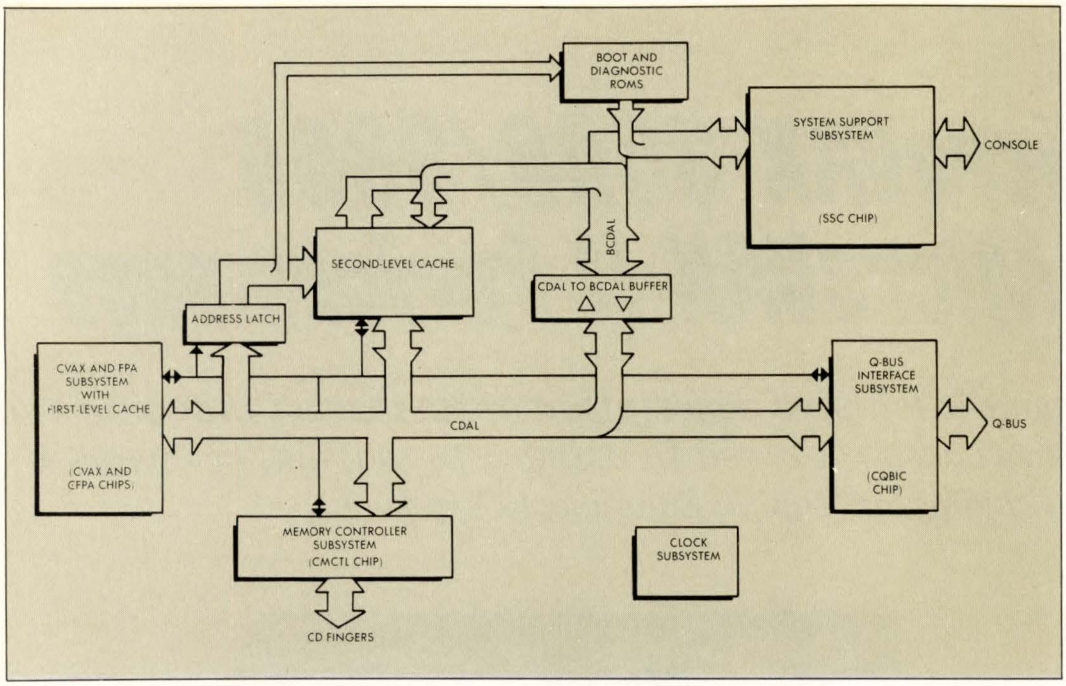


Figure 2*—The CPU is functionally partitioned into four major subsystems: microprocessor/floating point accelerator, memory controller, Q-bus interface, and system support. The second-level cache supports the first-level cache in the microprocessor (CVAX) chip.*

3600's increased performance is built into the microprocessor itself. The microcycle of the complementary metal oxide semiconductor (CMOS) VAX (CVAX) microprocessor chip is about half that of the MicroVAX II—90 nsec compared to 200 nsec. The remainder of the increase was attained primarily through implementation of a two-level cache architecture and multiword transfers over the internal bus.

The need to implement the MicroVAX 3500/3600 on the same size CPU module as the MicroVAX II led to extensive use of 2-μ CMOS very large scale integration (VLSI) technology. The microprocessor chip, floating point accelerator chip, and four other custom CMOS VLSI chips represent 80% of the CPU's functionality.

CPU Architecture

Initial requirements for upward compatibility meant first that, like the MicroVAX II, the MicroVAX 3500/3600's CPU had to provide full VAX processing capability on one quad-size (8½ x 10½ in.) module (Figure 1). It would run the VMS and Ultrix-32 operating systems. Similarly, the MicroVAX 3500/3600 system would be based on the 22-bit Q-bus (Q22) I/O bus in order to accept all Q22 compatible peripheral devices.

In addition to increasing CPU speed, system performance would be upgraded by quadrupling the architectural limit on main memory, from 16 Mbytes for the MicroVAX II to 64 Mbytes for the MicroVAX 3500/3600. The system would be packaged in the new BA213 (17½ x 24½ x 12 in.), the first system chassis to implement Digital's DECconnect interconnect architecture for factory and office.

Figure 2 shows the top-level partitioning of the MicroVAX 3500/3600. The four major subsystems are functionally similar to those in the MicroVAX II: microprocessor/floating point accelerator, memory controller, Q-bus interface, and system support.

The system support subsystem includes a variety of I/O-related functions: console serial line, 1-Kbyte battery-backed up RAM for firmware scratch pad and local storage, battery-backed up time-of-year (TOY) clock, interval timer, two programmable timers, and a register for diagnostic light emitting diode (LED) control. HALT arbitration logic protects the CPU from a second HALT request when it's executing code out of ROM to emulate a console processor.

The boot and diagnostic ROMs provide 128 Kbytes of firmware for self-test diagnostics, console emulation, and support booting from standard Q-bus peripherals. Since CPU performance isn't critical while performing these functions, two 8-bit-wide ROMs are used, saving both cost and module space over using four 8-bit-wide ROMs. The system support subsystem unpacks and reassembles output from the two 8-bit-wide ROMs into longwords (4 bytes) and places them on the 32-bit-wide control/data/address lines (CDAL) internal bus.

VLSI-oriented hardware partitioning of the MicroVAX 3500/3600 parallels its functional partitioning by implementing virtually all functions of the four major subsystems in custom 2-μ double metal CMOS surface-mounted cerquad chips. These chips are the microprocessor (CVAX) and floating point accelerator (CFPA), memory controller (CMCTL), Q-bus interface (CQBIC), and system support (SSC).

The Table lists the principal characteristics of these chips, which range in transistor count from 40,870 for the CQBIC to 180,000 for the CVAX CPU. (The MicroVAX 78032 microprocessor chip in the MicroVAX II contains 125,000 transistors.) The MicroVAX 3500/3600 clock, which in the MicroVAX II is implemented in the microprocessor chip, is provided in a separate, relatively simple custom CMOS chip in order to conserve pin allocations on the microprocessor chip and retain flexibility in modifying the processor's microcycle.

The reasons for implementing so much of the CPU's functionality in VLSI were not unusual: more functions could be designed in less space on the module and, in sufficiently high volume production, hardware

Table—Double Metal CMOS Surface-Mount Cerquads (Feature Size 2 μ)

Custom Chip	Die Size (mm x mm)	Number of Transistors	Number of Pins	Spacing (mils)	Power (mW)	Clock (MHz)
CVAX	9.7 x 9.4	180,000	84	50	2.5	20–22
CFPA	7.3 x 9.1	60,000	68	50	1.1	20–22
CMCTL	7.9 x 7.6	25,000	132	25	1.8	20–25
SSC	8.5 x 7.5	83,000	84	50	1.0	20 MHz–25.6 KHz
CQBIC	9.2 x 9.4	40,870	132	25	1.5	20

cost could be reduced with a design based more on discrete chips. On the other hand, there was an unusual degree of risk in depending so completely on brand-new custom chips. In contrast, with the exception of its microprocessor and FPA chips and two gate arrays, the MicroVAX II was implemented predominantly with off-the-shelf hardware.

Digital's semiconductor development group designed the custom VLSI chips with distinct VAX-oriented partitioning so the chips could also be applied to equivalent functions in other MicroVAX CPU products. For example, the SSC chip could be used on new designs using the MicroVAX microprocessor, replacing what are now several system support chips. Second-level cache control logic isn't integrated into a custom chip because sufficient module space was available to use discrete components.

To reduce time-to-market for the new CPU module, the custom chips, second-level cache, and module-level circuitry were all designed concurrently. To allow testing before hardware was built, there was extensive module-level simulation throughout most of the design process.

Whereas the MicroVAX II CPU design only required individual simulation of the microprocessor, FPA and gate array chips, all MicroVAX 3500/3600 custom chips, and the second-level cache were first simulated individually and then together as parts of a complete CPU. The designers of each chip had to assume the characteristics of its interfacing chips until the first chip prototypes became available. Extensive use of simulation shortened time-to-market because a number of design bugs were identified early in the development cycle.

The MicroVAX 3500/3600 was one of the first two Digital development projects to use DECsim simulation software at the module level. This highly compute-intensive software was run on a VAX 8650 computer, as well as on numerous networked MicroVAX IIs.

Memory Controller Subsystem

In both the MicroVAX II and 3500/3600, the primary function of the memory controller subsystem, which serves both the CVAX/FPA and Q-bus interface subsystems, is to perform read/write operations and to keep the memory RAMs refreshed. The MicroVAX II's memory controller subsystem is dual-ported to minimize the impact of DMA memory accesses on CPU performance by providing DMA devices and the microprocessor with different data paths into memory. Microprocessor, DMA, and refresh cycles are all interleaved.

It was possible, on the other hand, to use a less complex, single-ported design in the MicroVAX 3500/3600's memory controller subsystem because of significantly reduced traffic between the CVAX/FPA and memory. Traffic is reduced because most microprocessor memory accesses hit in first-level cache (and so never leave the microprocessor chip) and also because the remaining accesses are multiword transfers. The reduced microprocessor traffic allows microprocessor and I/O accesses to main memory to share a single data path on the internal bus. Multiword transfers from both directions use the shared bus more efficiently.

A new 8-Mbyte quad-size memory module permits as much as 32 Mbytes of main memory in the BA213 enclosure (occupying four of its 12 slots). These slots are linked to the CPU module by means of an independent local interconnect, which consists of special control signals on the CD rows of the backplane and a 50-pin ribbon cable for data. With the memory modules thus linked directly to each other, control signals, addresses, and data flow between CPU and memory modules without using the Q-bus.

The new memory module provides two features not available in the MicroVAX II—page mode and error correction code (ECC). Page mode, which supports multiword transfers from both the microprocessor and Q-bus, allows memory access through multiple column addresses following each row address, rather than one for one. Because the MicroVAX 3500/3600's main memory can be four times the size of the MicroVAX II's, the MicroVAX 3500/3600 needs the higher data integrity that ECC offers over the byte parity method. ECC detects and corrects single-bit errors and detects double-bit errors, in contrast to single-bit detection only for byte parity.

The larger main memory of the MicroVAX 3500/3600 also indicated a need for a faster mechanism for power-up memory testing. The MicroVAX II user may have to wait as long as 30 sec. while each bank of up to 16 Mbytes of main memory is tested in sequence. The MicroVAX 3500/3600 tests all banks of up to 64 Mbytes of RAM simultaneously in about 15 sec.—less time than for testing 8 Mbytes in the MicroVAX II.

Decoupling I/O, Memory Design

The I/O and memory subsystems were designed to accommodate processor microcycle times anywhere between the expected maximum of 100 nsec and 80 nsec, rather than a single known microcycle as with the MicroVAX II. This approach was necessary because, to shorten development time, all subsystems were designed in parallel with the microprocessor; early simulations of the CVAX chip showed that its microcycle could be at least 100 nsec and possibly shorter. The opportunity to anticipate later upgrades of the CPU module's performance with faster microprocessor chips was also there.

In the interest of higher CPU speed, common practice in single-

module CPU development is to design (as much as possible) the CPU to operate synchronously with the known processor microcycle, at the same time recognizing that memory references by peripheral devices on the I/O bus are inherently asynchronous. In the MicroVAX II, the Q-bus interface subsystem is, therefore, asynchronous on its Q-bus side but synchronous for memory accesses on its CDAL internal bus side.

In the MicroVAX 3500/3600, design of the Q-bus interface and memory controller subsystems was decoupled from design of the CVAX/FPA subsystem. Decoupling the Q-bus interface subsystem permitted optimizing Q-bus performance independently of the processor cycle time. Similarly, it was possible to optimize memory performance at both 100 and 80 nsec.

Design of the MicroVAX 3500/3600 Q-bus interface subsystem was decoupled, in part, by making its memory accesses asynchronous on its CDAL bus side as well as on its Q-bus side. Asynchronous DMA accesses to memory require additional CDAL bus bandwidth, but any effect on CPU performance is offset by the first-level cache keeping most of the microprocessor's memory accesses entirely off the CDAL lines.

Design of the synchronous memory controller subsystem was decoupled by allowing the choice of adding a wait state for correlating the CVAX microcycle (100 nsec or lower) and the fixed main memory cycle time (400 nsec or longer for one address longword and one data longword). By setting or not setting a bit position in the memory controller, a wait state is disabled or enabled in order to establish the number of CVAX microcycles the memory controller uses to access the memory RAMs.

With the wait state in the memory controller disabled, each longword transfer requires four CVAX microcycles. At the expected maximum CVAX microcycle of 100 nsec, reading a longword from main memory takes 400 nsec (4 x 100). With the wait state enabled, each longword transfer requires five microcycles. At the expected minimum CVAX microcycle of 80 nsec, a longword read from main memory also takes 400 nsec (5 x 80). Therefore, at both 100 nsec and 80 nsec microcycles, the bus transfer time for reading one longword equals the minimum main memory cycle time of 400 nsec.

Design Focus: Effective Memory Cycle Time

A CVAX microcycle of 100 nsec, compared with the 200-nsec microcycle of the MicroVAX II, would itself only double the speed of the CPU (and the minimum projected microcycle of 80 nsec wouldn't do much better). Both memory systems have a minimum main memory cycle time of 400 nsec, their speed being limited by the standard dynamic RAMs used in main memory. How, then, could CPU performance be further improved?

CPU performance is usually limited by effective memory cycle time, which can be reduced even though the processor and main memory cycle times are unchanged. Effective memory cycle time is the average time required to move one longword between the processor and memory.

Two CPU design techniques, caching and multiword transfers, reduced the effective memory cycle time of the MicroVAX 3500/3600 from 400 nsec to 115 nsec, only 27% longer than the CVAX microcycle of 90 nsec. In contrast, because it has no cache and uses single-word transfers, the MicroVAX II's effective memory cycle time is 400 nsec, the same as the minimum main memory cycle time. The MicroVAX 3500/3600's CPU performance is, therefore, more than three times that of the MicroVAX II.

Two-Level Cache

Most of the decrease in effective memory cycle time is provided by the two-level cache architecture. Without multiple-word transfer, the two-level cache reduces effective memory cycle time to 131 nsec.

The first-level cache is built into the CVAX chip itself; its 1-Kbyte size occupies the largest chip area that the semiconductor designers were able to allocate for cache. The 64-Kbyte second-level cache is implemented on the CPU module and also occupies the largest module area that the CPU designers were able to allocate (the next step up in second-level cache size would require considerably more space). The size of the data block is one quadword, or 8 bytes, in each.

Whenever the microprocessor requires data or instructions, it checks the first-level cache to determine whether the content of the specified memory location is stored there. If there is a hit in first-level cache—which happens approximately 70% of the time—the microprocessor retrieves the data block associated with the referenced address. If a miss, first-level cache control logic passes the address to the second-level cache and main memory simultaneously.

If there is a hit in second-level cache—which happens approximately 25% of the time—the referenced data block is transferred to both the first-level cache and microprocessor. Meanwhile, the memory controller, sensing that the second-level cache has responded, aborts its own response (the second-level cache has long since completed the transfer back to the CVAX chip). If there's a miss in second-level cache, the memory controller retrieves the requested data block from memory and transfers it to both the second-level cache and CVAX chip for the microprocessor and first-level cache.

The first and second levels, together, handle 95% of cacheable bus transactions (noncache transactions result from interlocked instructions and I/O page references). The first-level cache helps increase CPU performance by storing high frequency accesses, the second-level cache by storing medium frequency accesses. Low frequency accesses are momentarily stored in each, but are quickly replaced.

Multiword CVAX-Memory Transfers

Transactions between the CVAX chip and main memory consist of multiplexed transfers of addresses and data through the chip's 32 I/O pins and the CDAL bus. In single-word transfers, as in the MicroVAX II, each transfer is a two-part bus transaction involving an address and one data or instruction word. (In 32-bit systems, the word is actually a longword.)

In multiword transfers, each address is followed by two or more data words, and the effective transfer time per word is reduced. The reduction can be substantial in applications where most bus transfers consist of many data words in sequential memory locations following the address of the first word.

Simulations indicated that maximum reduction in effective memory cycle time could be achieved with min-

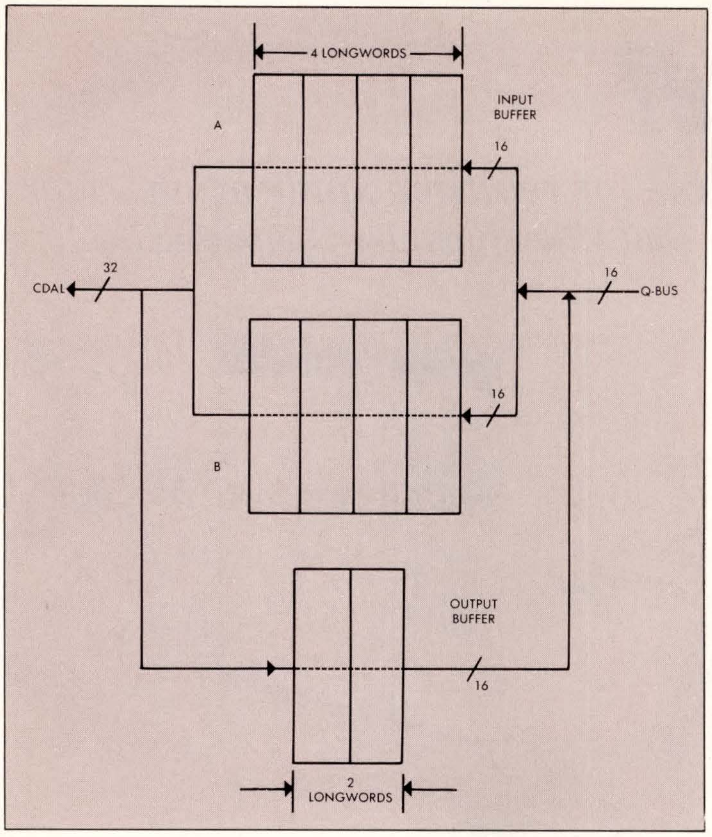


***Figure 3**—A buffer array in the Q-bus interface subsystem packages individual words of Q-bus data into octawords (two longwords) for transfer over the CPU's CDAL internal bus.*

imal complexity by making the size of multiword transfers equal to a quadword—the size of data blocks in the two-level cache. On bus transactions to cache that miss in first-level cache, the MicroVAX 3500/3600 takes advantage of the memory RAM array's page mode capability. It transfers two longwords (one quadword) of data or instruction for each longword of address the microprocessor issues onto the CDAL bus. The transfers are executed via quadword bus protocols in second-level cache and in the memory controller subsystems.

At the actual CVAX microcycle of 90 nsec, the wait state in the memory controller subsystem is enabled, so that the memory cycle times are 450 nsec for the first longword and 270 nsec for the second longword. Note that the memory controller is cycling the memory RAMs more slowly than the minimum 400 nsec. The performance loss is negligible, however, because the microprocessor is only accessing main memory 5% of the time.

Multiword transfers between the CVAX chip and second-level cache or main memory complete the reduction in effective memory cycle time to 115 nsec.

Bus Interface Subsystem

Multiword transfers from DMA devices on the Q-bus side of the memory controller subsystem, while having no effect on CPU performance, help improve system performance. The Q-bus interface subsystem transfers asynchronously as many as four longwords of data (one octaword) for each address, the largest multiword transfer supported by the memory controller (page mode itself supports multiword transfers of up to 16 longwords). For a 90-nsec processor microcycle, asynchronous transfer time for an address and octaword of I/O data is 1170 nsec, in contrast to 1440 nsec if four longword transfers were used.

On block mode DMA writes, a buffer array in the CQBIC chip (Figure 3) packages individual words of Q-bus data into octawords for transfer over the longword-wide CDAL bus. Eight 16-bit-wide locations in buffer A fill up first and form four longwords, which are then transferred in sequence over the CDAL bus as an octaword following the first longword's physical address. In the meantime, buffer B is being filled. Before buffer B is full, buffer A completes its transfer and is ready to be filled again so the cycle can be repeated.

Data blocks smaller than an octaword are transferred as one to three longwords; data blocks smaller than a longword are transferred as a masked longword. On block mode DMA reads, quadword transfers back from memory to the CQBIC chip's I/O buffer are handled by a two-longword output buffer.

The MicroVAX 3500/3600's CPU, like the MicroVAX II's, includes a scatter-gather map to translate between 22-bit Q-bus virtual addresses and CDAL physical addresses—it's 26 bits wide for the MicroVAX 3500/3600 compared to 24 bits wide for the MicroVAX II. The Q-bus interface control logic of the MicroVAX II is linked to a separate scatter-gather RAM array via a dedicated bus.

But there wasn't enough space on the CQBIC chip for either the required 32 Kbytes of scatter-gather map or the more than 30 additional pins that a dedicated scatter-gather bus would have required. Therefore, a Q-bus map cache that required little space and no additional pins was implemented on the CQBIC chip. The 32-Kbyte scatter-gather map is located in main memory so that map accesses require neither a dedicated bus nor space on the CPU module for a mapping RAM array.

When the Q-bus interface subsystem receives a 22-bit Q-bus address, a hit in the Q-bus map cache means that the 26-bit CDAL address is immediately available on the CQBIC chip. If there's a cache miss, the base register in the CQBIC chip's map points to the scatter-gather map in main memory. The appropriate scatter-gather map entry is transferred over the CDAL bus to the CQBIC chip, where the desired CDAL address is assembled. At the same time, the scatter-gather entry is stored in the Q-bus map cache for that Q-bus address.

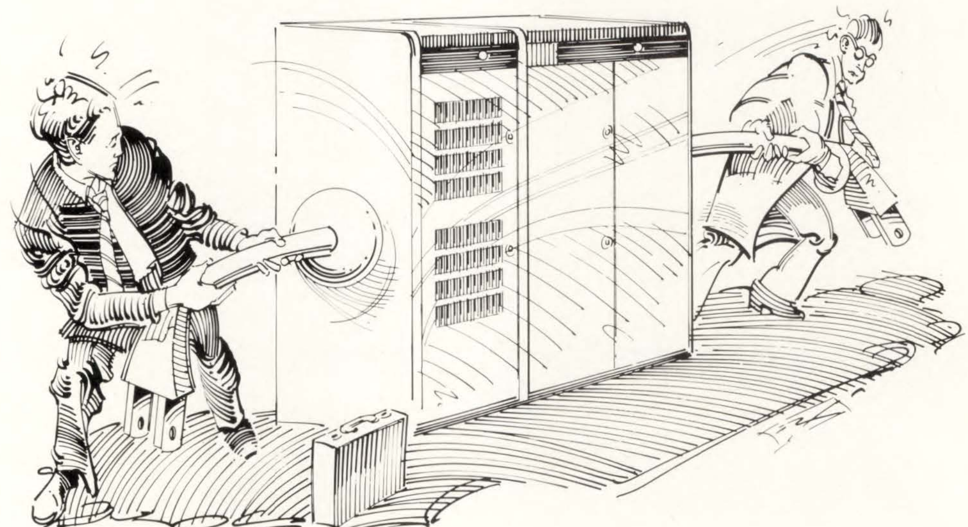
The Q-bus map can contain up to 16 scatter-gather map entries, each of which translates the addresses associated with one page (512 bytes) of memory. If four pages of memory are assigned to each of four DMA devices—one disk controller, one tape controller, and two communications controllers, for example—then all address translations for those devices are handled at maximum speed in cache on the CQBIC chip.

VMS For Realtime?

Many claim that VMS isn't suitable for realtime applications, but Century Computing disagrees/by Phil Miller [Century Computing Inc.]

Is VMS a suitable operating system for realtime applications? This article concludes that, for a large class of applications, VMS is an excellent realtime operating system. Users are generally pleased with VMS for realtime, and techniques exist for bypassing some VMS weaknesses.

For the purposes of this article, realtime is defined as an application where the software is expected to respond to external events within a short, predefined time from the occurrence of each event. If the response doesn't occur within the time limit, then an error condition exists, and data may be lost or system output may be too late to be effective.


ROGER XAVIER

A sample configuration demonstrating the viability of VMS as a realtime operating system might consist of a disk-based computer with multiple, interactive users or operators monitoring realtime operations. For lack of a better term, applications running under this configuration are referred to as realtime data systems. An example might be a satellite ground system based on a VAX-11/780-class machine: satellite telemetry (and possibly payload data) is received and processed in realtime, with various online displays of the satellite's status.

Realtime data systems can be distinguished from diskless processors that are integrated within a larger system. Flight control applications, front-end communications processors, and intelligent device controllers are examples of this embedded application class.

VMS For Realtime?

Many claim that VMS isn't suitable for realtime applications. Such claims are often traceable to one or more of the following:

- *Definition of realtime*—VMS isn't designed to handle all realtime applications. For example, there's no diskless version of VMS, and, consequently, most embedded applications are not suitable for VMS.
- *The mainframe operating system myth*—Because VMS has the features normally associated with a mainframe operating system—batch processing, time-sharing, sophisticated file systems, demand paging, print spoolers, etc.—people assume that realtime applications are out of the question. This conditioning exists as a result of IBM mainframe operating systems where online is a struggle and realtime isn't practical. What makes VMS a major technical achievement is that the mainframe features are present in conjunction with realtime responsiveness.
- *VAXELN marketing*—VAXELN is often thought of as Digital's proposed solution for a VAX realtime operating system; the consumer is now being led to believe that VAXELN is *the* realtime operating system and that VMS is the "other" operating system.
- *The cluster conflict*—Digital cautions against using clusters for realtime applications. One reason is an extended loop in VMS that runs at a high interrupt priority level (synchronizing members of the cluster). Another reason is that Digital wants the flexibility to make changes in the cluster software that might conflict with realtime.

" . . . low priority processes generate realtime terminal displays, usurping the processor from higher priority processes. . . . "

VMS is a general-purpose operating system, but with the capability for supporting realtime applications. Running realtime under a full-function operating system has many advantages:

- *Development and execution under the same operating system*—Because VMS supports a powerful software-development capability, development and execution are under the same operating system.
- *Use of nonrealtime features*—A realtime system often contains nonrealtime components that need the functionality associated with online—

Phil Miller, co-founder of Century Computing Inc. (Laurel, Md.), a data systems development company, holds a B.S. in math from Georgia Tech and an M.S. in computer science from Purdue.

as opposed to realtime—systems. An online system is defined as one responding to external events, but the events are usually human-generated and occasional sluggish response is acceptable.

Multiple Levels Of Functionality

VMS provides multiple levels of functionality. The programmer may use high level features—and accept associated performance penalties—or use low level features for high performance.

If the file I/O supported by a high level language doesn't provide sufficient throughput, then a program may call RMS directly; if RMS is too slow, then the program may issue I/O requests directly to the disk driver. Figure 1 illustrates the levels of file I/O.

If a program cannot withstand the overhead associated with paging and swapping, the program may be locked into memory.

If DECnet/Ethernet is inappropriate, special-purpose protocols may be implemented by issuing I/O requests to the Ethernet driver. If the VMS standard Ethernet driver isn't suitable, an installation may implement a homegrown Ethernet driver.

If issuing VMS I/O requests to a special-purpose device is too slow, a program may map directly to the device's registers and issue hardware commands from process level.

Interrupt Response

One critical measure of a realtime operating system is the interrupt response time, which can be defined as the time between the external device's request for an interrupt and the execution of the first "useful" instruction in the corresponding device driver.

For VMS, the number and nature of the instructions involved in interrupt response varies according to the processor type, but the code for a number of processors suggests an efficient interrupt response architecture. On the MicroVAX II, 11/750, 8200, and 8800, there are two VMS instructions from the point of the interrupt until entrance into the device driver; on the 11/780 and 8600, there are seven such instructions. For all processors, the driver itself must execute about three additional instructions to establish the proper context for performing useful work.

At the Fall, 1986 DECUS symposium, Richard Somes presented interrupt response times for the MicroVAX II. His data is quite valuable, indicating an average response time in the 40-μsec range.

Occasionally, there are wild deviations from this average response due to higher priority interrupts and elevated interrupt-level processing by various VMS modules. The potential for extended response times is a major design constraint for realtime systems; the standard approach is to place buffering and intelligence in the device controllers, minimizing the response burden on the central processor.

Context Switching Overhead

Context switching overhead is the time required to save the context of one process, decide on the next process, restore the context of the new process, and begin execution in the context of the new process. In realtime applications, a number of concurrent, communicating processes are used, and the time for the operating system to switch control between processes is critical. The speed of context switching is also an issue with respect to process-level response to a device interrupt.

VMS context switching is very efficient; most of the work is performed by the microcode associated with the save context, load context, and return from interrupt instructions. The logic to select and activate the highest priority process from the ready to run queue consists of 20 instructions and no loops.

Efficiency Of System Services

For realtime applications, the VMS system services of greatest interest are:

- timer,
- event flag manipulation,
- create process, and
- I/O request.

Approximately 1.5 msec of VMS overhead is required to handle a queue I/O request (QIO) on a VAX-11/780. This time is required to initiate I/O, field the interrupt, and return to the process level. The measurement includes the device driver processing for a reasonably straightforward DMA device. Though QIOs are time consuming, systems typically have controllers that support large DMA transfers, thereby minimizing the QIO overhead. It's the QIO rate—not the data rate—that drives operating system overhead.

The other realtime services are considerably faster than the QIO; most of the services run less than 200 μsec on a VAX-11/780. There are virtually no situations where one of these realtime services can enter an extended loop or unexpectedly block the requesting process.

Realtime VMS: Some Problem Areas

Some weaknesses exist in using VMS for realtime, but workarounds address these problems.

Process creation is slow. It's common to see about 1 sec. of elapsed time for the creation of a process on a VAX-11/780. In addition to process creation, the loading of a disk-resident program into an existing process is slow.

If programs must be efficiently activated in realtime, several techniques are available to work around the sluggishness of process creation and program loading. If sufficient memory is available, the programs can be run dur-

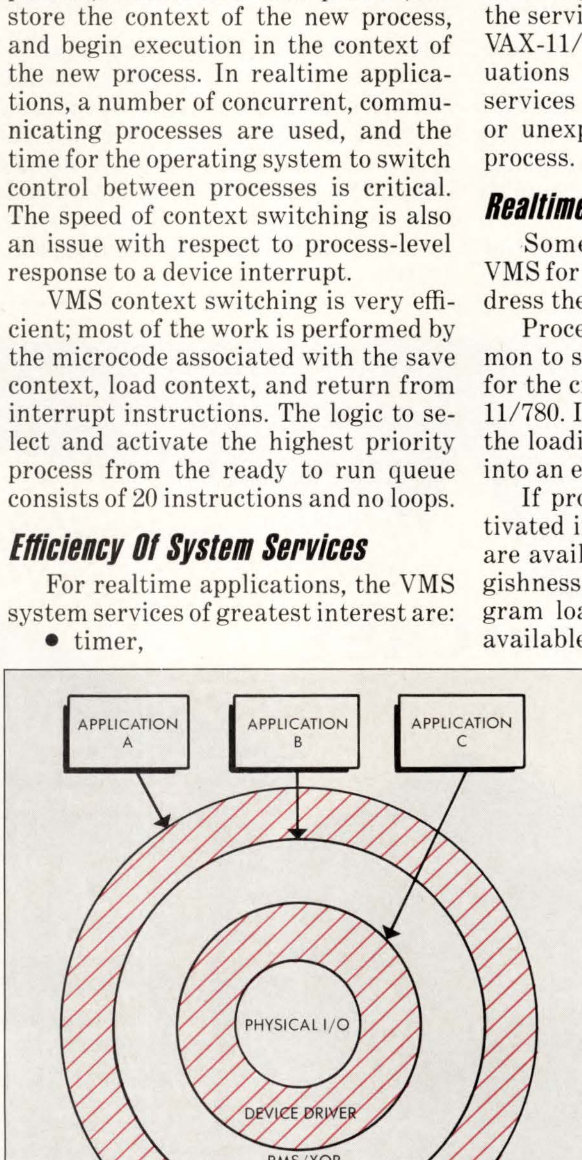


Figure 1—*For file I/O, VMS includes multiple levels of functionality: application A uses language features for I/O, B makes calls to RMS, and C issues QIOs directly to the disk device driver.*

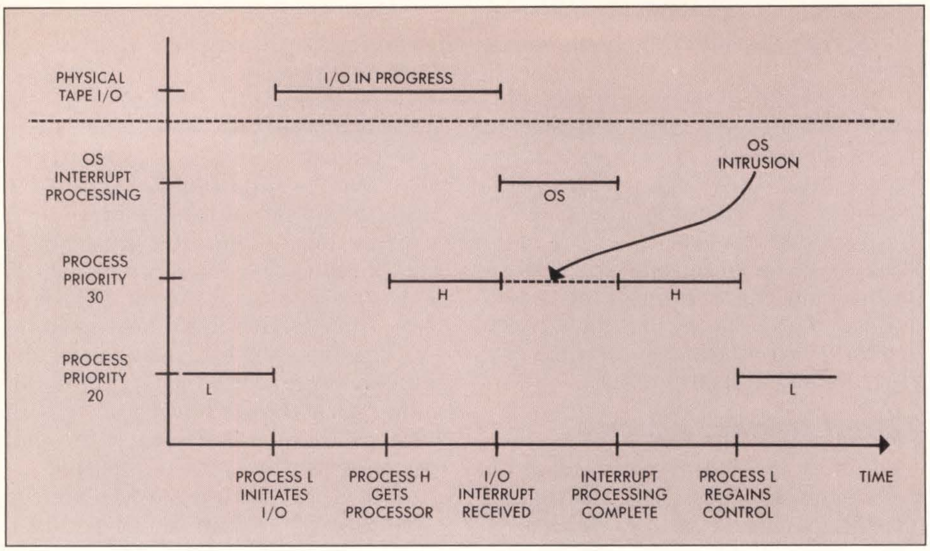


Figure 2*—Operating system intrusion, as demonstrated in this example, is a main concern for realtime applications.*

ing initialization, locked into memory, and stored there until needed. If memory is tight, then the programs can skip memory locking and migrate to disk via paging and swapping. Resuming such programs in realtime is reasonably efficient.

If running programs during initialization isn't practical, there's a scheme called process pooling, where a pool of processes is created during initialization. When a program must be executed in realtime, the program is run in the context of an available process selected from the pool. This technique avoids the realtime overhead of process creation (but still incurs the program activation overhead).

Operating System Intrusion

The VMS priority scheme reserves process priorities 16-31 as realtime, with enforcement of the traditional scheme where the highest priority process wanting the processor has the processor. For processes with priorities in the 1-15 range, VMS performs automatic priority adjustment in order to optimize time-sharing and batch performance.

A critical characteristic of an operating system is the level of intrusion on the realtime priority scheme (i.e., processing performed by the operating system that is higher priority than any realtime process priority). The classic example of intrusion is illustrated by the following scenario (Figure 2):

- Process L at priority 20 issues a magnetic tape read request and waits on I/O completion.
- Process H at priority 30 begins to execute.

• While H is active, the interrupt from L's read request is received, and the device driver takes control. The driver converts a 32-Kbyte data record from EBCDIC to ASCII, usurping H's demand for the processor.

In this example, H is intruded upon by the operating system. This particular scenario is an example of priority inversion, where the lower priority L, in effect, usurps the processor from the higher priority H.

Fortunately, this particular example does not apply to VMS; the magnetic tape device driver is efficient, and data formatting is performed at process priority level 8, where the magnetic tape ancillary control process executes. However, VMS does have intrusion, and some of the intrusion is severe. The following are known sources of nontrivial VMS intrusion:

• *Cluster synchronization*—This is achieved using an extended VMS loop running at high interrupt priority that examines the failure of another cluster member.

• *DSA drivers*—The device drivers associated with Digital Storage Architecture (DSA) disk controllers have substantial error recovery logic that runs at high interrupt levels. Though unrelated to processor intrusion, this recovery also blocks the disk's I/O request queue until the recovery is complete.

• *Terminal handling*—The interrupt processing for terminal I/O can generate substantial intrusion. The DMA terminal multiplexers minimize this problem, but designers should still measure the amount of overhead involved in handling terminals. Terminal handling presents a classic case of priority inversion: low priority processes generate realtime terminal displays, usurping the processor from higher priority processes.

• *Application-specific drivers*—User-written drivers should minimize the processing performed at high interrupt levels. For example, any routine data processing is best deferred to process level.

In addition to processor intrusion, there's also intrusion presented by disk I/O: disk operations from a low priority process often cause a high priority process to wait longer for disk access. Though certainly not unique to VMS, this form of intrusion is made somewhat worse by the DSA controllers, where there is no prioritization of I/O.

VMS is suitable for the class of realtime applications that are characterizable as data systems. There are some problems with VMS for realtime, but reasonable workarounds exist.

Digital is drifting away from VMS support for realtime. Signs of this drift are the VAXcluster conflict with realtime and the lack of prioritized I/O in the DSA disk controllers. Digital is, of course, most concerned with making modifications to VMS that will make it more acceptable to corporate computing environments, so it remains to be seen how well future versions of VMS will support realtime applications.

Readings In VMS For Realtime

• "Real Time Throughput of MicroVAX II and MicroVMS," Richard K. Somes, Proceedings of the Digital Equipment Corp. Computer Users Society, Fall 1986, page 51. Though the proceedings carry only (sketchy) notes from the speaker's presentation, the interrupt response timetables are invaluable. The author shows that, though the average response is about 40 msec and the 99 percentile response is less than 100 msec, occasional responses might drift considerably higher. Some of the wild points were due to inefficiencies in the QVSS software supporting the author's graphics device.

• "Disk System Latency in VAX/VMS," Richard F. Wrenn, Mark Freeman, Proceedings of the Digital Equipment Corp. Computer Users Society, Spring 1984, page 499. Although this paper does not directly address realtime issues, the authors do present insights on VMS performance, especially concerning the optimizations present in DSA and HSC50 controllers.

• "Disk System Performance in VAX/VMS," Richard F. Wrenn, Proceedings of the Digital Equipment Corp. Computer Users Society, Spring 1983, page 339. This is an earlier version of the 1984 paper mentioned previously. This paper makes some important observations on prioritized I/O requests and the realtime consequences of QIO re-ordering by DSA controllers.

• "Digital, RT-11 Users Continue Dispute Over Realtime Operating System for the VAX," Milton Campbell, *Hardcopy* magazine, March 1987, page 77.

—*P.M.*

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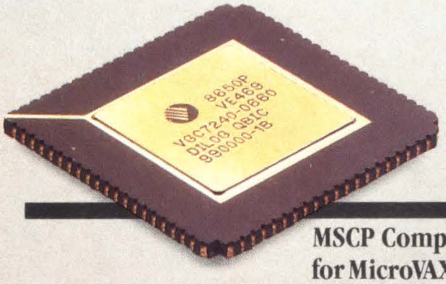

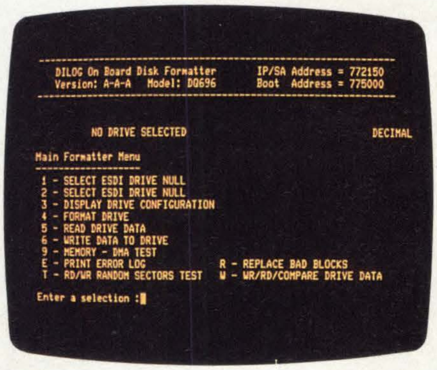

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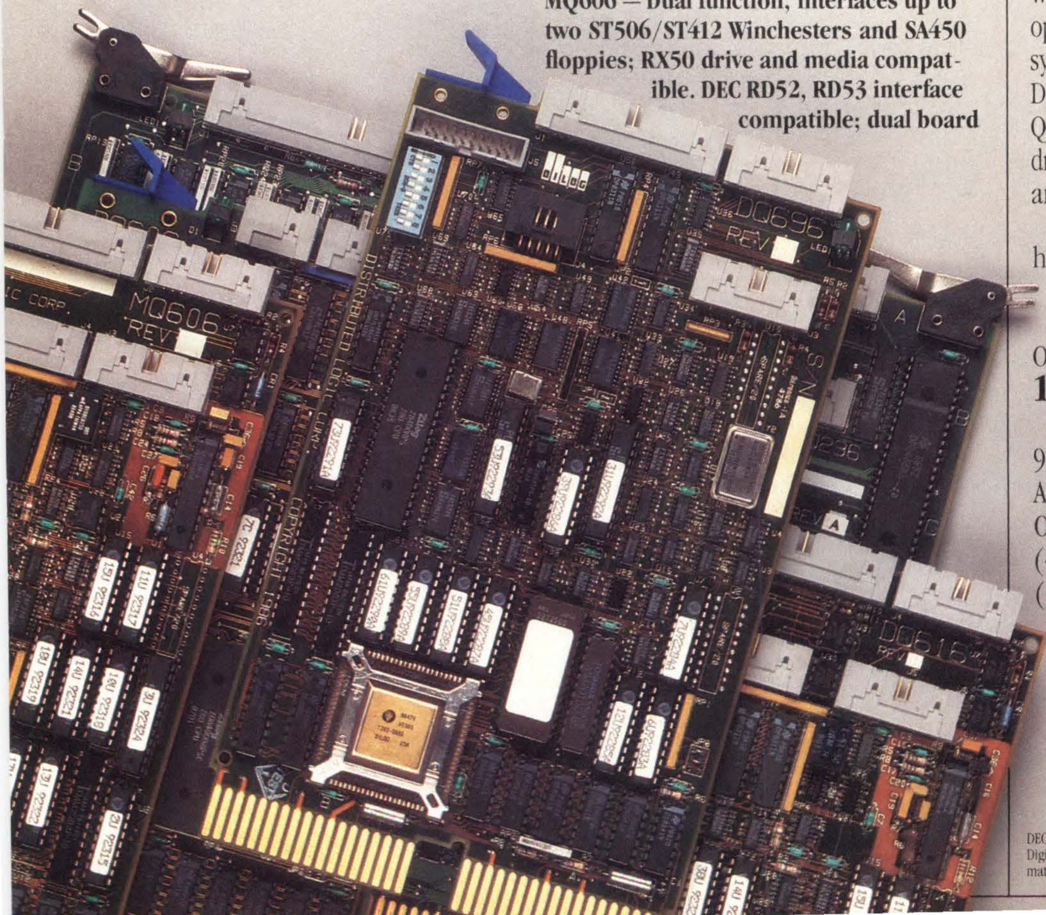

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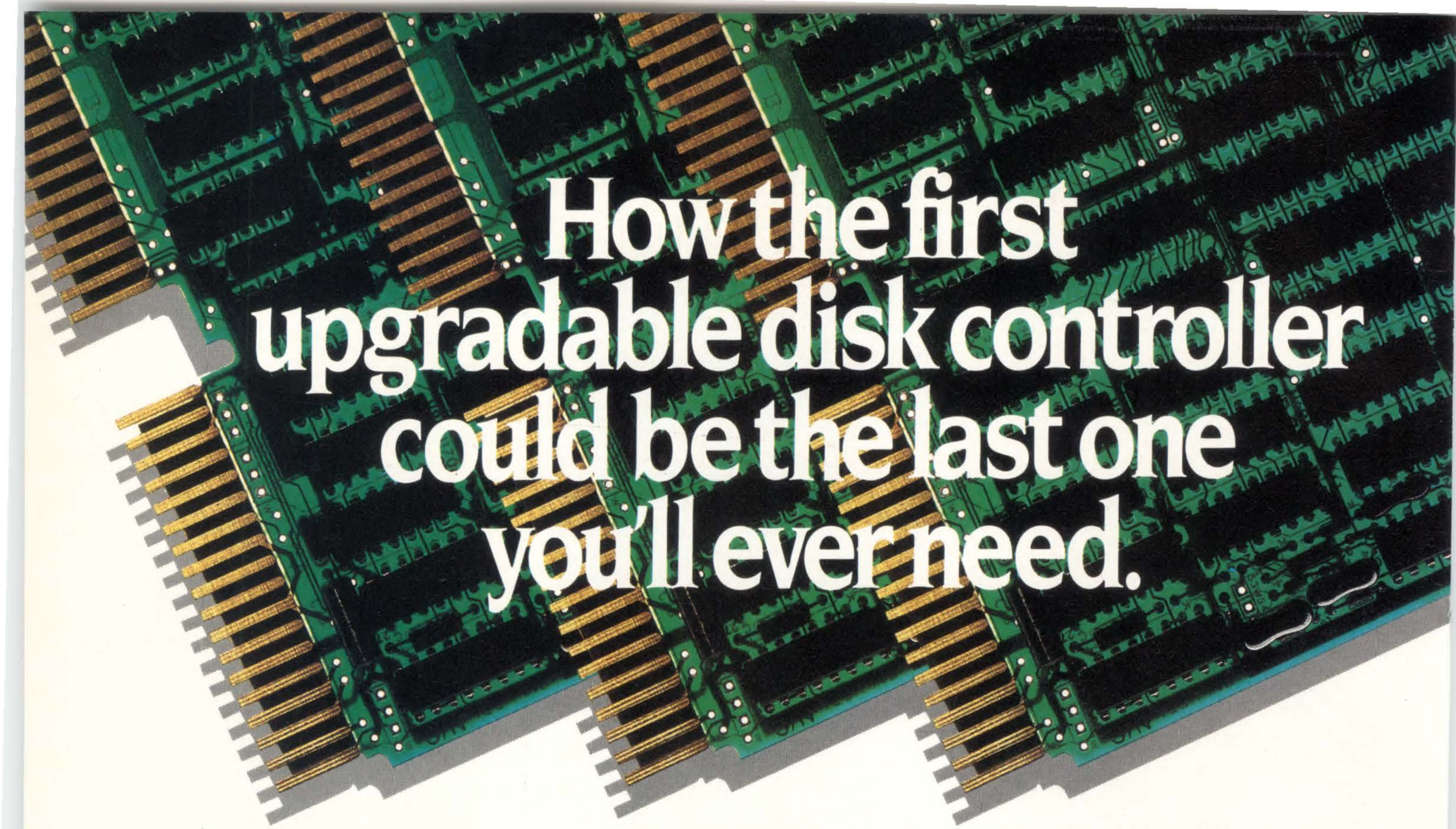

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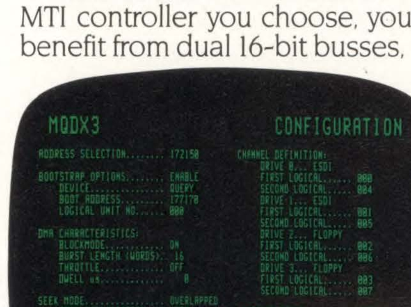

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VAX Storage Forecast: A Growing Third Party Market

Vendors are packing more storage in and on VAX systems with everything from 3½-in. Winchester disks to multi-Gbyte 14-in. subsystems/by Carl Warren

It may seem that with all the PC fever going around, no one would be interested in adding anything to something as impersonal as Digital Equipment Corp.'s VAX or MicroVAX systems. But just the opposite is true (Figure 1).

Indeed, storage system market analyst, Dataquest Inc.'s (San Jose, Calif.) Phil Devin, is predicting that by 1990 end-user sales of rigid disk drives in the Digital (VAX and MicroVAX) market will exceed $130 million. And vendors of optical disks can expect to have "... $25 million to spend in 1990. ..."

Devin says that although current Winchester add-ins and add-ons range from 5¼ to 14 in., the trend will most likely be to smaller form factors during the next few years. "What we are seeing is 5¼-in. Winchesters providing capacities that make sense on VAX-type systems."

For example, running fast in the storage subsystem attachment race is U.S. Design Corp. (USDC). The company, a captive subsidiary of Maxtor Corp., is planning to offer Q-bus users a subsystem incorporating Maxtor's Model XT-8760E, 765-Mbyte, 5¼-in. enhanced small device interface (ESDI) Winchester. The subsystem, dubbed the VIP, costs about $37,000 and is configured as 3 Gbytes of unformatted storage using multiple drives.

As enticing as the advanced storage technology may sound, it's still at the ship-and-return stage. The Maxtor drive, introduced last year, is shipping in evaluation quantities. Companies such as Emulex Corp. and System Industries (SI) are among the Digital add-on vendors who are evaluating the hefty storage device for possible future products. An SI spokesman claims that SI is "... taking as many of the 765-Mbyte drives as we can get."

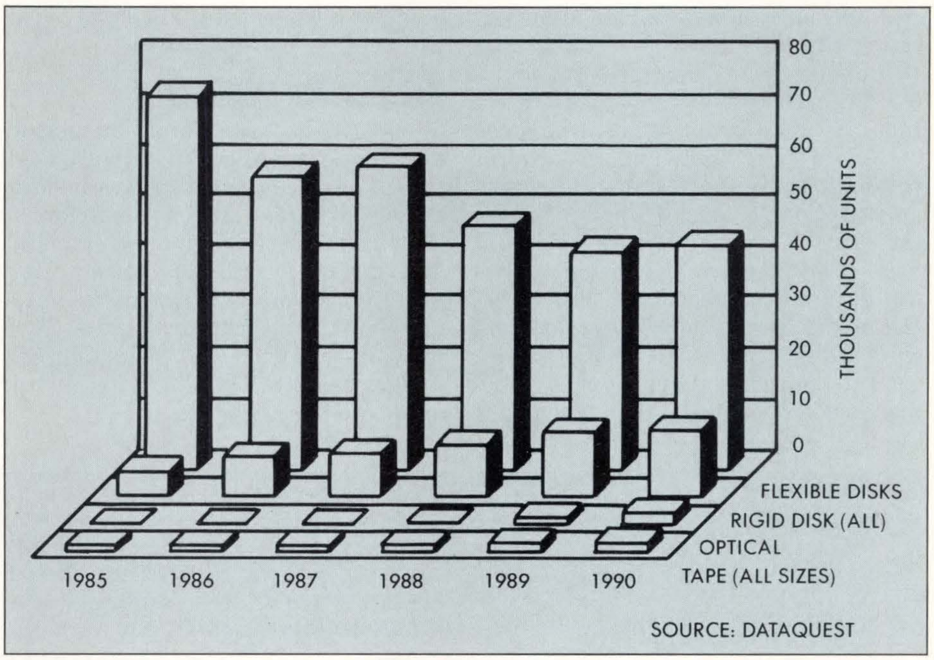

Figure 1—*Projections for total Digital third party peripheral drive units shipped show a stabilizing in flexible disk sales and a consistent increase in rigid disk sales.*

Currently, Emulex is providing subsystems using 170- and 380-Mbyte 5¼-in. Winchester drives from Control Data Corp. and Maxtor. Larger form factors use Fujitsu drives with the extended storage module drive (ESMD) to obtain the 3 Mbyte/sec. transfer rate needed on fast machines like Digital's 8000 series.

For the most part, manufacturers of VAX add-ons such as Emulex and SI tend to lean toward the larger form-factor drives. SI has, in fact, begun shipping a new version of its C-series subsystems that contains an NEC Information Systems Inc. 1.1-Gbyte 9-in. drive. This represents a marked change for SI since it has primarily relied on Fujitsu for high performance drives.

Consider The Smaller Package

Not all the storage performance is in 5¼-in., or larger, form factors. Among the newest contenders for add-on business, such as the MicroVAX, is newcomer, Conner Peripherals.

Conner currently isn't well-known as a supplier to Digital system add-on vendors. The company supplies Compaq with 3½-in., high performance Winchester drives for the Portable III and Deskpro 386, and is looking at the PC market as a prime source of revenue. Its newest models, the CP342, 40-Mbyte formatted and CP-3100 100-Mbyte formatted drives, offer Mi-

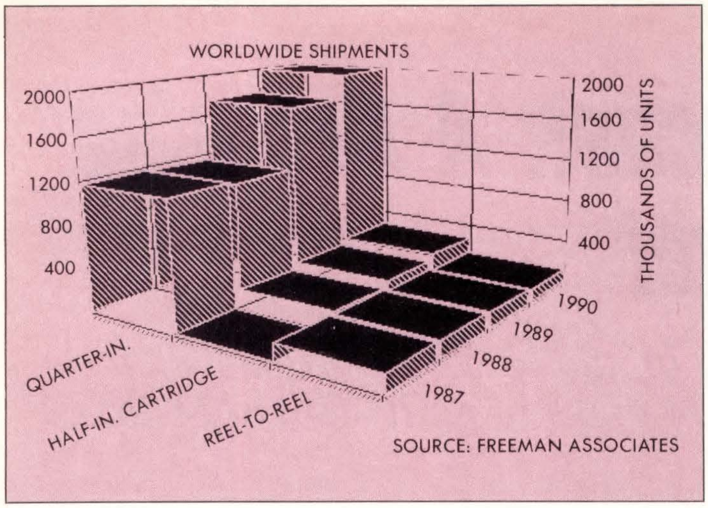

***Figure 2**—Projections for worldwide shipments of tape drives show ¼-in. expanding rapidly.*

croVAX subsystem vendors an interesting alternative.

Conner uses common command set (CCS) small computer systems interface (SCSI) for its general-purpose drives, but isn't limited in interconnect possibilities. In fact, Conner developed a tightly coupled bus to function in concert with Compaq. Rather than use SCSI host adapters, the backplane bus signals are extended to the drive. A series of gate arrays and application-specific integrated circuits (ASICs) are used to convert the bus signals to the drive's needs, and vice versa. The result is faster data transfer and better utilization of the bus and drive.

Debating The Interface

Most Q-bus and BI add-on vendors are relying on either the standard Digital-supplied controller or a translator system to match an SMD interface to the backplane. The enhanced small device interface (ESDI) seems tailor-made to match the performance of the drives to the bus characteristics. Similarly, it's expected that ½-in. tape cartridges using ESDI will find their way onto both buses as well.

Interest in ESDI doesn't mean drive and subsystem manufacturers aren't interested in SCSI. Until recently, developers were reticent about employing SCSI due to a lack of an adequate protocol chip. Emulex has developed the Emulex SCSI Protocol (ESP) chip that allows full arbitration of the bus while maintaining 4 Mbyte/sec. transfer rates. This chip, combined with the company's merged architecture controller (MAC), buffer, and tape format chips, allows board designers to have full control over the SCSI environment.

No Format Problems

An enticing aspect of using SCSI in subsystem attachments is that the storage device can be made transparent to the rest of the system. Consequently, subsystem suppliers can be more inventive in the combination of drives, and efficient in the use of the storage media.

Transparency of the storage system to the host isn't necessarily counter to the performance criteria established by Digital either. The Mass Storage Control Protocol (MSCP) is part of the Digital Storage Architecture (DSA) defined by Digital. Both DSA and MSCP subscribe to the notion of disassociating the peripheral parameters from the host processor—a factor that makes

Confusion Over 3½-In. Cartridge Tape Standards

Despite the long history (about 10 yrs.) of cartridge magnetic tape storage, there are almost no standards available that define the performance you can expect from a drive, or regulate the interchangeability of information recorded on data cartridges.

There are interface standards. But these regulate plug compatibility or the ability of a component to plug and play. Such standards don't prescribe the performance of the drive, other than to set the maximum performance possible within that standard. Nor is performance guaranteed by either the interface or drive technology, largely because the software that controls reading, writing, and formatting also controls performance. A particular software driver might not take full advantage of the capabilities offered by either the drive or controller. Although drive vendors try to work closely with OEMs and system integrators, the drive or controller vendor cannot be certain that the programmer truly understands the hardware. As a result, the performance of products from two vendors might be radically different, although they both rely on exactly the same hardware. It's all in how the complete package is implemented. Thus, a SCSI-interfaced data cartridge drive might define the system requirements, but it won't tell you much about what you can actually expect.

There are two recording format standards used with the DC-2000 cartridge drives: QIC-40 and QIC-100. These formats attempt to standardize the three elements of interchangeability: physical size, physical format, and logical format.

In practice, the actual usefulness of such standards is hampered by the interpretation of the standards by the vendors. Another problem is that many vendors turn to proprietary formats in an attempt to reach data transfer rates, error rates, or storage capacities that can't be achieved with standard recording formats. As a result, the interchangeability of recorded data cartridges based on standards is not a reality. It exists only in those cases where the vendors have taken pains to ensure such compatibility.

Currently, only one company, Sytron Corp. has been able to achieve across-the-board interchangeability—at least in the PC world. Its SY-TOS tape operating system for DC-2000 QIC-40 drives has been adopted by more than a dozen third party PC add-on vendors, and is being eyed by envious Digital supporters as well. But company President Anthony Antonuccio is noncommittal on the future for SY-TOS on Digital equipment.

—C.W.

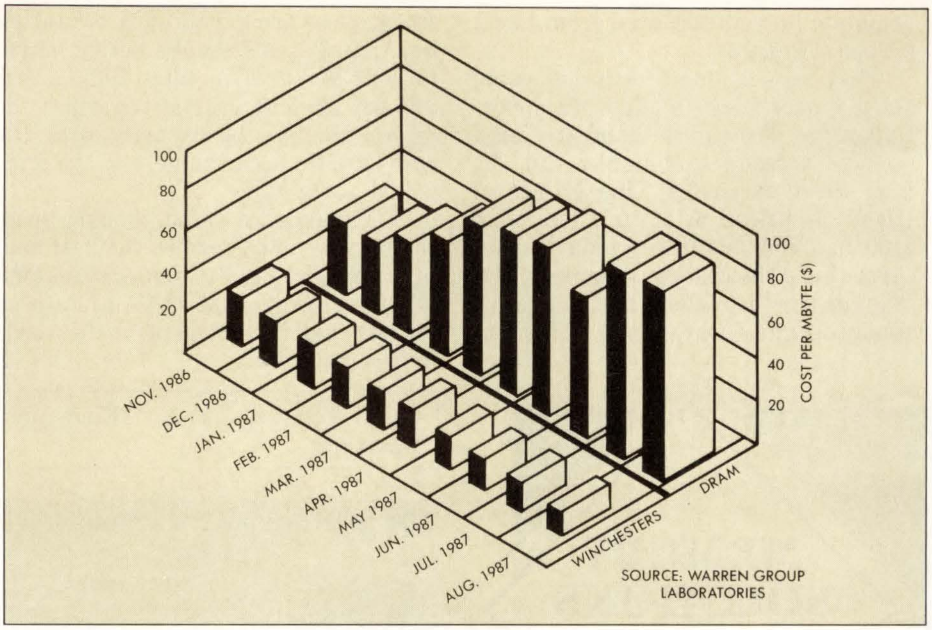

Figure 3*—A comparison of semiconductor vs. Winchester in cost/Mbyte shows an increase in the cost of high speed DRAMs and a decrease in the cost of Winchester storage. Today, 1 Mbyte of storage on a 5¼-in. Winchester costs about $10.90.*

SCSI a compelling approach to subsystem designers.

MSCP allows the mechanism to improve performance of the storage subsystem, verify proper controller operation, add sophisticated defect management facilities, and minimize host interactions during peak I/O loading.

Since MSCP is an interface between the host and peripheral controller, it can—and does—introduce excess overhead in the storage hierarchy. Thus, there is a worry about redundant latencies being incurred due to MSCP and SCSI. For example, a SCSI command can take as long as 1 msec to execute in a pure SCSI environment. "You can double that when MSCP is encountered," says Richard Steincross, president of RMS Laboratories (Long Beach, Calif.).

Unfortunately, MSCP doesn't make provision for developers to punch holes easily through the interface layer. Steve Bostwich, president of Query Computing (Torrance, Calif.), complains that MSCP limits how much functionality can be squeezed out of a storage device. "You can design a storage system with lots of capability. But, in the MSCP environment, you lose some of the functionality since you are bounded by their [Digital's] constraints."

Tape Up The Cracks

Winchester storage may be the backbone of the VAX data storage system, but tape in all forms—reel-to-reel and ½-in. and ¼-in cartridges—holds real dollar promise for manufacturers and system integrators alike (Figure 2). Raymond C. Freeman, president of Freeman Associates Inc. (Santa Barbara, Calif.), says that the sales of ½-in. reel-to-reel are declining, but will still ship in the order of 119,000 units in 1990, worldwide. Half-inch cartridge tape (based on the IBM 3480 form factor) is expected to grow from 119,000 units this year to 276,000 in 1990. Quarter-inch is expected to be slightly less than 2 million (1,985,000 units) in 1990. Dataquest's Devin notes that the number of third party tape drives attached to VAX systems will be between 1200 and 2100. "That's not all that bad when you consider that equates to around $26 million in end-user revenue," he says.

Qualstar Corp. is one of the companies that offers reel-to-reel add-ons for the MicroVAX that run with VMS, RSX, or UNIX. What makes this product attractive is that it offers a standard for data interchange across a broad range of system architectures.

Freeman suspects that the ½-in. cartridge will be slow in finding its way onto Digital equipment, and the 3½-in. DC-2000 may not be used at all. Others disagree; a spokesman for Scientific Micro Systems (SMS) says that the DC-2000 may prove to be a low cost alternative to generating transportable data from a MicroVAX to a PC environment. To be viable, the DC-2000, 3½-in.-style cartridge drive will have to settle down. Currently, no standards other than electrical exist for the small drive (see sidebar, "Confusion Over 3½-In. Cartridge Tape Standards").

Optical Illusions

Optical storage is one of the more promising, but disappointing, add-on opportunities. The technology, which has been touted for the past 3 yrs., still isn't ready for widespread commercial application.

Laser Magnetic Storage International Co. (LMSI) is one of the few American manufacturers that has the ability to deliver usable product in the 12-in. form factor. And it typically finds use on VAX systems with a SCSI host connection.

Optical storage, especially the write once read many (WORM) versions like that sold by LMSI, are ideal for large-scale archive storage and large (in the Gbyte range) backup. The difficulties all appear to be in smaller form-factor, 5½-in. designs.

One Digital add-on vendor that's expecting to throw a ray of hope onto the small form-factor optical business is SMS with the $10,000 Optical Development Kit.

The kit consists of an SMS 0109 Q-bus multifunction controller with a SCSI port on the optical disk and a Maxtor RXT-800S 5¼-in. WORM drive; the subsystem is MSCP compatible, and can attach two ESDI or ST506/412-type Winchesters.

The Maxtor drive is from Ricoh and uses a dye polymer read/write technology, as opposed to drives using ablative methods. SMS provides the necessary drive utilities for use under the VMS operating system, and, according to a company spokesman, has developed a SCSI pass-through mode, thus reducing the overhead latencies of MSCP and SCSI.

Very Bright Futures

Despite the slowness of technology maturity for optical drives, both Dataquest's Devin and Freeman Associates' Freeman project a bright future for optical. "Optical is a natural attachment for VAX-type systems," says Devin. "It provides the basis of a low cost, easily retrievable information source—an environment that is well-suited to VAX architectures."

Freeman agrees. He suggests that the steady growth, at least for the interim, will be in the 12-in. WORM drives, with 5¼-in. erasable optical having a bigger influence in MicroVAX by 1990.

The Bottom-Line Cost

Clearly, everyone gets to win in the VAX and MicroVAX business: vendors, VARs, and end users. Capability is going up and prices are coming down. A recent study comparing the prices of 1 Mbyte of fast (less than 100 nsec) semiconductor dynamic RAM (DRAM) to 1 Mbyte of Winchester storage revealed a dramatic price differential from just 1 yr. ago (Figure 3).

Fast semiconductor storage using sub-100 nsec DRAMs offers the opportunity for developers to create large storage array attachments. But the fast speed is costly. One Mbyte of DRAM is priced at a little less than $100 in OEM quantities today: about three times the cost of a year ago. But Winchester storage has been on a steady decline. One year ago, 1 Mbyte of storage was around $22-$25; today, it's less than $11. It's about a buck a Mbyte for a 60-Mbyte ¼-in. tape (add another $.85 for the first year, if you count the drive). Double the capacity with the new 120-Mbyte cartridge, and the price is just about half.

For real dollar value, though, ½-in. 3480-style cartridges are the best deal in town. Priced as little as $10 for a 200-Mbyte cartridge, the bytes are stored for less than it costs to print the words in this magazine.

Carl Warren is a Hardcopy *columnist.*

The following vendors were mentioned in this article

Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
800-231-0900

Conner Peripherals
2221 Old Oakland Rd.
San Jose, CA 95131
408-433-3340

Control Data Corp.
1101 E. 78th St.
Bloomington,
MN 55420-1478
612-851-4051

Emulex Corp.
3545 Harbor Blvd.
P.O. Box 6725
Costa Mesa, CA 92626
714-662-5600

Fujitsu America
3055 Orchard Dr.
San Jose, CA 95134
408-432-1300

Laser Magnetic Storage International Co.
4425 ArrowsWest Dr.
Colorado Springs,
CO 80907
303-593-4412

Maxtor Corp.
150 River Oaks Pkwy.
San Jose, CA 95134
408-942-1700

NEC Information Systems Inc.
1414 Mass. Ave.
Boxborough, MA 01719
617-263-2627

Qualstar Corp.
9621 Irondale Ave.
Chatsworth, CA 91311
818-882-5822

Ricoh Corp.
S. Dedrick Pl.
W. Caldwell, NJ 07006
201-882-2114

Scientific Micro Systems Inc.
339 N. Bernardo Ave.
Mountain View,
CA 94043
415-964-5700

System Industries
560 Cottonwood Dr.
P.O. Box 789
Milpitas, CA 95035
408-432-1212

Sytron Corp.
135 Maple St.
Marlboro, MA 01752
617-460-0106

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 by Dr. Robert J. Schlesinger and Sylvia Tiersten

Advanced manufacturing solutions for small-to-medium-sized companies

You're the owner of a manufacturing plant that generates $4 million in annual revenue. You've heard about computer integrated manufacturing (CIM) activities at the Fortune 500 level, and wonder how your company could benefit from advanced techniques. You call Digital Equipment Corp. and ask: "What do you have that could bring me into the 20th century?"

While Digital could end up supplying the hardware, chances are that problem assessment, design solution, systems integration, and custom programming would be passed on to vendors who normally work with smaller companies. "Usually," explains Jack Conaway, Digital's manager of CIM planning, "when we get our own people involved in systems integration, it's for large companies. We are interested in doing high volume projects that we can transport around to different industries and companies within industries. Our capabilities are generally too expensive for smaller companies."

Assuming that the customer lacks in-house expertise to engineer an advanced system (and, with most small-to-medium-sized companies, this is a reasonable assumption), a Digital sales account manager would probably notify sales support people. They, in turn, would call in a systems integrator or turnkey systems house to perform the job. Digital's responsibility in such cases, says Conaway, is to "understand what the manufacturing problem is, and then determine who supplies what in a given geographical area."

While some small-to-medium-sized companies decide to automate on their own, others are being pushed by their mega-customers into adopting advanced techniques. "Small companies that supply components for cars or aircraft," Conaway points out, "need to be integrated into the larger enterprise." General Motors, for instance, specifies integration protocols such as Manufacturing Automation Protocol (MAP) and IGES for its suppliers. (IGES is an applications protocol for exchanging data that describes geometry and text on mechanical and electronic design drawings.) Ford Motor Co. is trying to persuade its vendors to adopt a particular CAD/CAM system. And when Digital arranges for third party manufacturing of disks, tape drives, and other mechanical parts, a company division

". . . the small company should stick with stable products. . . "

is apt to send an electronic purchase order with an IGES file appended to it.

Compared with the industry giants, smaller firms are blessed with simpler operations, a manageable range of products, fewer computing architectures and applications software, and quite often, a single manufacturing site. Hence, complex networking schemes are not needed and the introduction of information technology and automated machinery "can almost be considered a green field operation," Conaway says. His across-the-board advice to small companies in search of advanced manufacturing solutions is to "avoid exotic hot boxes, deal with standard platforms and proven software, and try to reduce the number of vendors you have to deal with." While large firms can use their clout to get software vendors to change codes or jointly develop CAD/CAM and materials requirement planning (MRP) systems, the small company should "stick with stable products," Conaway says.

A good way for small firms to garner information is to talk to users in the same or a similar industry. Another approach is to visit one of Digital's Application Centers for Technology (ACTs), where demonstrations of applications software are on tap. (Digital maintains 19 ACT facilities around the world.) Yet another source of information are Digital's Manufacturing Research Centers in Santa Clara, Calif.; Detroit; and Enfield, Conn., which deal with management consulting, planning, design, and implementation issues.

Undoubtedly, the efforts of Digital, General Motors, et al will successfully foster some top-down integration and automated machine installation in vendor and would-be vendor firms. But lest these leviathans forget, information does not flow exclusively from large-to-small companies. Smaller firms are notoriously creative, and Digital cannot afford to take these users for granted. The last time Digital did this, it missed the microcomputer market, took a nose dive, and had to play catch-up for a couple of years. Now Digital is in the driver's seat again—with, we hope, a good memory and concern for the smaller customer.

Dr. Robert J. Schlesinger, a registered professional engineer, teaches courses in operations research, manufacturing, and automated production at San Diego State University. Sylvia Tiersten is a business writer.

Cache Memory: The Secret Of Increased Performance

When upgrading older systems, performance/cost trade-offs are particularly important/by Andy Anderson

The performance of a computer system depends on a number of interrelated factors. The apparent speed of a computer isn't only a product of the raw speed of its processor, but also the attached memory, I/O devices, and the nature of the application. Cache memories are an important architectural feature for increasing system performance by increasing the effective speed of the memory.

A cache is a turbo-charger for a computer system. It is a small amount of high speed memory closely coupled to the processor. The memory used for the cache might have an access time of 15-75 nsec, while main memory might have a typical access time of 100-500 nsec. These speeds refer to the speed of the memory chips and don't take into account the speed of the addressing hardware or bus timing. The close coupling also decreases access time by eliminating the overhead of bus protocol that inhibits main memory access speed.

Why A Cache Works

Cache memory relies on the locality of memory references to increase system performance. There are two types of reference locality: temporal and spatial. Temporal locality refers to program loops where instruction and data are used several times in a short space of time. In this case, the cache stores the instructions of the loop, reducing access to main memory. One look at a portion of any program illustrates that loops are an important programming construct. Spatial locality refers to related data items such as variables and arrays where the next variable to be accessed is likely to be adjacent to the one just accessed. The sequential nature of instructions is another form of spatial locality. The costly accesses to main memory are reduced when the cache already contains the needed data.

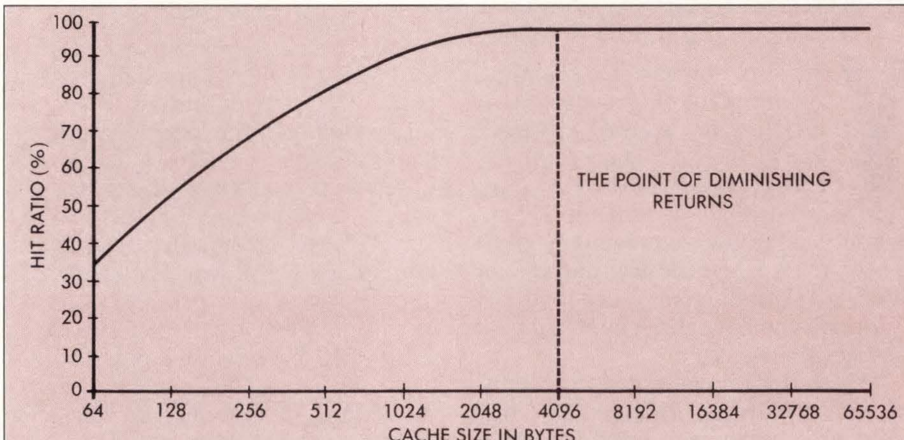

Figure 1—*For a direct-mapped, singleline cache running a single process, hit ratio vs. cache size shows that the point of diminishing returns is reached at about 4 Kbytes. The data was developed from studies on PDP-11 caches running single processes.*

A simple loop that increments a variable can be used to illustrate how the number of main memory accesses can be reduced.

```
for i:= 1 to 1000 do
    x:= x+1;
```

The compiled version of this program might contain four assembly language instructions. During the first pass of the loop, each of the four instructions and the two variables must be read from main memory. The variable x might already be in the cache. For the remaining 999 iterations through the loop, all of the processor reads/writes are to the cache.

The effectiveness of a cache is measured by the hit ratio, which is the number of accesses for which the required data resides in the cache compared to the overall number of memory accesses. A good hit ratio is between 85-95%. This means that most of the data accessed is already in the cache. Thus, 85-95% of the time, the main memory isn't accessed and the data comes from the cache.

The effective memory speed of a cache system can easily be calculated. Assume that the hit ratio is 92% and the cache memory is 10 times faster than main memory.

92%*.1 (cache speed) + 8%*1 (main memory speed)
=0.172
or 5.8 times faster than main memory alone.

The higher the hit ratio, the faster the computer runs. The cache architect tries to maximize the hit ratio across a variety of potential programs, while restraining costs, board space, and power consumption. There are three important cache design parameters:

- cache size,
- cache organization, and
- line size.

Cache Size

Cache size is one of the most important design parameters. A small cache will result in a low hit ratio, while a

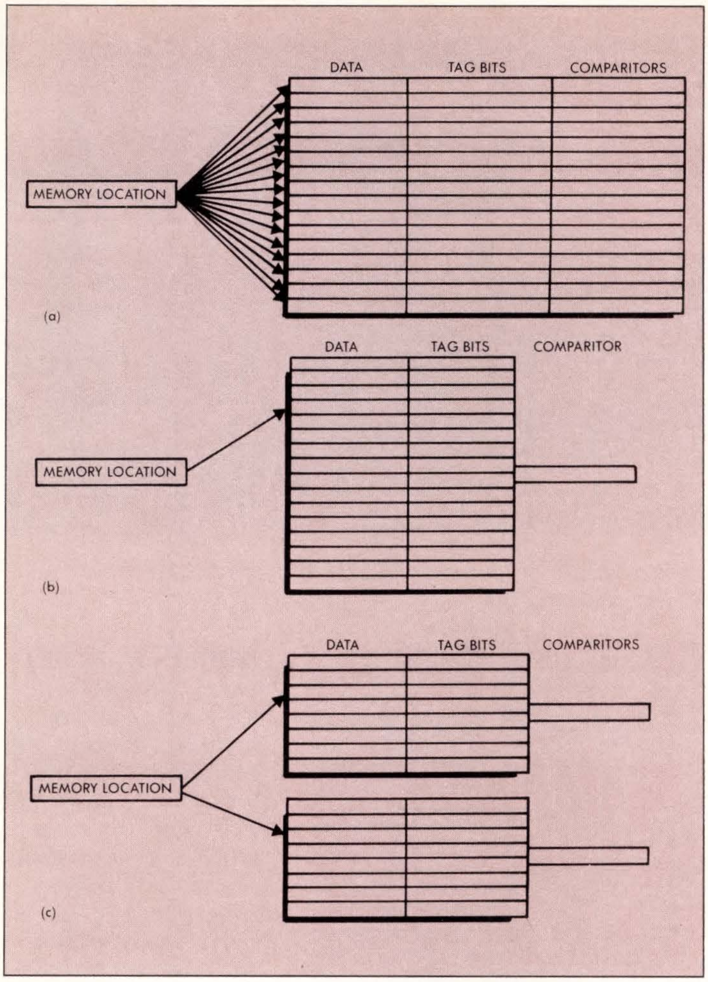

***Figure 2**—A fully associative cache* (a) *provides the highest hit ratio compared with the direct-mapped* (b) *and set-associative* (c) *structures, but it requires a large investment in comparator hardware. The direct-mapped cache is the simplest and least costly design, but results in a lower hit ratio. The set-associative cache provides the best of both worlds: a good bit ratio at a low cost.*

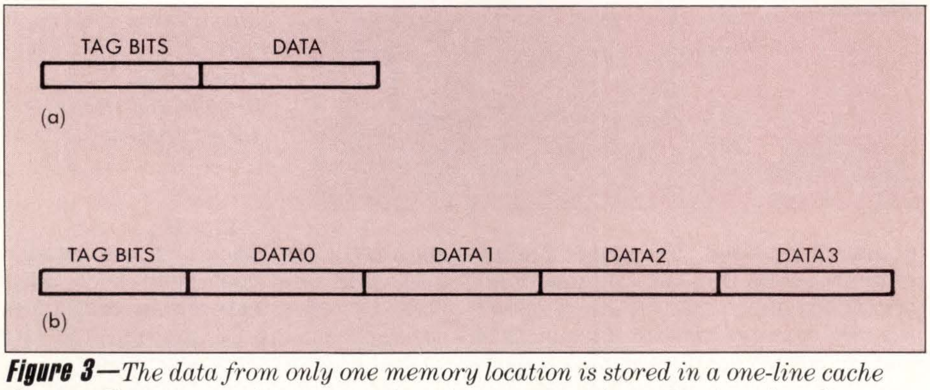

***Figure 3**—The data from only one memory location is stored in a one-line cache format. Four consecutive memory locations are stored together in a four-line cache format.*

large cache may be too expensive to justify the increase in performance. Figure 1 illustrates the diminishing returns of a large cache. It should be apparent that a cache must be larger than 512 bytes. A cache larger than 8 Kbytes may give a slight increase in hit ratio, but probably is not cost-effective.

Cache Organization

Ideally, a cache memory is organized so that any memory location can be mapped to any cache location. This is called a fully associative cache. A fully associative cache contains the most recently accessed data. A comparator is required for each cache entry to determine if there's a hit. The fully associative cache is a costly solution due to the hardware required to make the comparison.

At the other extreme is a direct-mapped cache, where each memory location is mapped to only one cache location. A direct-mapped cache requires only one comparator. A direct-mapped cache has a lower hit ratio because not all the most recently accessed information may be available from the cache. This is caused by the several memory locations competing for the same cache entry.

A set-associative cache is a compromise between the fully associative and direct-mapped structures. A set-associative cache is a multilevel design consisting of two or more direct-mapped caches. Each direct-mapped cache is referred to as a set. The sets are connected in an associative manner. Data for a particular memory address can potentially reside in any one of the sets. Unlike the direct-mapped cache, a memory location can be mapped to any of the sets. The three different cache organizations are illustrated in Figure 2.

Line Size

The number of words stored per cache entry is referred to as the line size. It's important to note that comparing line size in bytes across systems of different data width can result in false conclusions. A 16-bit system might have a line size of 4 bytes, but a 32-bit system must have a line size of 8 bytes to obtain a similar hit ratio. To avoid confusion, consider line size in terms of words (the data path size). Since the PDP-11 computer family has a 16-bit data path, a word is 16 bits or 2 bytes.

Figure 3 illustrates the difference between a one-line and a four-line direct-mapped cache. A larger line size may not be better than a smaller one.

A large line size takes advantage of spatial locality. The sequential fetch of instructions is a good example of where a large line size is beneficial. A cache with several lines automatically performs a type of instruction prefetch, resulting in a higher hit ratio. The disadvantage of a large line size, however, is that during a miss, several memory cycles are necessary to update the cache.

In a PDP-11 system, a larger line size is effective in reducing the total access time for several memory locations because several words can be accessed in one bus arbitration cycle. This is particularly attractive if the main memory provides a nibble mode where sequential data can be accessed quickly. This requires a tight coupling between the cache and main memory. In most PDP-11 systems, the cache and main memory are not tightly coupled. The cache is forced to communicate to main memory through the bus.

The effectiveness of a line size larger than one word depends on the spatial locality of the data to be accessed. A very large line size is counter-productive, since it implies that most accesses are sequential. A very large line size is equivalent to a prefetch mechanism.

Each line in the cache consists of two fields: data and tag bits. The tag bits contain the address where the data resides in main memory. Each entry also contains one or more valid bits that indicate if the entry is valid. When the computer is first powered up, the address-data pairs are invalid, so all of the valid bits must be reset. There may also be one or more parity bits to ensure the integrity of the data.

Example

To illustrate the possible choices of the three organizational parameters outlined, examine the cache on the Quickware Engineering & Design Inc. (Boston, Mass.) QED 11/85 upgrade processor board (Figure 4). The cache is on the right-hand side of the board and can be easily identified as 16 24-pin static RAMs.

A block diagram of the cache, containing 16 Kbytes, is shown in Figure 5. The larger cache allows for operating system calls and task switches to occur without degradation of the hit ratio.

The cache is organized as two 4-Kword sets. Each line contains one word. The set-associative organization using two sets provides a higher hit ratio than a direct-mapped cache, at a slight increase in cost.

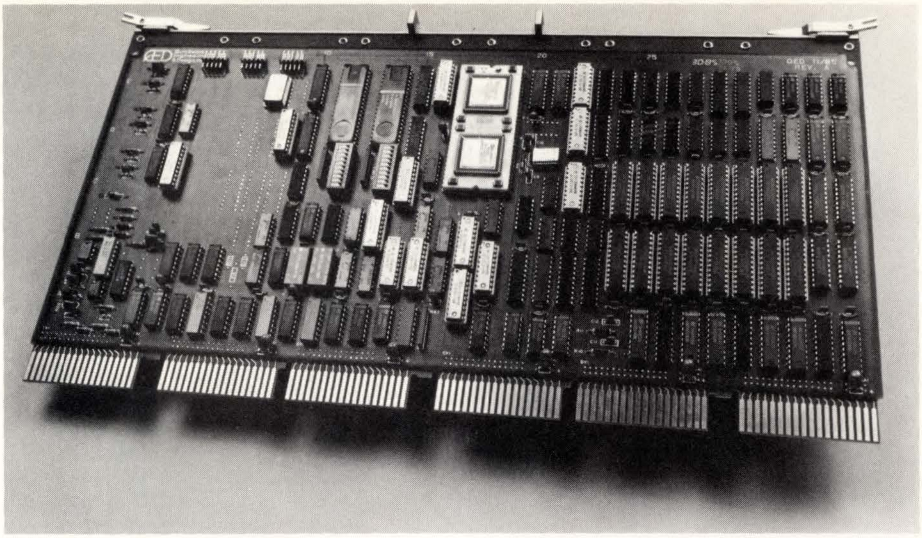

Figure 4—*The Quickware QED 11/85 is a Unibus PDP upgrade board that implements a two set-associative cache.*

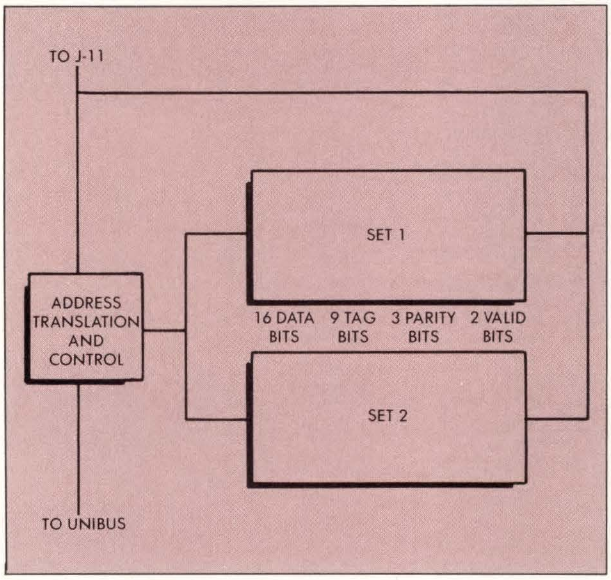

Figure 5—*In the QED 11/85 two set-associative cache, each set contains 4 Kwords organized as one-word lines for a total size of 16 Kbytes. The cache implements a random replacement policy. During a miss, one side is chosen at random to accept the new data. Parity and valid bits are stored for each byte. A third party bit is generated for the tag bits. A parity error forces a miss.*

Cache Management

There are two cache management decisions that must be made. The first is the memory update algorithm for maintaining consistency of main memory. The second is the replacement algorithm to determine which set will receive a new piece of data.

During memory reads, the cache is first checked to determine if it contains the requested data. If not, the data is read from main memory and the cache is updated. During a write cycle, several possible sequences can happen. If there's a hit, either the cache and the main memory can both be updated or just the cache can be updated. A write-through strategy updates both the cache and main memory. Main memory is written through the cache.

Another possibility is storing the data in cache and not updating main memory. This strategy is faster, since the system doesn't have to wait on the main memory cycle to complete. When a line is replaced, the store-in algorithm requires that the line must first be written out to main memory before the new data can be read. This method has the advantage if a variable is written several times, such as the index in a loop. The disadvantage of store-in is that the cache and main memory are inconsistent. If there is another device accessing the main memory, it can potentially read old data. DMA cycles in a PDP-11 require that main memory contain the correct data. Thus, store-in isn't a good alternative in a PDP-11 system. All PDP-11 caches use the write-through technique.

If there's a miss during a write cycle, the cache may not be updated. Only two PDP-11 instructions, MOV and CLR, perform writes without first reading the word. It's unlikely that the data used by either of these instructions will be needed again soon. Data used by other instructions may be in the cache during a write, since the data is first read before it's written.

The final design choice is the replacement algorithm. In a set-associative or fully associative cache, the assignment of a line to a new piece of data must be made. If all of the sets contain a valid address-data pair, one of them must be replaced by the new address-data pair. The key is to choose the one that has the least liklihood of being accessed soon.

There are three popular replacement algorithms. The first is the first-in first-out (FIFO) algorithm. The new address-data pair replaces the line first stored in the cache. The FIFO algorithm is based on the notion that data that has been in the cache the longest is least likely to be accessed in the future. The second replacement algorithm is the least recently used (LRU). LRU replaces the address-data pair that hasn't been accessed for the longest period of time. The third alternative is random replacement. One of the sets is randomly selected to store the new line. It would seem that either LRU or FIFO would result in a higher hit ratio than a random replacement strategy. In real applications, it turns out that none of the replacement algorithms is significantly better than the others.

The QED 11/85 uses a random replacement policy. This can be a good choice because the LRU or FIFO algorithms require storing additional information along with each line in the cache. They also require that the information be read before a replacement decision is made. A random replacement policy is easy to implement and is quick to make the replacement decision.

Cost/Performance Trade-Offs

A cache enables a memory system to appear to be fast, while remaining inexpensive. All of the memory hierarchy could be constructed from high speed memory, but this would include mass storage, and most people aren't willing to pay the cost for 10–100 Mbytes of high speed memory for their PDP-11 systems. Even replacing all of the main memory is cost-prohibitive. A cache is an alternative that requires only a small amount of high speed memory.

One of the more expensive components of a cache is the high speed memory. The designer must carefully select the right amount. This is a difficult decision because the cache must work well under real loads.

Other potentially expensive components are the comparators. If the cache is fully associative or contains a large number of sets, the cost of the comparators can be significant; however, the best hit ratio is obtained from a fully associative cache.

Cache Performance

The success of a cache is based on several assumptions. The first is that memory accesses are closely spaced in time; the second is that memory access speed is the bottleneck in the system. A particular system may be running slow because the application is requesting a large number of I/O operations.

A cache is a small amount of fast memory placed between the processor and the slower main memory. Adding a cache can greatly improve the performance of a PDP-11, in particular. The performance of a cache is measured by its hit ratio, which is usually between 85–98%. There are several important cache design decisions to be made, including size, number of sets, line size, replacement policy, and main memory update policy. The QED 11/85 contains a J-11 processor enhanced by a 16-Kbyte, two set-associative cache. The successful blend of these choices allows it to run two to three times faster than a PDP-11/24 or 11/34 for most applications.

Andy Anderson, a practicing professional engineer, holds M.S. degrees from MIT in electrical engineering and computer science. He specializes in speech recognition, ASIC design, and AI tendon manipulation systems.

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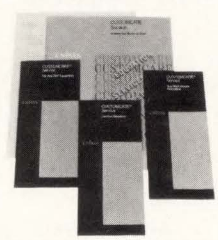

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Depot Repair: The Trend Toward Self-Maintenance Of Computer Installations

Depot service can provide the extended capability to keep computer operations running as smoothly and efficiently as possible/by Warren K. Haeberle [Electronic Service Specialists Ltd.]

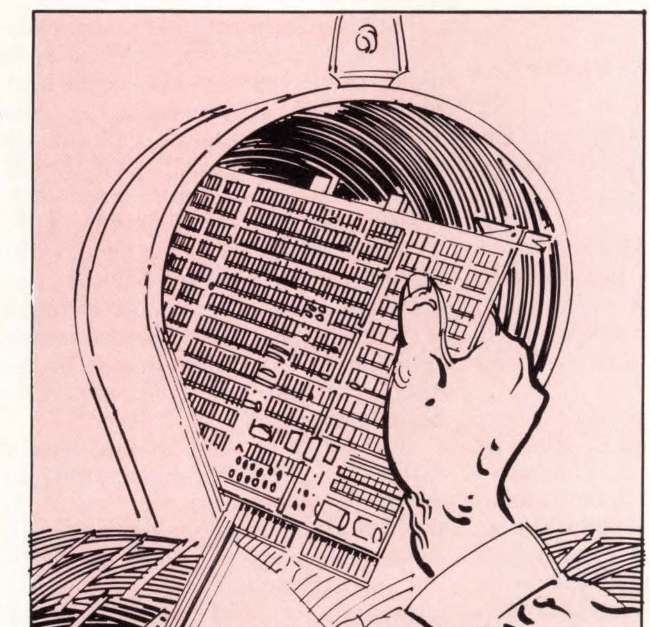
Depending on size, structure, and equipment type, many corporations have chosen to perform maintenance functions on their own computer systems and peripherals. Cost-effectiveness and the security of having in-house repair capability are primary reasons why organizations choose this route.

But, self-maintainers don't have the expertise, equipment, or time to repair defective circuit boards or replaced power supplies when maintaining their equipment. These parts are repairable, and represent investments running well into the tens of thousands of dollars each year. In many cases, the DP or MIS manager returns the damaged part to the OEM for repair. Another option, however, is for the company to have the part serviced by a depot repair facility.

Depot Repair

Depot repair is certainly not a new concept and can provide many of the

Warren K. Haeberle, president of Electronic Service Specialists Ltd. (Menomonee Falls, Wis.), holds a BSEE from Marquette University and an MBA from the University of Wisconsin. He has worked as both an engineer and manager in the electronics industry.



ROGER XAVIER

"The self-maintainer can expect repaired or swapped boards back in his hands in a matter of days. . . . "

same services obtained from an OEM, such as bringing circuit cards up to current revision levels. Third party maintenance companies have been using their services for years, and now self-maintainers have discovered depot repair can fulfill many of their needs as well. The computer systems manager should consider whether depot repair service may be an option for his company; and, if it is, how to select the one best-suited to his company's needs.

First, the systems manager may want to examine price. Typically, depot repair services are 20-25% lower than those of the OEM. If the self-maintainer is a large organization with several mainframes and minis, the savings can be substantial.

"A visit to the depot's facility can provide the systems manager with the most accurate overview of the company's capabilities."

Turnaround time is another reason for investigating this option. The self-maintainer can expect repaired or swapped boards back in his hands in a matter of days—versus weeks or months for the OEM.

Some depot repair companies are beginning to expand their capabilities beyond parts repair to include additional services needed by the self-maintainer, such as parts sales and training. In offering these services, depot repair companies can effectively become an extension of the self-maintainer's capabilities.

Competitive pricing, fast turnaround, convenience, and additional options are all possible benefits of depot repair. The DP or MIS manager must know exactly what he needs and what he can expect from a depot repair service.

Finding Depot Repair

An obvious place to start looking for a depot repair service is with publications covering the computer industry. Advertisements for depot repair will often provide lists of equipment serviced along with other capabilities. Articles and features offer information about aspects of depot repair service not covered in the advertisements.

Independent computer consultants are another resource for recommendations. While primarily concerned with matching equipment and systems with particular applications, they are committed to advising their clients on all aspects of computer systems, including maintenance.

After this preliminary survey, the systems manager has a list of potential depot repair services. The next step is to talk directly to these companies to find answers to both technical and nontechnical questions about how they could meet his operational needs.

A visit to the depot's facility can provide the systems manager with the most accurate overview of the depot's capabilities. During a tour, many aspects about the business, its credibility, and the quality of its organization and services come to light.

Questions About The Business

Analyzing the prospective list of depot repair services can most easily be undertaken by first looking at the business profile of the company. The strength of a company's finances, the quality of its customer list, and the efficiency of its business procedures quickly separates the wheat from the chaff.

The systems manager should also learn what other corporations or organizations use a particular depot repair service, and should ask for references. In doing so, the systems manager can discover if the services offered parallel his own needs.

In looking at the customer list, or talking to the references, find out where the companies are located. If they are all in one geographical area, it could mean the depot repair service is limited in the amount of territory it can adequately service. This may not be an important consideration if the self-maintainer is located in the areas serviced. However, if the systems manager is planning to use the same service for his company's other facilities at various sites throughout the country, a depot service limited by geographic coverage may not be the best choice.

The DP or MIS manager needs to scrutinize the depot's capabilities list, not only for equipment he already has on hand, but for systems his company may be purchasing in the near future. It would, therefore, be prudent to find out what plans the depot repair company has to keep pace with new equipment introductions.

In order to repair equipment, a depot repair company needs parts. Although it's easy to assume a depot repair company will have an adequate parts supply, it's no small point. Parts for certain makes and models of equipment may be in short supply or difficult to obtain. From what sources does the repair facility obtain its parts? How reliable is the supply? Both are questions that need to be addressed.

In reviewing the list of equipment the depot service repairs, the systems manager should find out whether repairs are done in-house, or subcontracted to other companies. Sending certain equipment out to specialty houses is not uncommon, even for the OEM. But it's important to know what equipment is sent to other facilities since it may have an impact on turnaround time or on the quality of workmanship.

Turnaround time is one of the primary benefits of using a depot repair service. Understandably, all will claim to have the repaired part back in operation in the fastest possible time. But what methods and procedures does the repair facility use to support its claims? To what lengths will the company go to deliver repaired parts as promised? If problems delay the return of a repaired part, most depot repair services will swap the board with a good one to get the system up and running. Is this program available in emergency situations?

In terms of quality performance, a depot repair service must be willing to stand behind its repairs. Check the warranty; make sure there are no hidden conditions or exceptions.

Quality Control

The best way to determine quality control capabilities is to visit the facility. A systems manager who knows exactly what he is looking for will be able to ascertain within minutes whether or not the service is following prescribed quality control standards. The information can be obtained over the phone if a visit is not feasible.

The main culprit in quality control is static electricity. If uncontrolled, it can ruin delicate, complex repairs. In combating static electricity, the depot repair service must implement anti-static measures. The most recognized standards are those established by the 3M Corp.

There are a variety of methods to

control static discharge in the work environment. Employees who are handling circuit boards and components, for example, should be grounded at their workstations. This includes not only technicians, but anyone coming in direct contact with the boards, such as those working in shipping and receiving. The most common and effective method is to have the person wear a grounding wristband while working with the boards.

In addition to using the wristbands, the depot should also be storing its components and boards in specially designed bins. These bins are made of materials that conduct the static charge away from the contents. Worktables, too, should have a special laminated surface fulfilling the same function.

Another precaution the systems manager should look for in the control of static electricity is anti-static bags. Here again, the bags serve to conduct the charge away from the contents. A depot repair service concerned with quality control will place circuit boards in an anti-static bag as soon as they arrive from the customer. A board remains in the bag—except, of course, when removed for repairs—the entire time it's at the facility, as well as during return shipment to the customer.

A depot repair facility following quality control measures will implement environmental safeguards, such as controlling temperature and humidity, to guard against static.

In order to ensure quality, extensive and complete testing is also necessary. Circuit boards, for example, should be tested by running them on the same systems for which they were designed. Measuring the board's performance requires operating it for an extended period of time. The length of testing depends on the system and function of the card, but a service that runs a test for only 5–10 min. is not enough time for a thorough check.

The MIS and DP manager should also be familiar with other services depot repair companies provide in addition to board repairs. Depending on the needs of the systems manager, these options may be the deciding factor when choosing one firm over another.

The sale of parts is a common option that many depot repair facilities offer. There are those that will provide special services such as 24-hr./7 days a week emergency equipment sales. Some provide subassemblies for sale—an option usually not available from the manufacturer. Spare parts kit leasing or sales may also be available.

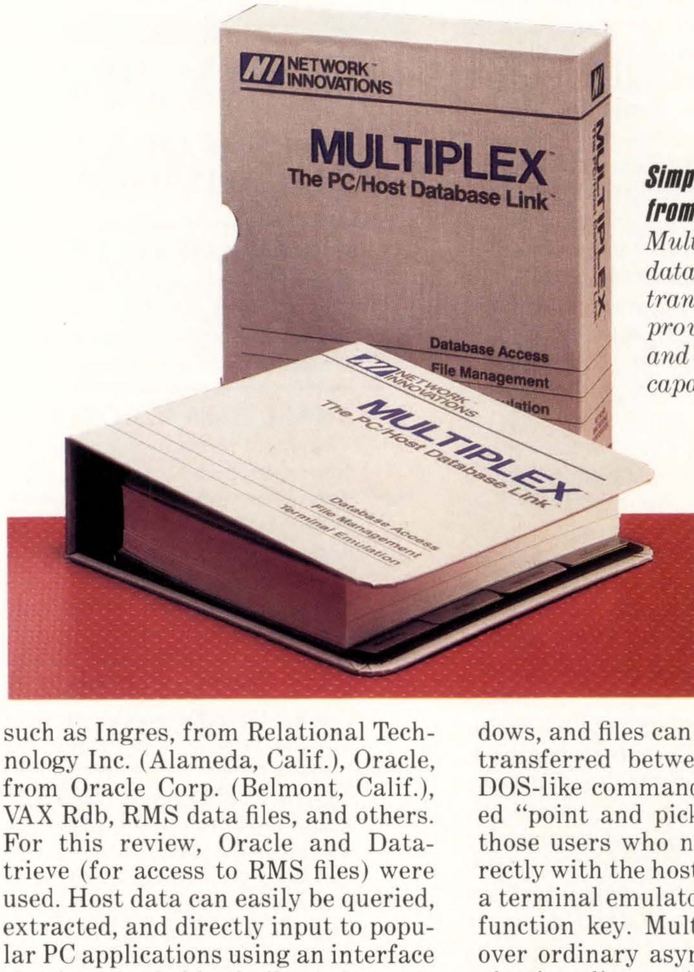
Depending on available resources, and the needs of the customer, the depot repair facility may be able to provide hands-on instruction to a company's own maintenance staff for either refresher training or to bring them up to date on the latest engineering changes.

If the self-maintainer has a need for detailed information on its systems, such as logic diagrams, there are depot repair companies that will provide this information.

In reviewing the various services and capabilities available through depot repair, it becomes obvious that this segment of the computer maintenance industry is becoming multidimensional. For the self-maintainer, the right depot service can provide that extended capability necessary to keep computer operations running as smoothly and efficiently as possible.

Hardcopy *Product Review: Network Innovations' Multiplex*

Multiplex distinguishes itself from other PC-to-VAX connectivity solutions by implementing a unique database access method/by David J. Molta



Simple DBMS access from the PC— *Multiplex specializes in database extraction and translation, and also provides file transfer and terminal emulation capabilities.*

As organizations become increasingly dependent upon database management systems (DBMSes), data processing managers commonly experience frustration in attempting to meet increasing demands by end users for integration of personal computer (PC) workstations into host-based systems. These user demands often call for some form of data extraction to allow incorporation of specific portions of up-to-date, organization-wide statistics into departmental reports.

To address these demands, most mainframe database software vendors have developed proprietary query and extraction tools. While generally useful, these techniques usually require departmental users to learn a new application, and engage in a series of query and conversion processes before the information can be placed in a format recognizable to microcomputer applications software—typically spreadsheets, word processors, or database management packages.

Multiplex, from Network Innovations (Cupertino, Calif.), provides users with an alternative to this often awkward process by establishing a direct link to popular VAX databases such as Ingres, from Relational Technology Inc. (Alameda, Calif.), Oracle, from Oracle Corp. (Belmont, Calif.), VAX Rdb, RMS data files, and others. For this review, Oracle and Datatrieve (for access to RMS files) were used. Host data can easily be queried, extracted, and directly input to popular PC applications using an interface that is remarkably similar to Lotus 1-2-3. Since the software interface will be familiar to most PC users, training costs are minimal. In addition, because it's exclusively an extraction tool, data processing administrators can embrace it without fear of adventurous users corrupting the organization's database.

Multiplex also provides users with the capability of easily moving files between host and PC environments. The contents of host and PC directories can be displayed in separate windows, and files can be easily copied or transferred between the two using DOS-like commands or menu-oriented "point and pick" procedures. For those users who need to interact directly with the host operating system, a terminal emulator is available via a function key. Multiplex can be used over ordinary asynchronous communications lines or in a DECnet Ethernet network using Digital's VAX/VMS Services for MS-DOS. Multiplex is not copy-protected and requires a minimum 256-Kbyte memory on the PC.

Installation

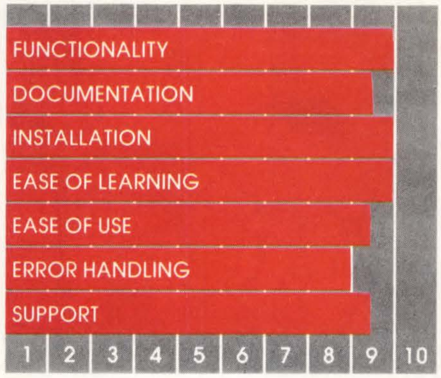
Installing Multiplex is both easy and well-documented. Once you have collected the necessary site-specific information (communication network configuration, host DBMS, log in prompts, etc.), installing both the PC and host components should take less than 30 min. On the PC side, an install utility automatically copies the necessary files to a floppy or hard disk. Once these files are copied, Multiplex is initiated by entering MPX from the Multiplex directory (or from anywhere on the disk if a path to the Multiplex directory has been defined).

A menu appears with CONFIGURATION as one of the options. By moving the cursor to highlight this option and pressing <ENTER>, network communication parameters and host prompts can be defined. In our test using a Sytek asynchronous LAN, the default parameters were correct and no modifications were necessary. On the host end, installation is greatly facilitated by the use of the standard VMSINSTAL installation procedure. Once the installation procedure has been executed, the only remaining step involves the addition of one line to the systemwide SYLOGIN.COM file. Multiplex occupies a maximum of 2250 blocks of disk space and requires VMS V. 4.4 or later.

The Multiplex Access System

In its attempts to make Multiplex as easy to learn as possible, Network Innovations chose to incorporate most aspects of the familiar Lotus 1-2-3 interface into its product. The spreadsheet interface itself is replicated, including colors and cursor movement keys (see Figure). The highlighted point and pick menu structure and one-line command descriptions are also quite similar, as are the cell editing commands. Multiplex even borrows the access system concept as an "umbrella" around the program's three major components: the database link system, the file manager, and the terminal emulator. More experienced users also have the option of bypassing the access system and directly entering the individual program modules.

Most users will probably enter Multiplex through the access system, which provides the user with five options: DBLink, File Manager, Terminal Emulator, Configuration, and Exit. By moving the cursor to highlight the CONFIGURATION option, users can select default configuration parameters or create alternate configuration files (useful, for example, if you are interacting with both local and remote hosts over a variety of



communications media). The configuration system is very easy to use and provides a high level of control over the program's operation. Creating configuration files for specific users allows inexperienced VAX users to easily enter the host system, query databases, and extract information without any knowledge of the VMS operating system.

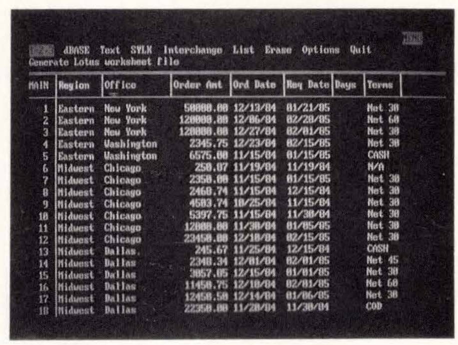
DBLink

The heart of the system is DBLink, the Multiplex Database Link. DBLink allows the user to browse the contents of host databases in a familiar spreadsheet format, perform simple or complex relational queries of the database, and automatically down load the selected information into a format fully compatible with PC applications software. Multiplex even provides facilities for automatically starting the application for which the queried data has been formatted. Data type characteristics are fully supported and automatically converted to a format recognizable to PC applications software. Thus, fields that are in currency format on the host database will appear in currency format on the PC application.

DBLink can be run as a standalone application or executed from the access system. A menu appears that allows a user to browse a database, select columns for viewing, create multiple windows, perform a database inquiry, select a new database or table, and output results to the PC.

The first step in extracting host data is to select a database and a specific database table. Selection will usually take place by choosing from a menu, but this process can be automated to accommodate inexperienced users. Once the database and table have been selected, the browse function allows the user to scan data elements in a row/column format. The window option allows for the browsing of two tables simultaneously on the upper and lower half of the screen. In most cases, a user will only be interested in viewing a subset of a table's data elements. By choosing the column selection option, specific fields can be included or excluded from the browsing session. Once the desired fields have been selected from the main table, queries can be performed to select relational fields from other database tables by using the LOOKUP option from the INQUIRY menu. Records can be excluded by specifying any of eight different row-selection criteria on any number of fields. Finally, Multiplex allows the user to specify multilevel sort criteria in ascending or descending order.

One of the major benefits of Multiplex is that it allows users to perform complex database queries without the need to learn a query language, thus



Figure—*Multiplex displays host database contents in row/column format. The menu at the top of the screen allows the user to extract data into a PC file, properly formatted as a 1-2-3 worksheet, dBase database, text file, symbolic link file, or data interchange format file.*

making data extraction accessible to relatively inexperienced users. However, since queries of large databases can be time-consuming (both in terms of host processing and host-to-PC data transfer), users should be encouraged to plan their queries ahead of time to minimize processing overhead. Recommended Multiplex query guidelines are:

- Select columns (fields) from the main table early in the query since each additional column imposes additional host and data transfer overhead.
- Specify row (record) selection

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criteria early since this will also reduce overhead.

- Specify sorting after columns and rows are selected to reduce the volume of data to be sorted.
- Use table lookups judiciously since each lookup increases the amount of time needed to perform an inquiry.

DBLink generates output in a variety of industry standard file formats, including WKS (1-2-3, Symphony), DBF (dBase), text (for use in word processing programs or as raw input data to other programs), SYLK (Microsoft), and DIF (many graphics and other applications software).

While the query and conversion facilities found in Multiplex greatly simplify the host data extraction and conversion process, the program's developers have taken this process one step further by including a query template facility. Most organizational extraction needs call for periodic queries of the same fields of a database for use in the preparation of routine reports or analyses. Using the query template facility, a user can set up a database inquiry once and save it on disk for use at a later date. The process of setting up these templates is as simple as performing an inquiry, selecting the inquiry template SAVE command, and assigning a filename. At a later date, the user would simply enter the inquiry template RETRIEVE option, select the desired template from a list provided, and press F9/Query. The query would then be automatically executed without further user intervention.

File Manager

The Multiplex File Manager allows users to transfer files easily between host and PC systems. The proprietary file transfer protocol, which is also used in the DBLink system, is based on a 16-bit cyclic redundancy check (CRC) error-detection scheme. It supports text and binary transfers as well as wildcard batch transfers. In addition to data transfer, the File Manager includes facilities that allow files on either the PC or host system to be browsed or output to either system's printer.

The File Manager user interface is similar to the DBLink interface. The contents of directories on the PC and host systems can be displayed in separate windows using either a standard or detailed file list format. Individual files can be transmitted by highlighting the source file or by directly entering commands. Likewise, multiple files can be transferred by highlighting filenames or by entering wildcard commands. While not as flexible as virtual-disk facilities found in other PC-to-VAX communications products, the File Manager is extremely easy to use.

Terminal Emulator

While Multiplex's designers have attempted, in most cases, to shield the user from the complexities of the host database application and operating system, the integrated terminal emulator provides the user with the capability to directly interact with the VAX host. While not as powerful as many standalone PC communications programs, the emulator is adequate for its intended purposes. It supports VT100 emulation, printer logging, file capture, and keyboard remapping. In addition, it is accessible through a single function key from either the DBLink or File Manager programs. The user interface is also quite similar to the other modules.

Documentation

The documentation included with Multiplex is both extensive and well-written. Separate sections are included covering the Access System, DBLink, the File Manager, and the Terminal Emulator; each is broken down according to its major subsystems. A command reference is also included at the end of each section, summarizing each command and including a summary of the command's purpose, step-by-step operational instructions, and relevant notes.

Throughout the manual, examples are used referencing a sample database that is included with the product. Thus, users can follow the examples using the same database on their own system. Appendices summarize the sample database, provide information on default configuration parameters, explain error messages, and discuss the peculiarities of the DBMSes supported by Multiplex. A thorough index and command tree are also included, as is a PC keyboard template.

The user documentation deserves high marks. The only criticism involves the order in which some material is presented. For example, while the manual appropriately recommends selecting rows prior to sorting a database inquiry, the chapter on sorting precedes the chapter on row selection. I only wish I could be so picky when evaluating other products' documentation.

While it's quite fashionable for software vendors to refer to their products as "productivity enhancement tools," very few live up to this claim to the extent that Multiplex does. This product is not only a pleasure to use, but it will almost certainly save your organization vast amounts of time and effort in meeting the needs of end users for the extraction of information from host databases. Users who have been forced to resort to manual re-entry of host data and conversion of data types to PC application formats will find this product a godsend. The only people who might not appreciate this product are the DP programmers who find job security in a 6-mth. backlog of user-requested reports.

While Multiplex is a superior product in almost all respects, it should not be thought of as a replacement for other popular virtual-disk products such as Digital's VMS Services for MS-DOS, Möbius (FEL Computing, Williamsville, Vt.), and RAF (Datability Software Inc., New York, N.Y.). These products provide functions not supported by Multiplex. Rather, Multiplex performs one task—database extraction and translation—very well and supplements this capability with file transfer and terminal emulation capabilities. Granted, this terminal emulator could be improved by incorporating a few useful features such as a capture buffer review facility, and it would also be helpful if the File Manager included a simple text editor to supplement its browse capability. However, in the larger context, this wish list does not detract from the overall quality of this product.

David J. Molta, a data communications analyst at North Texas State University (Denton, Texas), holds an M.A. from the university, and is completing work on his Ph.D. He's responsible for integration of all PCs into a campuswide broadband communications network with Digital computers at the hub.

AI On The Factory Floor

The automation of process planning utilizes a number of different computer technologies/by Peter Marks [CimTelligence Corp.]

A key component of computer integrated manufacturing (CIM) is computer aided process planning (CAPP). Process planning is the step in manufacturing that specifies how a company's product is to be produced. In the case of a machined part, for example, a process plan details the operations necessary for selecting the stock and choosing the correct tools and machines for manufacturing that part.

Various techniques have been developed to aid in the development and management of process plans—methodologies that make this aspect of manufacturing more efficient and productive. Many of these methodologies have been automated during the past 15-20 yrs. The automation of process planning is an interesting example of an application that has evolved to take advantage of the most up-to-date software/hardware techniques available.

CAPP Systems

Why automate the process planning function of a business? Most companies produce a variety of products and models. Over a period of time, product variations result in a part design proliferation and duplication. Proliferation is the slight variation of an existing part design, while duplication is the exact replication. Proliferation and duplication result from inadequate design retrieval methods. Some studies have demonstrated that proliferation can account for up to 40% of a company's parts, and duplication can account for up to 8%. Using the technique of group technology (GT), it's possible to significantly reduce these unnecessary manufacturing costs and decrease the time necessary to produce a process plan for a new part.

> **"Much of this data can be captured directly from CAD information. . . . "**

GT is a philosophy that recognizes all parts have similar characteristics that can be used to group them into families. Parts can be characterized by their function, form, or method of manufacture. Thus, when confronted with a new part, it's possible for a planner to look at previous plans and find similar parts. Taking an existing part's plan and modifying it is called variant planning.

Utilizing GT requires some method of classifying parts; there are many classification schemes. Some schemes involve assigning codes to a part's characteristics, and these codes are grouped together to serve as keys for accessing groups of similar parts.

Computer Implementations

Initially, automation of process planning involved the development of software to aid in management of manufacturing data: the plans and other related information such as tooling and machine specifications. In computer terms, this is primarily a data management application; however, there are various methods of data management. Some methods can make the CAPP system useful and easy to use; some methods are little more than computerization of manual systems, taking little advantage of more useful data manage-

Peter Marks, manager of AI Development , CimTelligence Corp. (Lexington, Mass.), has more than 20 yrs. experience in the development of software for computer languages, data management, office automation, and expert systems.

ment methods.

More recently, CAPP systems have succeeded in capturing one aspect of process planning that heretofore hadn't been addressed: the management of knowledge. Knowledge, in this case, is the expertise of process planners—the rules of thumb and decisions utilized by planners when confronted with a new part in the development of a process plan. Now, as a result of development in artificial intelligence (AI), it's possible to capture this knowledge in a form closely resembling the thought processes of a process planner.

Data Management

The earliest computer applications were as electronic "filing cabinets." The computer could store more information than manual systems, and it could retrieve that information much more quickly. However, as with so many applications in the early days of computing (and a number of present systems), it was necessary for the user to format the business' information for presentation to the computer. This formatting often entailed the encoding of information—assigning codes to data, for example. Such was the case with CAPP systems. The coding techniques developed for manual GT systems were carried over, unchanged, to the computer. The burden of encoding information still remained with the user. The computer was able to retrieve the information—in this case, a process plan—more quickly, but it was still necessary to be trained in the use of a coding system.

In retrospect, coding very often became an unnecessary demand upon the user. Clearly, today's computers and their software are quite capable of performing this function or, better yet, eliminating it entirely. The latter has occurred. In certain CAPP systems, such as CimTelligence's (Lexington, Mass.) IntelliCapp, it's no longer necessary to use code numbers. This system, which runs on Digital Equipment Corp.'s full range of VAX hardware, has been successfully installed at a number of different manufacturing sites. Here, users describe the characteristics or attributes of a part's shape, use, or manufacture with terms they've been using for years—English.

Previously, the use of codes was necessitated, in part, by the immaturity

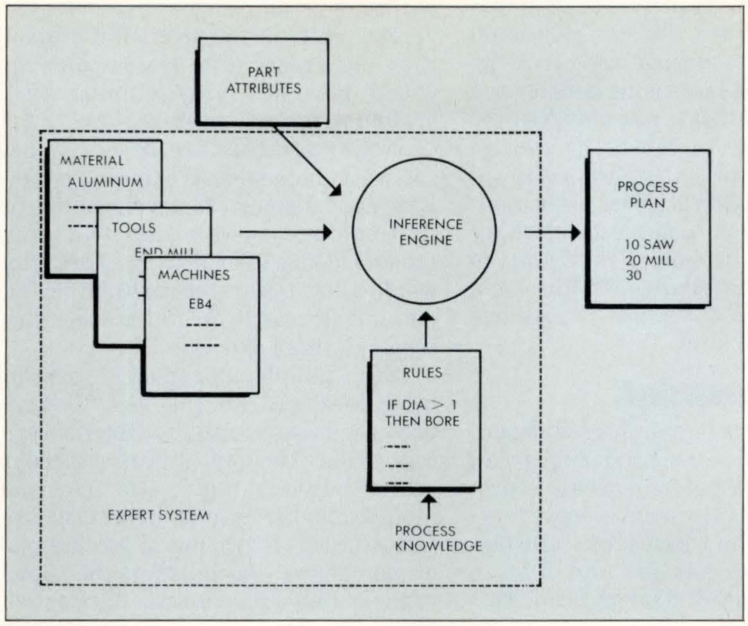


***Figure 1**—An expert system can develop a process plan based on part-attribute data.*

Part_number: 34071010-001   Revision: -   Material: AL6061-T6

Length: 2.975   Width: 1.250   Height: 0.830

Description: 'Coolant Connector Fitting'

Part_shape: 'CUBIC'   Bag_tag: 'YES'

NUMBER OF FEATURES:

Side	A	B	A'	B'	C	C'	Total
Bosses	2						2
Chamfers			5				5
C' sinks	4						4
Faces	1		2			1	4
Grooves	1						1
Holes	11					5	16
Notches	1		2			2	5
Outside Radius	4						4
Inside Radius	2						2
Taps	8						8
Total	34	0	9	0	0	8	51

BOSSES :

Nbr	Side	Type	O.D.	Depth	X-Pt.	Y-Pt.	Z-Pt.	Span	Clear
1	A	ROUND	0.77	0.200	1.075	-0.625	0.00	0.690	0.230
2	A	ROUND	0.77	0.200	2.075	-0.625	0.00	0.400	0.230

Host-length	Host-width	Entry
2.80	1.25	0
2.80	1.25	0

CHAMFERS :

Nbr	Side	Length	Leg	Entry	Rotation	X-Pt.	Y-Pt.	Z-Pt.
1	A'	2.80	0.200	45	B			
2	A'	2.975	0.100	45	B			
3	A'	2.975	0.100	45	B'			
4	A'	2.80	0.200	45	B'			
5	A'	1.25	0.200	45	C'			

***Figure 2**—Data from a CAD system can serve as the part-data input to the expert system.*

of database technology—both hardware and software. Today's relational approach to data storage and retrieval, coupled with the increasing density and access speed of disks, has obviated the need for coding. In short, the storage and—more importantly—the retrieval of part information is closer to the real-world perception and description of that data. It's no longer necessary to encode a part's attributes. Planners can now directly ask for a list of "all parts made with aluminum."

Knowledge Management

Variant process planning is dependent on existing plans; producing a plan from scratch is called generative process planning. Generative systems choose operations based on information about the part(s) and human knowledge encoded in some form. This knowledge is derived from a human expert—the process planner.

Early systems were decision trees. Inflexible, they often consisted of hundreds of interlinked program units. The ability to modify such a system was severely limited; moreover, it's unlikely that the expert (the process planner) would have the programming background to make it smarter.

Newer systems are based on new software technology: expert systems. Expert systems were developed by the AI community as a means to capture the knowledge of experts in a form that would allow the system to come close to emulating the decision-making processes of those experts.

For example, an expert system has been developed for the VAX that has been used successfully to generate process plans. The expert system accepts manufacturing logic, and part and manufacturing data as input. The system proceeds to produce a process plan or part of one, depending on the knowledge available relevant to that particular part's attributes. The architecture of this system is shown in Figure 1.

Manufacturing logic or process knowledge is captured in the form of rules or productions. They are essentially IF-THEN statements that specify what to do when certain conditions are all true. These rules are stored in what is called the knowledge base. Facilities are provided for managing the software (e.g., adding, changing, and deleting rules).

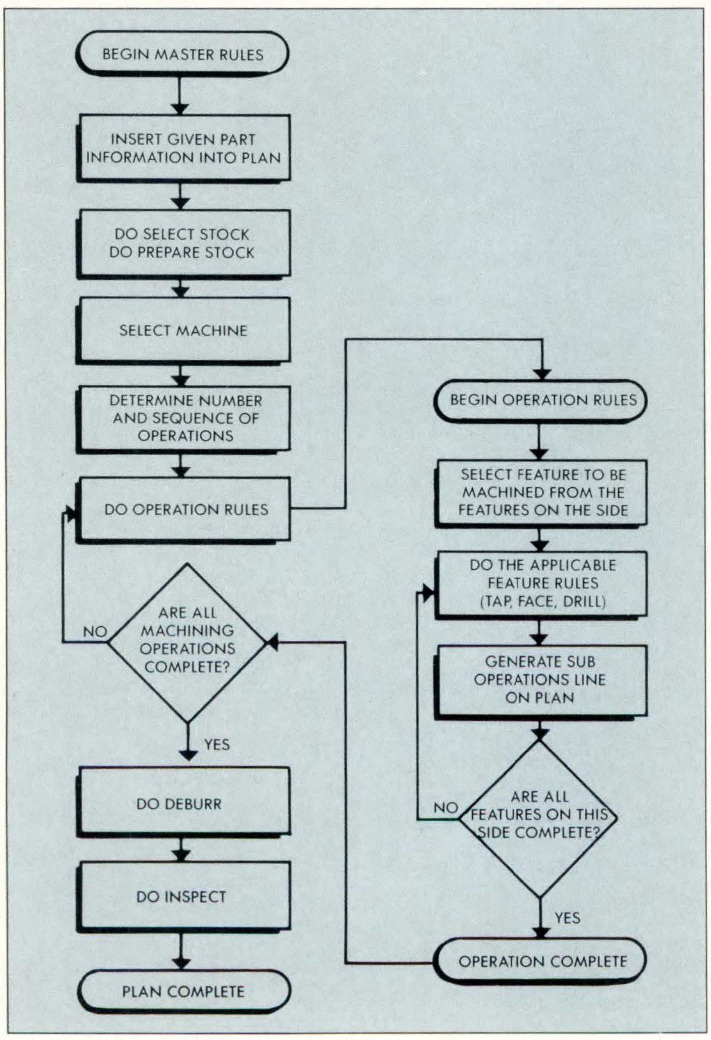


Figure 3—*In a flow chart of an expert system for development of a process plan, each process box represents some number of unsequenced rules that are "mini-experts" in some limited area of knowledge.*

Part data is the description of the part's attributes: material, number of features (e.g., holes and grooves), lot size, and so on. Much of this data can be captured directly from CAD information—the drawing of the part. An example listing of CAD information is shown in Figure 2. Manufacturing data consists of information relevant to the availability of material and the capabilities of tools and machines.

Other capabilities of this expert system include the ability to use GT techniques with rules—that is, rules relating to the manufacture of prismatic parts should be grouped separately from those rules applying to the manufacture of round parts.

Another notable characteristic is the ability to control the order in which sets of rules will be executed. Experience proves that for process planning, at least, giving the user some form of control is necessary (Figure 3).

The expert system is totally integrated into the existing CAPP system and has access to all facilities available in the CAPP system: data access, word processing, classification, and note retrieval. It should thus be viewed as an adjunct or assistant to the process planner. It's another tool that can be used in the efficient and productive development of process plans.

Because of the availability of the generative system, as a result of integration, users can begin automation of process planning using the variant approach. As they become adept at this style of process planning, they can look at areas of planning to be done automatically by the expert system. This evolutionary approach reduces the shock often felt when a company automates some aspect of its business.

The automation of process planning has taken advantage of new software techniques. Developments in information management have led to CAPP systems that are significantly easier to use and that more closely model real-world information. Developments in AI have resulted in CAPP systems capturing and utilizing the expertise of process planners. These expert systems needn't replace process planners, but, rather, should be thought of as assistants in the development of plans.

PDP-11 Compatibility For VMEbus

Mounting Digital's J-11 CPU on a VME board provides an ideal solution for designers of realtime control systems/by Keith Cribbin [ISKRA VME Technologies]

The attractiveness of the VMEbus has surpassed even the most optimistic expectations of the original VMEbus pioneers. Users are finding there's plenty of product available to encompass all their needs, be it 16- or 32-bit CPU designs. For system designers and others looking for a base of software for realtime control systems, mounting Digital Equipment Corp.'s J-11 CPU on a VME standard board provides an ideal solution. The software base available for the PDP-11 family, coupled with the performance and worldwide acceptance of the VMEbus architecture, provide developers with a powerful and true "open system" combination.

The VMEbus has become the world's standard for realtime, high performance 16/32-bit bus architecture. It has been standardized by the International Electronics Commission; it's currently a proposed standard of the IEEE, and has earned the support of more than 200 board and system manufacturers around the world.

Realtime Applications

Coupling a standard bus architecture, like the VME with the Digital J-11 microprocessor, with full RSX-11M operating system development support makes for a potent combination for any application requiring realtime data acquisition and control. With full PDP-11 compatibility on a VMEbus, a user's costly software investments are preserved.

Such a board would offer several advantages to a systems designer. For example, the data transfer rate across the VMEbus outpaces those in the comparable Digital bus structure. While the theoretical bandwidth across the Q-bus is 3.3 Mbyte/sec., the bandwidth of the VMEbus has a theoretical top end of 40 Mbyte/sec.

An important factor affecting the speed of the VMEbus is its asynchronous clocking scheme. Address and data lines on the bus are hard-wired and nonmultiplexed, making it possible to adjust the speed across the bus to the speed of the bus master.

"The VMEbus has become the world's standard for realtime, high performance 16/32-bit bus architecture."

The interrupt structure in an asynchronous system makes a big difference in system efficiency. This is because the speed with which one board responds to an interrupt signal and relinquishes control of the bus governs how quickly another board can access information and continue processing. A VME board responds when its interrupt-request line is driven low. This causes its interrupt handler to drive the current master off the bus. Simultaneously, the handler issues a priority request to the bus arbiter. The arbiter decides which master can access the bus next.

The essence of realtime control, however, is the speed at which a board acquires and passes data. For example, in a realtime VME acquisition and control system, several boards may have their own CPU and memory, and can act as a bus master by taking control of the bus.

But transfer rates alone wouldn't make such a board a winner; its biggest plus is that it can run on the VMEbus in a true multiprocessor system. J-11 VME processor boards are designed for integration into a multiprocessor system with distributed handlers and bus lock support that enables two or more processors to receive and service bus interrupts and requests and share the same peripherals and controllers of the system. Each co-processor in the system executes its own part of the system executive and services only those interrupts directed to it by the other processors or peripherals in the system.

Board Architecture

VME processor boards follow the standard 9.2 x 6.3-in. double height VME form factor. All VME boards use the popular pin and socket DIN connector to the backplane to increase overall reliability.

The Digital J-11 CPU on a VME processor board communicates with local memory, clocks, and devices connected to the serial and parallel interfaces across the board's bus. The four levels of pipelining and prefetch within the CPU permit overlapping of bus transfer and internal microprocessor operations. The CPU also contains a 64-bit

Keith Cribbin, North American sales manager for ISKRA VME Technologies (Farmingdale, NY), holds a B.S. in biology/chemistry from St. Johns University.

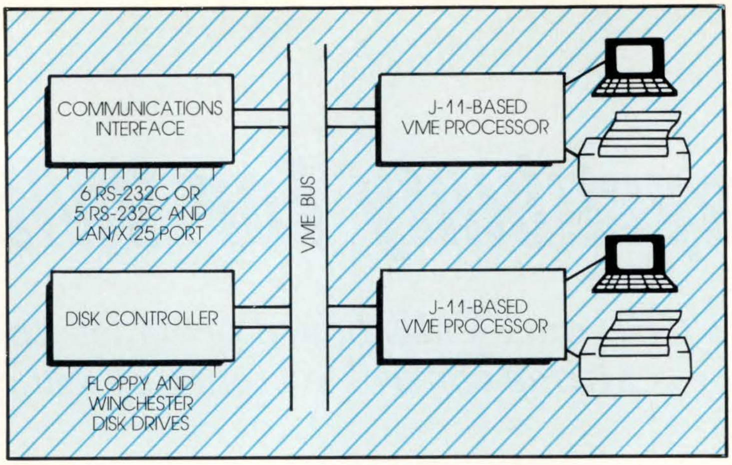


Figure 1— Multiple J-11 VME processor boards can be combined in a single system.

floating point and 32-bit internal data path optimized to handle the floating point arithmetic. The memory management section of the CPU provides three levels of memory protection for multiuser, multitasking applications and extends the 128-Kbyte directly addressable memory to about 4 Mbytes of physical address space.

Memory available on a J-11 VME processor board can include 512 Kbytes of dynamic RAM and 4 Kbytes of EPROM. Local memory can be accessed across the local bus by either the CPU or an external DMA device. The memory module is also fitted with programmable array logic (PAL) for flexible address decoding. Byte parity can be checked in local memory access operations.

The dedicated on-board memory yields "cache-like" performance and increases overall CPU efficiency. For example, local memory stores a version of the RSX-11 executive, which substantially decreases bus overhead. Efficiency is also augmented by using global memory for shared data and device drivers and local memory serves as a site for specific application software.

The serial asynchronous interface is DL-11 compatible. Serial-to-parallel conversion is handled by a universal asynchronous transmitter/receiver (UART). The serial line serves as a console terminal port and has a standard PDP-11 address.

The parallel interface can be used as I/O ports or as a printer interface that is Centronics compatible and is fully software supported. The programmable timers can be used for general purpose realtime applications.

The realtime clock provides the heartbeat for a J-11 VME processor board in realtime applications. An MC146818 CMOS device features a complete time-of-day clock with alarm and 100-yr. calendar, a programmable interrupt, and 50 bytes of static RAM connected to external battery backup. The battery maintains data integrity in the RAM while the board is powered down.

Functionality

The toughest part of the board design is to map between the interrupt structure and the bus maps of the PDP-11 and the VME. The PDP environment calls for reserved interrupts and an 18-bit address, whereas the VMEbus supports the full 7-level interrupt structure and up to 32-bit addressing.

The PDP environment calls for reserved interrupts, but in the VME they can be assigned by the user to support multiprocessing. Making the J-11 VME processor play as the brains of a multiprocessing system means engineers have to configure the card with a single or distributed interrupt handler.

In a single-handler system, a J-11 VME processor board has seven levels of interrupts. Three of the interrupts are reserved for on-board control of the local bus, while four are reserved for the VMEbus interrupts and controlling system hardware. When a single-processor system is implemented, the VME assigns priority to the local board because it assumes it is acting as the VMEbus system controller.

In a multiprocessor system (Figure 1), a distributed interrupt handler is implemented. This means that, for example, the first CPU in the system is assigned a 4-level interrupt, while the second CPU uses a 3-level interrupt mode. If the multiprocessor system has a third CPU, it would be assigned only two levels of interrupts, and so forth. When an interrupt is issued, each CPU responds only to its specific level of interrupt, which greatly speeds the handling procedure.

In a multiprocessor configuration, a 4-level arbitration scheme services the four levels of bus request. This gives priority to the board acting as system controller and assigns priority to all other boards based upon their level of interrupts.

For example, two J-11 VME processor boards could become the heart of a multiprocessing system. One board assigned a 4-level interrupt could be taking care of system control chores, while the other board with the 3-level interrupt takes care of all data acquisition. If an additional processor is added, the system will drop down to two levels of

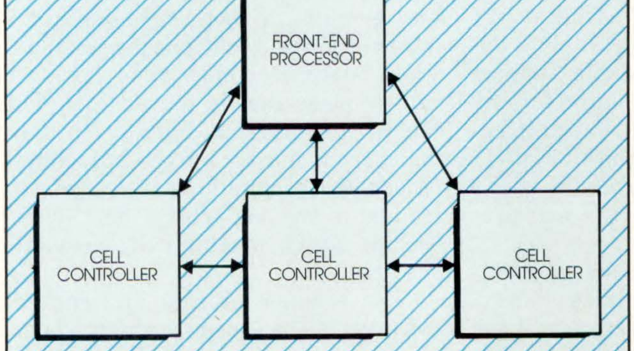


Figure 2—A representative distributed control system allows communications between a VAX and several J-11 VME processor boards via a front-end processor.

BI Accessibility To VMEbus/by Steve Kadner [Aeon Systems Inc.]

During the past decade, Digital Equipment Corp. has provided an increasingly sophisticated general-purpose computing environment based on the VAX family of processors. Users with scientific and industrial applications need and appreciate these capabilities, but also have additional specific requirements (e.g., process control, high speed data manipulation, etc.).

Additionally, it's frequently necessary to offload time-critical or processor-intensive tasks from the VAX, allowing it to provide services that are, in some aspects, more complex (e.g., file systems, development tools, etc.). With the introduction of the BI as the basic interface presented by VAX computers and the increasing availability of VME products, a method of connecting these two buses is required. As the performance of single-board computers increases, it's reasonable to place one or more in a VME crate; a BI/VME connection should supply both high data rates and an interprocessor communication protocol.

BI/VME Interconnect

The design goal then would be to build an intelligent communications device (ICD) for connecting a BI-based VAX with a VME system. To meet this goal, an ICD was designed by Aeon Systems Inc. (Albuquerque, N.M.), after receiving a BI license from Digital. The ICD consists of three boards; one resident in the BI and two in the VME crate. Each controller executes cycles on the local bus (BI or VME); they pass data and commands over a full-duplex RS-422 parallel highway of up to 70 ft. in length.

Both the BI and VME portions of the ICD have large (8 Kbyte) first-in first-out (FIFO) buffers to allow accesses on each bus to be independent. Further, the minimum transfer is an octaword (16 bytes) for efficient utilization of bus bandwidth. Maximum data transfer is 6 Mbytes/sec. The controllers also exchange command words that pass over the same parallel highway, but upon receipt are buffered into separate command FIFO buffers, allowing control information (e.g., next transfer setup) to be intermixed with data. While data is usually only moved in one direction at a time, having dual transmission paths eliminates the need to arbitrate for a single highway, thus increasing bandwidth.

The BI protocol is implemented with the Digital BCII/BCIA chip set, ensuring conformance with all other devices in a backplane. Data transfer is orchestrated by a J-11 microprocessor that executes code down-loaded from the host VAX during the ICD initialization. There are two direct memory access (DMA) engines; one is used to transfer from VAX memory to the J-11 and update the current VAX physical address over page boundaries for scatter/gather operations; the second controls access between the BI and the link to the VME controller. The VAX need only construct a communication request block describing the direction of transfer (read/write) and list the physical addresses of the pages that comprise the data buffer. The address of this request block is passed to the ICD, which moves it (with the DMA engine) to the local (J-11) memory.

The ICD implements a protocol that transmits datagrams on up to 1024 independent channels or sockets. When one host issues a write on a channel for which the other host has requested a matching read, the ICD initiates data transfer and informs both hosts when the transfer is complete. The ICD can act as a rendezvous agent to provide synchronization between the hosts. The ability to specify a logical destination (via channel address) allows the ICD to provide multiprocess communications.

The VME portion of the ICD is a two-board set: one has two DMA engines that perform 32-bit transfers from the RS-422 link to the VME bus, the other is a 68020-based controller. Both boards use Signetics BUSCON VME controllers to interact with the bus; the controller is a slave and interrupter and the DMA board is a VME master. They communicate over a private bus built on the uncommitted portion of the P2 connector on the VME backplane. The controller has a dual-ported memory into which a VME host places transfer requests. Each ICD channel has a unique 8-byte control/status area; a write to the control portion causes an interrupt on the 68020 that will then process the transfer request. Completion of the request is indicated in the status area.

Steve Kadner, Aeon Systems Inc. (Albuquerque, N.M.), has been with the company since its inception. Kadner is also executive vice president of Aquila Technologies Group Inc., Aeon's parent company.

interrupts, simplifying bus master designation and priority handling.

In mixed multiprocessor configurations, the J-11 VME processor board runs RSX-11 and serves as the system controller. Other VMEbus masters and peripherals can then communicate with the board by either DMA transfers directly to the on-board RAM or by the addition of shared global memory on the bus. Communications between tasks and processors and the sharing of data can then be regulated by the use of flags or semaphores. Thus, with the VMEbus multiprocessor and bus lock support, the designer can mix and match the processors, application software, peripherals, and operating systems as required.

Software is the key. With the growth of distributed control systems and factory automation, it's to the designer's interest to select the appropriate components and software for system integration. However, these intelligent controllers don't exist alone. Communications between the controller and the supervisory computers are becoming much more critical for factory automation and control.

Networks are now developing where these controllers must talk to a VAX, IBM mainframe, and/or a LAN (Figure 2). Software compatibility and the availability of "off-the-shelf" software packages often determine the success and the timely completion of the project.

The Digital J-11 CPU on the VMEbus can satisfy most of these requirements. With full PDP-11 compatibility, the designer has available a wide range of application packages and development tools such as supervisory control and data acquisition (SCADA) and DECnet. With the versatility and multiprocessor support of the VMEbus, front-end processors and cell controllers can be designed to mix and match the processors, peripherals, and software the engineer requires.

Optionally, the controller can execute a VME interrupt cycle to notify the requesting host. All data movement between the VME and the link to the BI is performed by the DMA engines. One engine is responsible for reads to VME addresses while the other handles writes; transfers are 32 bits wide within a 24-bit address space.

Software Support

While the ICD provides a high speed, logically multiplexed conduit for the exchange of datagrams, host-specific software is necessary for use by application programs. The ICD is supported under VMS, with a device driver and a library of interface routines. The driver will create a unit on request, and associate it with a user-specified ICD channel (providing no other unit has already allocated that channel). After successful creation, the application can transmit and receive datagrams from 4 bytes to 32 Kbytes in length. The driver also supports a special function to allow VME hosts to move data into buffers that can be kept allocated for multiple transfers, lowering VMS overhead. Support for this, as well as routines to implement remote procedure calls, are in a library that applications can link to, as appropriate.

The enormous diversity of systems possible in VME complicates the task of defining an access method. Therefore, two approaches have been chosen. A generic library of routines (written in C) is available that can be customized for a specific processor and operating system. To provide a more complete environment, an ICD ROM-based support package has been developed for the Motorola MVE133 single-board computer (based on the 68020 microprocessor with local ROM, RAM, and RS-232 terminal interface). This processor will execute either a diagnostic/checkout program or user code, depending on the state of on-board jumpers. The diagnostic/checkout program provides a simple-to-use, menu-style interface and communicates with a program presenting the same interface that executes on the VAX. All the functions of the ICD can be initiated from the terminal to ensure proper functioning of the hardware. The ability to control the ICD from a terminal also aids in the independent development of application programs on the VME and BI sides.

If the board is set to start executing user code, support routines provided in ROM can be used to access the ICD. These routines implement ICD channel arbitration, end of transfer notification, and a protocol for remote procedure calls (both as client and server).

The ICD is a flexible, high speed solution in applications that require both the high level services offered on a VAX and the specialized functions that can be implemented in a front-end VME system. Providing both a high bandwidth physical link and a communication protocol for delivery of addressed datagrams eases initial development of a multiple bus system and simplifies the implementation of any later modifications.

TECHNICAL CONSULTANT *by Robert Gezelter*

What should you do before disaster strikes?

One morning, as you're driving to work, you're stopped by a National Guardsman. He asks you where you're going. He then informs you that the warehouse located a half mile from your firm's complex has caught fire. There is a severe danger of explosion and toxic fumes. The entire area has been cordoned off. You ask how long the area will be restricted. The guardsman says, "Maybe a day, maybe a month."

All too often, the first time disaster planning enters our consciousness is after a problem has occurred. The results can be, and often are, catastrophic. If you're lucky, the impact of the incident is minor. However, a computer-related disaster can have a severe impact on a business' ability to operate, and can, in some extreme situations, destroy the business.

Ever since computing became an integral part of business, disaster planning has been a consistent part of a system manager's responsibilities. In large computer facilities, the system manager is able to draw upon the extensive resources of the organization to assist in the preparation of plans that deal with various disasters. In these large facilities, the typical manager has many years of experience and extensive exposure to such concerns.

However, in smaller facilities, expertise in disaster planning is not always available and the system manager generally has a less extensive background in coping with problems in the event of a disaster.

The trend toward local computing capacity has increased the vulnerability of the systems to disasters. With the advent of distributed and departmental computing, responsibilities that were previously the exclusive domain of the computer center have now become the responsibility of local and departmental staff. Local and departmental staff have inherited much of the responsibility for ensuring the safety of computerized data.

Disaster planning need not be a formal, expensive, bureaucratic process. Disaster planning merely means ensuring that the data and programs needed to operate your business are adequately protected against accidents occurring within your firm and in your area.

Obviously, each type of disaster requires a different type of precaution. While some precautions are effective only against particular types of incidents, backups (machine-readable copies of stored data) are a fundamental and indispensable part of planning for all types of incidents. Other precautions are effective only against certain classes of problems.

"Disaster planning need not be a formal, expensive, bureaucratic process."

Effective disaster planning must allow for a wide range of potential situations, including fire, flood, power outage, and evacuation. While fires are generally perceived as the major threat to a system, they are only one part of the overall threat. For example, many facilities rely on on-premises storage to guard against fire and equipment failure. Unfortunately, if a flood or other event destroys the facility (or makes the facility inaccessible), the backup information cannot be used.

Evacuations are also commonplace. A fire in a nearby warehouse can cause an evacuation for several hours or days. Tank car derailments can result in evacuations lasting days. A fire in another part of the same building can result in an evacuation lasting years. Any disaster plan, even for the smallest business, must take these issues into account.

Here are some basic guidelines that can be used to protect your data and programs.

Always maintain a complete machine-readable backup copy of all data and programs used in your facility. A duplicate set of these backups should be maintained at a location physically removed from your offices. Never allow all backup copies to be on the main premises at the same time. If necessary, make additional copies so there is always at least one copy off the premises at all times. Always store these off-premises backups in a location that will not be affected by incidents involving your office (for example, if you live in an area with a flooding problem, don't store the off-site backups at a location that probably will be flooded if your offices are flooded).

Make sure that the off-site (and on-site) backups are current. The exact frequency of the backups depends upon the activity of your facility. However, in no event should the backups be updated less than monthly.

Effective disaster planning is a crucial concern of everyone who runs any kind of computer facility, from a personal computer to multiple supercomputers, and should be done before disaster strikes!

Robert Gezelter is a software consultant with more than 12 yrs. of systems programming experience. Address correspondence to: 27-42 168th St. #312, Flushing, NY 11358-1130.

New UPS For VAX

FERRUPS Uninterruptible Power Systems (UPS); features Pulse Width Modulation (PWM), internal bypass switches, and the UL Listing Mark; available as standard equipment on all FERRUPS in the 7.5-15 KVA range; is a new proprietary design inverter using hybrid Pulse Width Modulated Ferroresonant technology circuitry that provides increased efficiency, better voltage regulation, lower distortion, faster response time, reduced heat, and extended battery runtime.

The standard internal bypass switch eliminates the need for a separate and costly breaker box in a facility's electrical system to cut the FERRUPS out of the system for test or service; Underwriters Laboratories Inc. (UL) has granted use of its Listing Mark on the top-of-the-line FERRUPS in the 7.5-15 KVA range; all Best FERRUPS from the 250 VA MICRO-FERRUPS to the 15 KVA models now are UL approved.

Best Power Technology Inc., P.O. Box 280, Necedah, WI 54646, 800-356-5794; In Wisc. 608-565-7200.

Enter No. 508

Winchester Controller For MicroVAX Systems

DQ616; disk controller intended for interfacing up to four ST506/412 Winchester disk drives to MicroVAX, MicroPDP-11, and LSI-11 computers; it is contained on a single, dual-height board, and is fully compatible with Digital's Mass Storage Control Protocol (MSCP) driver contained in the MicroVMS, RT-11, RSX-11M+, RSTS/E, and Ultrix operating systems; greatly enhances storage subsystem operation; contains an 8-Kbyte buffer to support 1:1 sector interleave, thus reducing software-generated latencies between the Q-bus and the disk drive; has a command queue buffer that can store up to 16 commands for up to four drives; this buffer stores the commands received by the DQ616 and queues them for the proper order of execution on each drive.

The controller employs an elevator seek ordering algorithm to determine the execution priority of commands for each drive in the command buffer, to optimize seek requests and reduce drive seek latencies; the controller supports 16-, 18-, and 22-bit Q-bus addressing, and supports both block and nonblock mode memory; $1,150.

DILOG, 1555 S. Sinclair St., P.O. Box 6270, Anaheim, CA 92806, 714-937-5700.

Enter No. 509

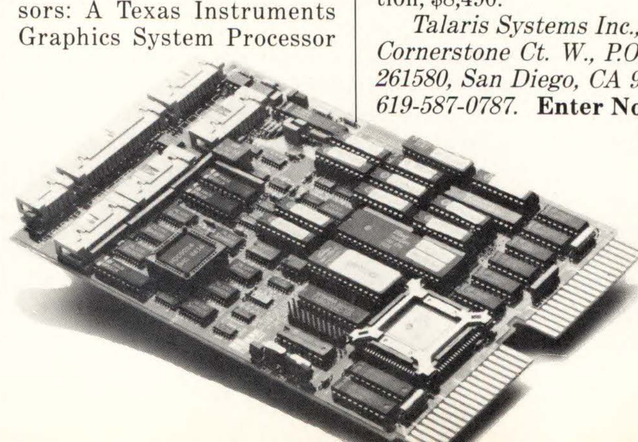
Multiuser Printstation

Talaris 1590 Printstation; a 15-page per min. laser printer architecture designed especially for the multiuser environment; provides flexibility, speed, power, and connectivity and allows for extensibility in the future; includes a new controller, designated the Talaris 1590 Printstation Control System (PCS), which has two processors: A Texas Instruments Graphics System Processor (TI 34010) performs highly efficient raster image processing, and a National Semiconductor 32016 manages I/O and interprets commands; the PCS architecture provides for expanding memory from 3 to 5.5 Mbytes; the printstation uses Talaris' Extended Command Language (EXCL), based on the ANSI X3.64 standard, with extensions to support emulations, page description languages (PDLs), and graphics.

The PCS architecture employs the ANSI standard small computer systems interface (SCSI), which permits

the printstation to accept data from the host network at speeds of up to 1.5 Mbyte/sec.; besides the SCSI, each printstation features an RS-232 and an RS-422 interface, as well as a Dataproducts parallel; an optional Centronics parallel interface is also available; the printstation offers compatibility with a wide range of word processing and graphics software; features built-in LN03 Plus, Tektronix 4014, and Diablo 630 ECS emulations; comes standard with 40 fonts stored in ROM, including a polygon fill font with 59 patterns; all fonts can be printed in portrait and landscape orientation; $8,490.

Talaris Systems Inc., 6059 Cornerstone Ct. W., P.O. Box 261580, San Diego, CA 92126, 619-587-0787. **Enter No. 510**



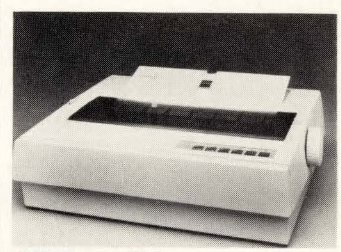
Parallel Transfer Disk Drive

Centaurus C-825-10 Parallel Transfer Disk (PTD); offers 825 Mbytes of storage with a peak data transfer rate of 18.6 Mbyte/sec.; is best suited for applications in the areas of realtime image processing, color digital video, wideband supercomputer data processing, and other special applications requiring very high bandwidths in the range of 10-300 Mbyte/sec.

The Centaurus PTD is a 14-in. drive that mounts in a 19-in. Retma rack; it can be connected to a variety of VMS, UNIX, and PC-DOS computers, and provides for ESMD, VME, or 16-bit parallel data interfaces; $27,000, quantity 100.

Ampex Corp., 401 Broadway, Redwood City, CA 94063-3199, 415-367-4151.

Enter No. 512



DEC Compatible Dot-Matrix Printers

9500D and 9515D; 250 cps dot-matrix printers for OEM markets that provide full compatibility with Digital's LA50 printer in both wide (10-in.—9500D) and narrow (15-in.—9515D) carriage models; they offer a choice of print speeds with a 60 cps near letter quality (NLQ) memo mode, a 28 cps letter quality (LQ) mode, and a 250 cps draft print speed; they use a 9-wire print head that forms characters in a 9 x 9 matrix in draft mode and a 10 x 9 matrix in NLQ mode; for letter quality output, they produce a character matrix of 18 x 27 in LQ mode; for business graphics and bar coding application, they have a resolution of 240 x 144 dots per in.

Designed for reliability, the 9500D and 9515D have a rated MTBF of 7000 hrs. and a head life of 100 million characters; for multipart form applications, the printers can handle the original, plus three copies; an expandable 2-Kbyte buffer is standard; standard interface for the Digital environment is RS-232C; plug-in cassettes provide a large selection of character and graphics fonts; 9500D $749, 9515D $949.

C.Itoh Electronics Inc., 19300 S. Hamilton Ave., Torrance, CA 90248, 213-327-9100. **Enter No. 513**

Disk Defragmentation Product For VAX

Diskeeper V. 2.0; eliminates fragmentation of files to allow data to be read from the disk at maximum speed, while also grouping free space at the front of the disk for efficient and contiguous creation of files; has the ability to run online as a detached process (in the background) while users are accessing the system; keeps disks running at peak performance without interrupting users; processes common system disks, quorum disks, data disks, volume sets, shadow sets, and any other FILES-11B ODS-2 disk supported by Digital; can process multiheader and multivolume files; file relocation algorithm maximizes consolidation of free space, while maintaining maximum VAX performance by freeing space near the beginning of the disk.

Diskeeper V. 2.0 can handle up to 16 disks per process, maintaining separate monitoring and run-frequency calculations for each individual disk; it also includes a proprietary file-locking mechanism, making the possibility of a user access conflict virtually impossible; product can be paused and resumed on any disk at any time, giving the VAX manager complete control over his system; an I/O throttling feature optionally limits Diskeeper's own I/O to the equivalent of disk I/O "idle time."

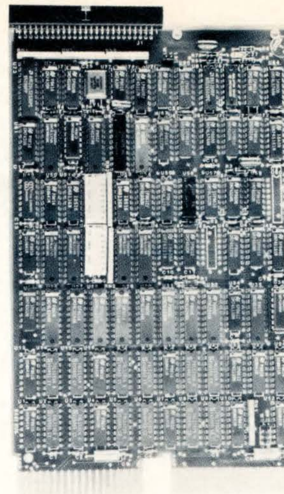
Executive Software Inc., 3131 Foothill Blvd., Ste. F, La Crescenta, CA 91214-2699, 818-249-4707.

Enter No. 514

SASI Bus To Q-bus Host Adapter

SDC-HA11; interfaces SASI bus devices to the Q-bus; plugs directly into any contiguous dual Q-bus slot and presents one load to the bus; up to eight SASI bus devices can be easily daisy-chained to the SDC-HA11; one device is selected at a time for processing on the Q-bus; can request up to 10 command bytes before executing the command from the host; upon completion of the command, the SASI device (e.g., disk drive or laser printer) stores the completion status in a register in the SDC-HA11.

The SDC-HA11 provides switch-selectable base address selection from 160000 to 177760 (octal) and interrupt vector selection from 000 to 374 (octal); parity enable/disable and interrupt priority selection (4, 5, 6, or 7) are jumper-selectable; $417.



Sigma Information Systems, 3401 E. La Palma Ave., Anaheim, CA 92806, 714-630-6553. **Enter No. 515**

High Resolution Color Image Printer

4693D; a high performance, 300 dots per in. thermal wax color printer featuring a built-in image processor; developed to produce color hardcopy from high end color graphics workstations, terminals, hosts, and personal computers; prints full-sized images from a palette of more than 16 million colors; with an 8-bit parallel interface, images can be offloaded to the 4693D in 6 sec., with production totalling 90 sec. for the first copy and 60 sec. for subsequent copies; provides hardcopy colors that represent true display screen colors for both paper copies and transparencies; a built-in frame buffer with 4 to 12 Mbytes of memory can store as many as three images, freeing the graphics system for computing; the high speed multitasking Motorola 68020 microprocessor accepts up to 2048 pixels by 1536 pixels by 24 bit/pixel of image data from the graphics system at a high speed 800 Kbyte/sec., or up to 3198 x 2440 at lower color depth.

With a 4-channel multiplexer, up to four terminals, workstations, hosts, or personal computers can be connected to the printer simultaneously; an easy-to-see display on the 4693D's front panel indicates which user's image is being printed, how many prints have been requested, and which images are printing next; $7,995; available now.

Tektronix IDG Marketing, P.O. Box 1000, M/S 63-447, Wilsonville, OR 97070, 800-225-5434; In Ore. 503-235-7202.

Enter No. 516

Tektronix 4107/4109 Emulation

EMU-TEK Seven Plus V. 1.21; software emulating Tektronix 4107/4109 graphics terminals; features include a new user interface, a streamlined setup mode, and support for more graphics adapters; newly supported graphics adapters are the PS/2 VGA (640 x 480), the PG 90 Model 10 from Adage Inc. (1280 x 1024), the AGC 1076-4N from Imagraph Inc. (1024 x 768), and the PEPE board from Vectrix Inc. (1024 x 1024); currently supports eight boards and the VGA, PCG, and EGA standards.

Other EMU-TEK Seven Plus V. 1.21 graphics adapters are available.

FTG Data Systems, 10801 Dale St., Ste. J-2, Stanton, CA 90680, 714-995-3900.

Enter No. 517

DEC Compatible Systems

Computer System For High Continuity Applications

MIRA (Microprocessor Implementation of a Reliable Architecture); based on the popular MicroVAX II computer; designed for use in developing applications where continuity of operation is essential; was developed to enable designers to implement systems for high continuity applications; ideal for OEMs and system developers; features dual computers that can be powered from separate external electrical supplies to guard against power failures; a single cabinet contains the two separate computers and integrated hardware controllers that, with associated software, can detect failure of one system and switch operations and attached devices to the other system.

MIRA is easily adaptable to applications such as message switching, manufacturing operations, and access control operations; a basic system is designed as a master/standby system: In the event the master computer malfunctions, software and hardware will automatically switch devices to the standby system and signal the system's operator to restart the operation; $66,820+.

Digital Equipment Corp., Maynard, MA 01754-2571.

Enter No. 412

New DEC Compatible Desktop Computer

QUBE QS-720; a DEC compatible desktop computer system that includes a 100-Mbyte half-height Winchester disk drive that interfaces with the CPU using the enhanced small disk interface (ESDI), and a 125-Mbyte ¼-in. tape drive for disk backup; the new peripherals may be integrated with all Digital Q-bus CPUs, including the PDP-11/73, LSI-11/73, and MicroVAX.

The QUBE QS-720 provides OEMs and system integrators with the ultimate Digital multiuser office system for vertical markets such as accounting, medical, dental, and legal; a typical configuration, such as a PDP-11/73 CPU with the half-height disk and tape drives, 1 Mbyte of main memory, and four user communication ports, is less than $9,500.

Unbound Inc., 15239 Springdale St., Huntington Beach, CA 92649, 800-862-6863; In Calif. 714-895-6205.

Enter No. 413

PC-To-VAX Connection

AST 220-Premium/286; offers the processing power of AST's IBM PC/AT compatible Premium/286 personal computer, combined with true VT220 terminal emulation features that enable communication with all Digital Equipment Corp. VAX and MicroVAX II systems; the pre-configured system is a 10 MHz IBM PC/AT compatible PC with an Intel 80286 processor and has a 40-Mbyte Winchester disk drive, a 1.2-Mbyte diskette drive, the AST 3G-Plus graphics board, 1-Mbyte Fast RAM, the 101-key keyboard, and MS-DOS V. 3.1 and GW BASIC software; installed into the system is an AST-220 board that has an on-board 80186 microprocessor and 128 Kbytes of RAM.

The AST 220-Premium/286 provides connection with any Digital host and emulates the VT52/100/220 and ASCII terminals; also supported are all of the downloadable Digital character sets (Multinational, Standard Supplementary, and Special Graphics), as are both

80- and 132-column display and double-width and double-width/double-height characters; connection to the Digital host is through two RS-232C ports; $4,190.

AST Camintonn Digital Division, 2121 Alton Ave., Irvine, CA 92714, 714-553-0247. **Enter No. 414**

Performance Enhancements

Enhancement Board For PDP-11 And VAX

68SUM; a 68020-based supercomputer designed to serve as a slave processor in high volume data processing applications on Unibus-based PDP-11 and VAX computers; uses a Motorola 68020 32/32 bit central processor and a 69991 floating point coprocessor to provide high speed computational capabilities at up to twice the performance of any PDP-11 or VAX 700 series computer; packaged with 2 Mbytes of dynamic RAM memory and a 68881 floating point coprocessor on a single hex-sized board; up to 256 Kbytes of host memory can be shared via windows; this allows direct access by the Unibus PDP-11 or VAX to the 68SUM's 2-Mbyte dynamic memory, as well as direct access by the 68SUM to the host's memory.

Users simply download their high level language programs via shared memory to the 68SUM and receive program results up to two times faster than if the programs had been run on the host alone; $5,850.

Ranyan Corp., 15239 Springdale St., Huntington Beach, CA 92649, 714-895-5504. **Enter No. 415**

Memory Expansion Board For VAXmate

DM373A; memory card is a fully populated, multifunction I/O enhancement product with EMS capabilities; supports up to 2 Mbytes of expanded memory and includes the most commonly used features, such as parallel printer port, RS-232 serial interface, realtime clock/calendar, and battery backup; allows the end user to maximize expansion slot usage by providing all these functions on one board; also included with the board is a utility diskette that contains EMM (expanded memory manager), RAM disk, print buffer, realtime clock/calendar program and example CONFIG.SYS and AUTOEXEC.BAT files.

The board slides into a 16-bit slot at the rear of the DM300 High Speed Expansion System and provides the end user with 2 additional Mbytes of expanded memory to allow increased usage of software application programs; $995.

dmi, 27635 Forbes Rd., Ste. H, Laguna Niguel, CA 92677, 714-955-2422 or 714-582-3118. **Enter No. 416**

Storage Devices

New High Capacity Disk Drives

14000 series and the T472; the 14000 series are half-high, 5¼-in. Winchesters; formatted capacities of 114, 140, and 170 Mbytes; designed for use with high speed controllers, based on either the high speed ESDI or SCSI standards; operates at average access times of 25 msec, and transfers data at 10 Mbps; uses thin-film head and media technology that improves data margins at the high bit densities needed to support storage capacities in excess of 25 Mbytes/disk surface; each 14000 series drive incorporates four disks and operates at a track density of 1440 tracks/in.; 19,405 bpi, using 2,7 RLL encoding; the drives use embedded sector servo information that guarantees positioning reliability.

The T472 is a 472-Mbyte removable pack disk drive; extends the company's 300-Mbyte T306 line; uses ESMD interfaces for ease of integration; operates at a transfer rate of 1.8 Mbytes/sec. and an average access time of 26 msec; the 14000 series pricing is as follows: 114-Mbyte 14404 ($1,500); 140-Mbyte 14405 ($1,700); 170-Mbyte 14406 ($2,000); 90 days ARO; the T472 is priced at $12,400; 90 days ARO.

Century Data Systems Inc., 1270 N. Kraemer Blvd., Anaheim, CA 92806, 714-632-7500. **Enter No. 417**

40-Mbyte Portable Hard Disk For The VAXmate

DM370; microportable hard disk unit for the VAXmate and IBM/AT compatible PCs; provides 40 Mbytes of storage; is small enough to hold in the palm of your hand and weighs less than 3 lbs.; data access time of 28 msec; doesn't require special packaging or handling when being transported, since the heads of the disk are automatically parked when the unit is disconnected; disk requires no external subsystem to operate since it gets its power and control from the host system.

Plug it into the back of your PC, and after use, a simple disconnect allows the user to remove the disk unit for portability or data storage protection; $1,995.

dmi, 27635 Forbes Rd., Ste. H, Laguna Niguel, CA 92677, 714-955-2422 or 714-582-3118. **Enter No. 418**

Optifile II Supports Maxtor WORM Drive

Optifile II; supports Maxtor Corp.'s 5¼-in. optical drive; with Optifile II, various types of WORM optical drives can be simply plugged into a Digital system and be immediately put to use; all software utilities (COPY, BACKUP, DIFF, etc.), applications, and layered products can be used without changes to any software.

Optifile II is literally a "plug and play" situation; it fits into a MicroVAX II to create an optical subsystem or can operate standalone with single or dual drives; a complete internal mounting kit for the MicroVAX II is available.

KOM Inc., 145 Spruce St., Ottawa, Ontario, Canada K1R 6P1, 800-267-0443.

Enter No. 419

RD54-Identical Disk Drive

Model 100; shipped with all switch panels and other hardware necessary for installation in a BA-123 MicroVAX enclosure; features include: 155 Mbytes of formatted storage, 30 msec access times, and no add-on chassis or controller required; fully compatible with Digital's RQDX3 controller; $3,200.

Westford Systems, Carlisle, MA, 617-371-7015.

Enter No. 411

Optical Disk Jukebox For VAX/VMS

LaserStar; an optical disk jukebox subsystem for Digital VAX and MicroVAX computers running the VMS operating system; provides automatic, VMS-transparent access to the massive storage capacity of optical disk jukeboxes; it is a complete, integrated, ready-to-use optical disk jukebox subsystem; it may be configured with either the OSI ODSR jukebox or the Cygnet Series 1800 Expandable Jukebox.

LaserStar can provide total online storage capacities of 15-141 double-sided 12-in. optical disks; each write-once disk can store up to 1 Gbyte (1000 Mbytes) of data per side; LaserStar can also be configured with up to five optical disk drives to accommodate a wide range of performance requirements.

Perceptics Corp., Pellissippi Center, Knoxville, TN 37922, 615-966-9200.

Enter No. 421

Controllers And Host Adapters

SMD/SMDE Disk Controllers

DQ246 and DQ256; DQ246 is designed to interface up to four SMD-type drives with 20 MHz data transfer rates to any Q-bus system; DQ256 has true differential drivers to interface up to four high performance SMDE-class drives, with 24 MHz data transfer rates; both units employ a newly streamlined internal data path to increase data transfer speeds between the disk and the CPU, plus they make use of the newest enhancements to DILOG's exclusive Dynamic Transfer Segmentation (DTS) to optimize disk interaction; provide more usable disk capacity, achieving formatted capacities greater than 85% of stated drive unformatted specs, which compares with the industry standard of only 80% of raw capacity; offer dual port capabilities for disk access by multiple host CPUs.

Both controllers are compatible with the mass storage control protocol (MSCP) driver contained in RT-11, RSX-11M+, RSTS/E, MicroVMS, Ultrix, UNIX, and DSM operating systems; support both block and nonblock mode memory with 16-, 18-, and 22-bit Q-bus addressing; DQ246 is $2,250, DQ256 is $2,850; 30–45 day delivery.

DILOG, 1555 S. Sinclair St., P.O. Box 6270, Anaheim, CA 92806, 714-937-5700.
Enter No. 422

Optical Disk Controller For MicroVAX II

SMS 0109; a multifunction controller that provides a SCSI port that allows an optical disk drive to be attached to any MicroVAX II system running standard VMS software; also supports two fixed Winchester drives and two floppy drives; has a logical port that converts the Digital MSCP protocol to the SCSI commands that are required for WORM devices; this conversion is transparent to the VMS operating system and requires no modification to the MSCP/DU device driver.

SMS 0109 provides independent access to the optical drive while simultaneously accessing the Winchester drive; to maximize disk data throughput, the SMS 0109 uses a noninterleaved disk format that allows access to data at the full disk data rate; multisector transfers occur without latency or rotational delay; $1,150.

Scientific Micro Systems Inc., 339 N. Bernardo Ave., Mountain View, CA 94043, 415-964-5700. **Enter No. 423**

Data Input And Display Devices

DEC Compatible Video Display Terminal

MC10; offers a new packaging design for improved ergonomics and a cartridge-based hardware and software configurability; designed to be used as a general-purpose display terminal in the ASCII and ANSI environments, as well as a platform for specialized vertical market applications; the unit is well-suited for simultaneous connection to multiple hosts, and can be used in environments where the multiple hosts are different types using different protocols.

The unit is available with an optional graphics package, with all-points-addressable display resolution of 720 x 348 pixels; can be configured with a variety of operating protocols and keyboards that allow it to be used in a broad spectrum of environments; $595.

Link Technologies Inc., 47339 Warm Springs Blvd., Fremont, CA 94539, 415-651-8000. **Enter No. 424**

Manufacturing/ Industrial Control

Enhanced Data Manager

The Factory Data Manager V. 3.0; provides a factory network to collect and validate both worker-entered data and sensors and programmable controller data; is a labor and machine data collection system that can track, to the second, who worked on what job and what component was worked on and the machines involved; V. 3.0 supports a factory network of micro-terminals with attached bar code or magnetic card readers.

V. 3.0 features include automatic holidays tracking, full resource tracking, support for SPC data collection, support for product liability tracking, and mainframe-style re-start/re-covery capability; supports AIAG-approved bar code label generation, UPC, and 2 of 5; MAP compatibility is assured; available for VAX and MicroVAX; $8,995+.

D.L. Hiller and Assoc., 14536 Island Dr., Sterling Heights, MI 48078, 313-247-0394. **Enter No. 425**

4GL MRP Module

Syman V. 2.3; the Advanced Manufacturing-MRP module allows management to plan material requirements based on production orders, customer orders, and forecasts, which can lead to improved scheduling and purchasing patterns and reduced inventory levels; key function is MRP generation, which anticipates when material shortages will occur and recommends orders to replenish these shortages; identifies "overstocked" situations and specifies when a planned order is unnecessary; from $2,995 to $13,995, depending on CPU.

MMS International, 2400 Corporate Exchange Dr., Ste. 200, Columbus, OH 43229, 614-895-0738. **Enter No. 426**

Data Output Devices

HP LaserJet Emulation Laser Printer

Talaris 810; has 256 Kbytes of graphics memory; includes all the HP LaserJet Plus commands in the emulation, the extra memory permits the use of device drivers that support the LaserJet Plus high density output for most applications; 12 fonts available, including: Letter Gothic 12 Pitch, Letter Gothic 15, Prestige Elite 12, Courier in 10 and 12 pitch, Orator 10 pitch, the DEC Technical scientific/math fonts in 10 and 12 pitch, the VT-100 Line Drawing fonts in 10 and 12 pitch, and a sans serif line printer font in landscape orientation; $3,450; is available with a Centronics interface for IBM PC users or an RS-232 for VAX/VMS users.

Talaris Systems Inc., 6059 Cornerstone Ct. W., P.O. Box

261580, San Diego, CA 92126, 619-587-0787. **Enter No. 427**

Raster Photoplotter With 8-Mil-Line Output

RPG-1620 raster photoplotter; uses an LED array as a light source; originally output film with 10 mil line width, now outputs with 8; accommodates an 18 x 22-in. film size as well as plots on glass or paper at a resolution of .001-in.; designed for CAD system users and service bureaus who want the advantages of in-house photoplotting; features include: automatic plot placement, automatic ground plane generation, with the ability to generate negatives with swells for solder masks, millions of built-in apertures, and nonvolatile RAM cartridges used to store custom aperture shapes, system parameters, etc.; $19,500; 60–90 days ARO.

Lavenir Technology Inc., 1041 Shary Cir., Concord, CA 94518-2407, 415-680-7400. **Enter No. 428**

Dual Bin Capability Available On LN03

JetFeed II Dual Bin Sheetfeeder; compatible with DEC's LN03 and LN03 Plus Laser Printers; intelligent in its paper monitoring system; a paper out sensor is provided in each bin; a paper path status sensor is also included to allow complete control of paper condition and location; there are two bins on the JetFeed II, each holding up to 200 sheets of paper.

This provides a total capacity without refilling of up to 400 sheets; the user may refill an empty bin during this endless feed mode without halting operation; compatible with VAX/VMS, DECMate, and other DEC systems; popular software such as All-In-1 and WPS is compatible with the sheetfeeder; $999.

Genesis Technology Inc., 30963 San Benito Ct., Hayward, CA 94544, 415-489-3700. **Enter No. 429**

Data Communications And Interconnects

9600 BPS Full-Duplex Modem

FASTCOMM FDX 9600; a full-duplex asymmetrical 9600 bps dial-up modem, based on the advanced modulation and forward error correction techniques of CCITT Recommendation V. 32; using a Frequency-Division-Multiplexed (FDM) full-duplex modulation technique, data is automatically directed, based on flow demand, to the high speed 9600 bps channel; the modem is available either as an external unit or in an FDC rack-mount; $1,195.

Fastcomm Data Corp., 12347-E Sunrise Valley Dr., Reston, VA 22091. 703-620-3900. **Enter No. 430**

Graphics

Graphics Software Supports Talaris Printers

SPSS Graphics; an interactive system for the creation of presentation and business graphics; supports Talaris full-page, bit-map laser printing systems; runs under

VAX/VMS, IBM CMS, IBM MVS/TSO; Prime PRIMOS, Honeywell GCOS, and Data General AOS/VS; provides more than 40 different chart types for presentation graphics; menus and forms quickly guide the user through the creative process and allow for quick editing of graphic output; offers software programs that are compatible with SPSS Graphics and can help users achieve the full benefits of laser printer technology.

SPSS Inc., 444 N. Michigan Ave., Chicago, IL 60611. 312-329-2400. **Enter No. 431**

PCB Worksystem VAXstation II/GPX

PCB WorkSystem; color graphics capabilities of the VAXstation II/GPX are well suited to the demands of SMT designs, and permit the printed circuit board designer, using PCB WorkSystem software, to design boards with devices on top and bottom surfaces; combining the powerful new capabilities of the PCB WorkSystem with Digital's high end color workstation provides a complete CAD solution to handle the complexities of today's surface mount technology designs.

The PCB WorkSystem software bundled with the VAXstation II/GPX workstation is priced below $100,000 and is available now.

Tektronix, CAE Systems Inc., 5302 Betsy Ross Dr., Santa Clara, CA 95054. 408-727-1234. **Enter No. 432**

Systems Software

New Version Of DBMS For VAX

InFoCen V. 7.1; a relational DBMS and 4GL application development system compatible with DEC, DG, Honeywell and other computer systems; introduces the new capabilities of Report Writer, resulting in painting functionality and flexibility for producing customized output; now permits users to design the report layout on their terminal screen as they would see it on the printed page; also provides extensive computational capabilities for Macro functions and user-defined calculations, such as subtotals and grand totals; introduces the new SEARCH command that provides a way to find a text string or a number of lines within variable-length SCAN items; also allows the user to locate a text string based on its proximity to specified words, lines, sentences, or paragraphs.

For DG MV users who have the WordPerfect Library installed on their system, InFoCen is now Library compatible through the new SHELL command; users can employ the new command to move back and forth between InFoCen and any compatible WordPerfect programs; users may also transfer data between the two systems; VAX WordPerfect users will also have this capability.

3CI Inc., 155 W. Harvard, Fort Collins, CO 80525, 303-223-2722. **Enter No. 433**

Data Analysis Program

V. 1.1 of the PLOT data analysis program for VAX and MicroVAX running VMS operating system and V. 1.03 of PLOT data analysis program for PDP-11 computers running the TSX+ operating system; PLOT is an integrated data analysis program featuring publication-quality graphics output for scientific and engineering applications; a simple English/DCL-like command language provides an easy-to-use interface while allowing the greatest flexibility; commands can be entered at any terminal; may come from command files, or the entire program can be run as a batch job; variables and functions can be defined by the user and referred to in standard algebraic form; up to 100,000 pairs of datapoints for VMS systems and 32,000 pairs for TSX+ systems may be in memory at the same time.

All commands are interactive and graphics output commands result in immediate display of the data or text without having to pass through device filters; from $2,500 on a MicroVAX to $12,500 on an 8800; PDP-11 ($1,000).

New Unit Inc., P.O. Box 428, Ithaca, NY 14851-0428, 607-273-6181. **Enter No. 434**

Optical System Software Utility For VMS

Optical System Software (OSS); a software utility and set of callable software routines that allow the VMS operating system to communicate with the Write Once Read Many (WORM) optical disk; is a VMS utility and a set of callable routines that manage the optical disk file structure; the write once disk structure is similar to the standard VMS ODS-2 file structure; the home block, file-header, file names, file name extensions, versions, dates, and characteristics are the same as those of any ODS-2 device.

Additional features include virtual volume support, triple redundant file headers, optical disk initialization command, copy command, and file structure verification; $2,000.

Scientific Micro Systems Inc., 339 N. Bernardo Ave., Mountain View, CA 94043, 415-964-5700. **Enter No. 435**

Micro-Mainframe Communications For Mac

Mac Connection for Macintosh XL, Macintosh 512 and 512E, Macintosh Plus and Macintosh SE users; with Mac Connection, communications can occur between a Macintosh and a host computer; between two Macintoshes, and between a Macintosh and an IBM PC or other personal computer; information can be transferred in Macintosh format, in binary format, or in text format; users can now connect to DEC, IBM, Hewlett-Packard, and UNIX host computers.

Users can migrate from

Macintosh to PC without having to learn a new interface, and corporate trainers only need educate users on one interface, regardless of the personal computer they use; priced at $300.

Linkware Corp., 128 Technology Ctr., Waltham, MA 02154, 617-894-9330. **Enter No. 436**

Data Analysis Software For VAX

RS/1 V. 3.0; specifically designed for the engineering, scientific, and manufacturing marketplace, includes new features and efficiency improvements and provides greater user-friendliness and performance benefits; a comprehensive data management, data analysis, and graphics tool for scientific, engineering, and manufacturing professionals; the fully integrated system includes statistical, graphics, curve fitting, modeling, and report gathering capabilities; complemented by a powerful, built-in programming language, RPL, for customized applications; software features the addition of two new data types, vectors and matrices, that speed execution of certain RS/1 computations.

An improved dictionary structure in V. 3.0 features the same command forms for all RS/1 object types; the ability to archive all related data objects in a single file, and faster and easier access to data objects; priced $3,900-$79,000.

BBN Software Products Corp., 10 Fawcett St., Cambridge, MA 02238, 617-864-1780. **Enter No. 437**

Applications Software

Patient Management System For MicroPDP-11

DENT-11 V. 4.1; accounting and patient management system designed specifically for the medium-to-large dental practice or clinic; features include: support for four insurance plans per patient, full terminal support for VT200, 100, and PCs; correspondence with over 3000 form letters, speed mailers, or post cards; automatic daily backup of all data; flexible and powerful report writer; insurance forms printed immediately for the patient; interface for popular word processors; virtual terminal and file transfer packages for communications with PC or other computers; and reports displayed on the users display, spooled to one of four printers or held in a file for later printing.

Developed for MicroPDP-11 family and uses the features of S&H Computer Systems Inc.'s TSX-Plus V.6 multiuser operating system with process windowing and Digital Information Systems Corp.'s DBL V.4 language; $26,000-$100,000+.

J.L. Computer Systems, 3401 Lancaster Ave., Wilmington, DE 19805, 302-998-8030. **Enter No. 438**

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Other features include an escape from reports option that provides an easy means of exiting from the processing of a report, and transaction data entry changes directed at adding speed to the program; $1,950-$3,900 depending on configuration.

Libra, 1954 East 7000 South, Salt Lake City, UT 84121-3094, 800-453-3827, 801-943-2084. **Enter No. 439**

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Costar V. 1.21; an interactive software cost estimation tool; intended for software managers who need reliable estimates of a software project's duration, staffing, and cost; runs on any VAX/VMS system or IBM PC computer; allows managers to make preliminary estimates during a project's initial definition, and then produce more accurate forecasts as the project's definition is refined; it performs trade-offs, sensitivity analyses, and what-if experiments.

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Softstar Systems, 28 Ponemah Rd., Amherst, NH 03031, 603-672-0987.

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CD Real-Time Systems Inc., P.O. Box 513, St. Charles, Il 60174, 312-377-2625.

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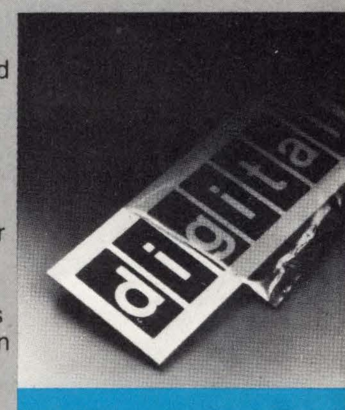

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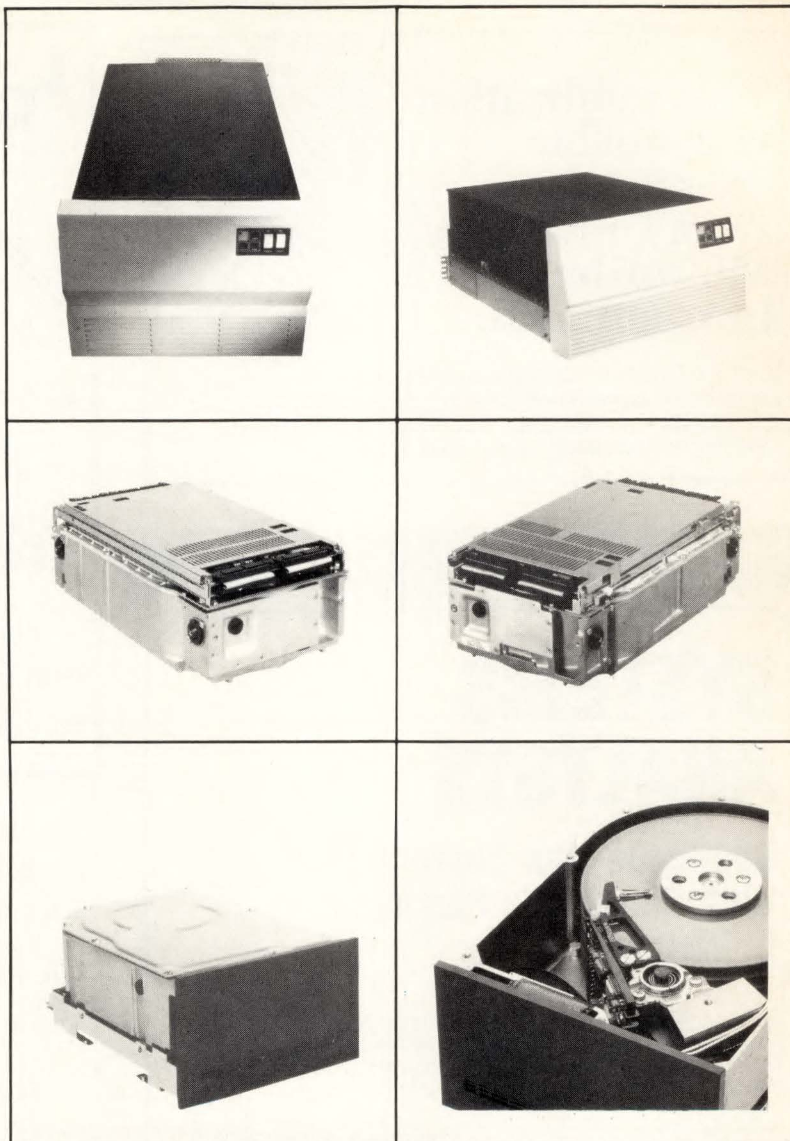

	10 1/2"			8"			5 1/4"		
CAPACITY (M Bytes)	474/ 689	689	474	690	337	168	389	171	86*
AVERAGE SEEK TIME (ms)	18	18	18	16	20	20	18	25	25
TRANSFER RATE (K Bytes/s)	9295 12288	2458	1860	2458	2458	1229	1250	1250	625
INTERFACE	PTD	MSMD	HSMD	HSMD	HSMD	SMD	ESDI	ESDI	ST506
RECORDING CODE	MFM/ RLL	RLL	MFM	RLL	RLL	MFM	RLL	RLL	MFM

*Half High

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