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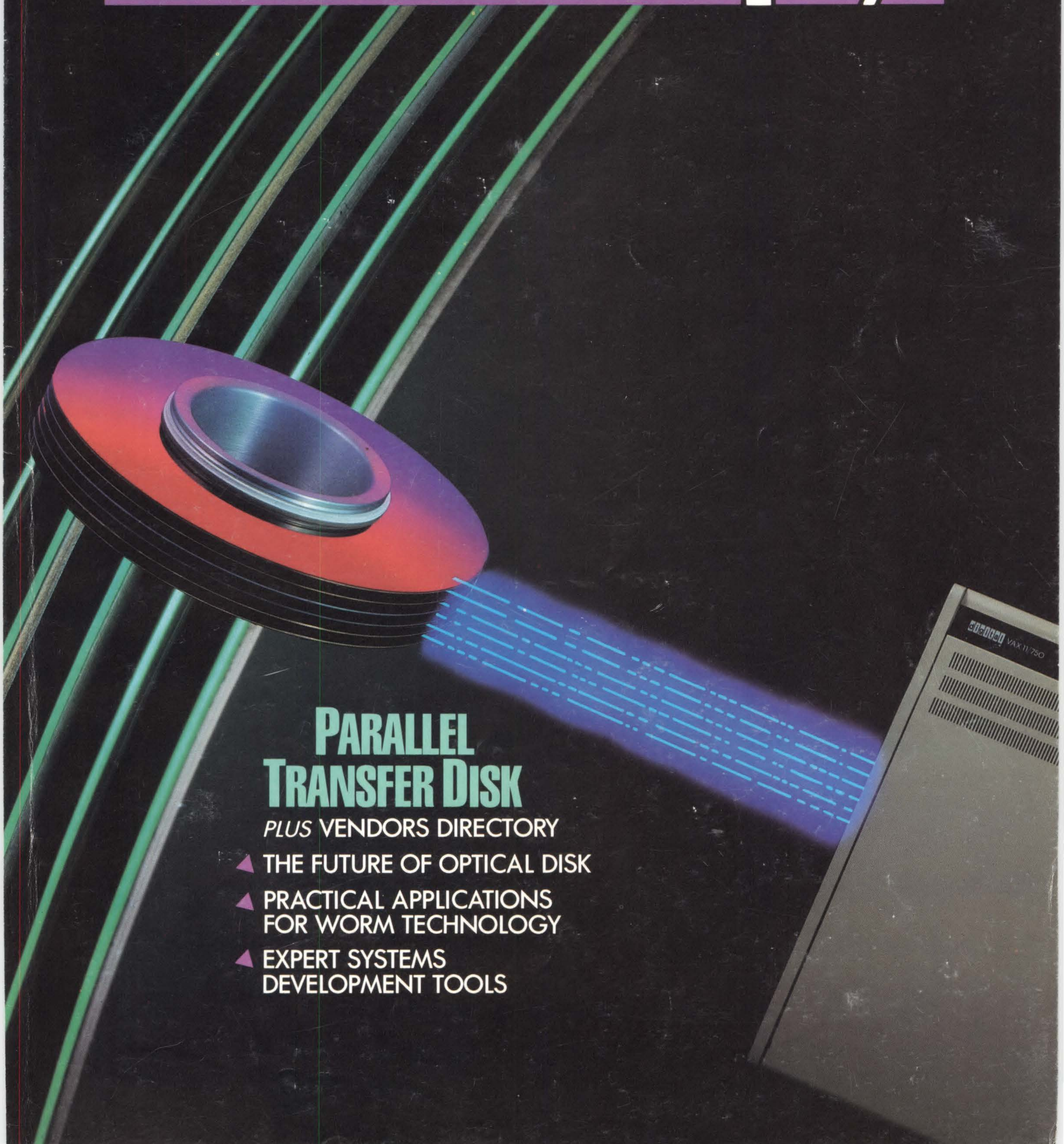
THE *NEED TO KNOW*™ MAGAZINE FOR DEC COMPUTING



Parallel Transfer Disk

PLUS VENDORS DIRECTORY

- THE FUTURE OF OPTICAL DISK
- PRACTICAL APPLICATIONS FOR WORM TECHNOLOGY
- EXPERT SYSTEMS DEVELOPMENT TOOLS

How To Hang On Terminals Without Getting Hung Up.

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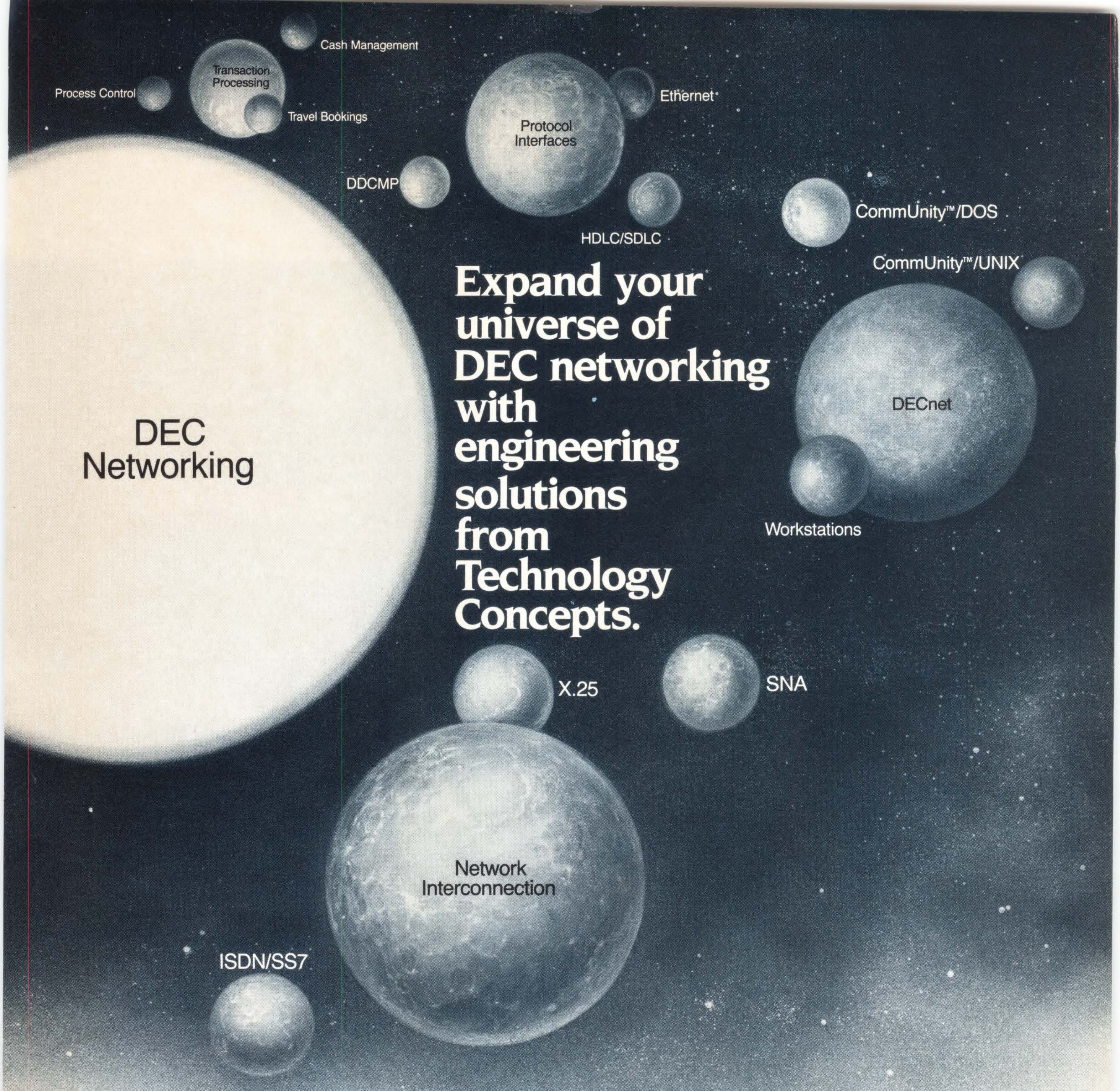

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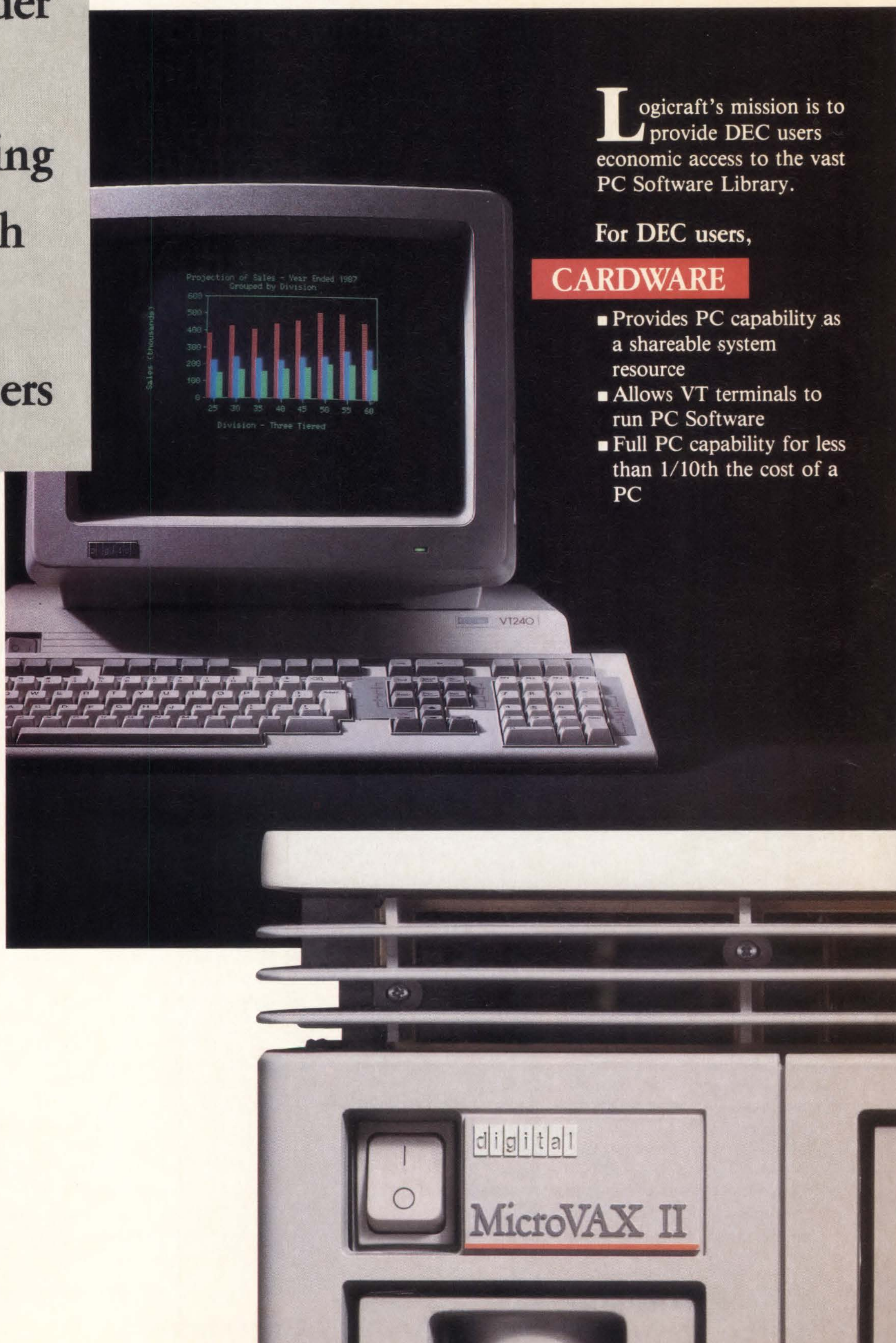

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With GraphOn local pan and zoom ability, you can zoom in on an image, and then pan and zoom again until you see every detail. The zoomed image can be saved locally and called back to the screen quickly and easily.

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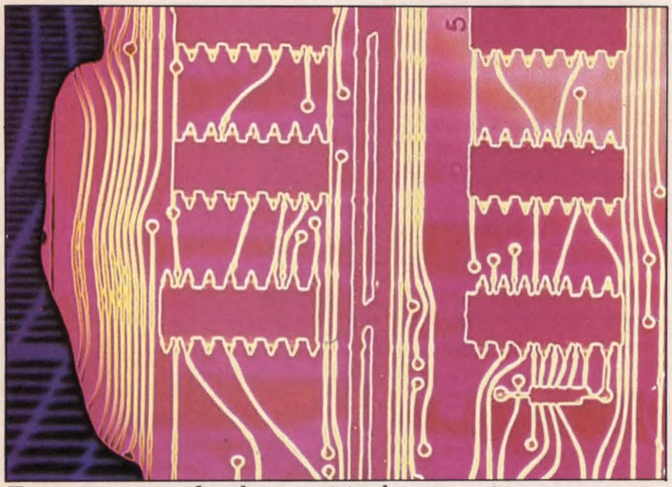

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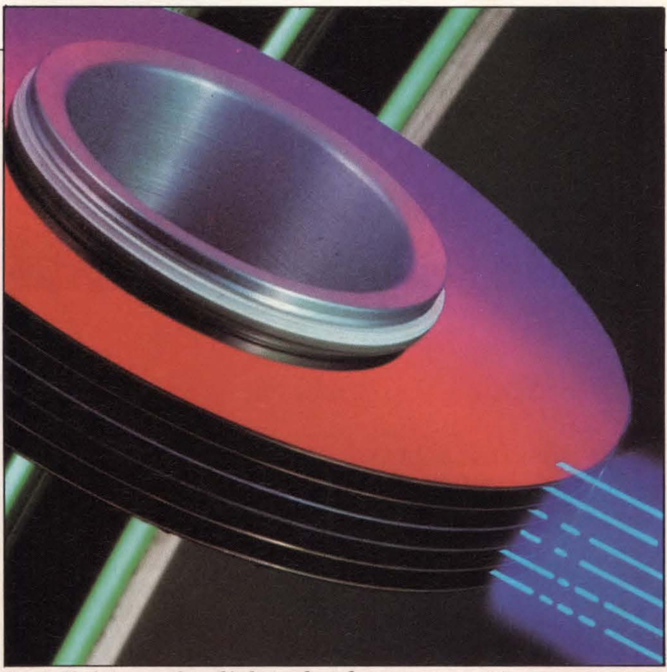

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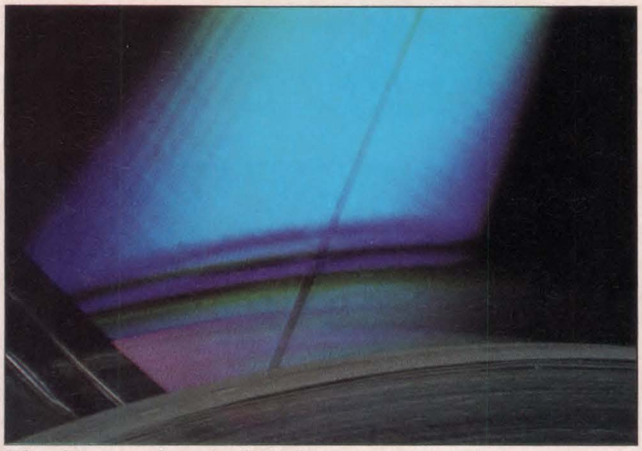

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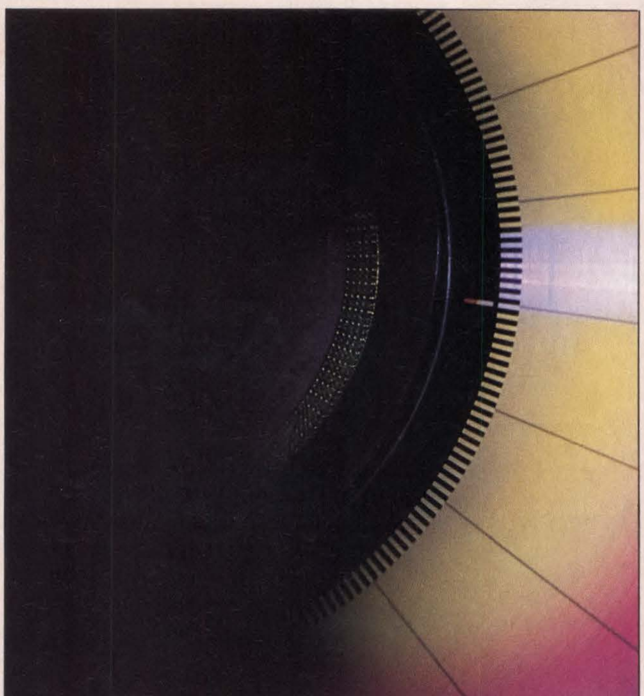
PERIPHERAL DEVICES



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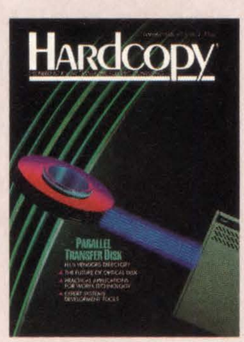

This month's cover, a photo illustration by Southern California commercial photographer Lee Karjala, depicts the dynamics of parallel transfer disk technology. The PTD was supplied by Ivis Systems Inc. (Westlake Village, Calif.).

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Publisher's Desk

Opportunity In Bad Times

When the computer industry suffers yet another lackluster no-growth year, with predictions of still another slowdown, Digital Equipment Corp. keeps pumping out higher sales and profits quarter after quarter. When the financial media echoes the remarks from the boardroom of "unfair competition," "weak economy," "tax disadvantage," and "market consolidations," Digital keeps coming up with new solutions and products. At a time when the Dow Jones Indicator breaks through the 2,000-point barrier and most computer stocks are catatonic, Digital is breaking through new highs almost daily.

It really feels good to be at the right place at the right time. The strength of Digital also gives way to opportunity in the form of career advancement within the responsibility and structure of existing positions. Digital's products can now address problems of office automation, factory automation, and communications in parallel with the engineering and scientific applications long the mainstay of the company. Those who have a keen grasp of management's need for information, and the credentials, can seek those high visibility jobs with yearly salaries as high as $250,000. These positions were once only available to IBM-oriented managers.

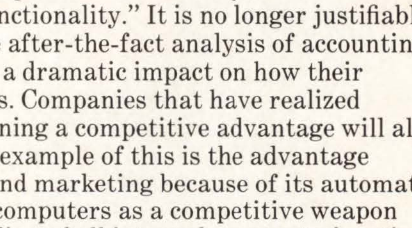
The position of Chief Information Officer is being created at many of America's leading manufacturing, financial, and service companies. Wells Fargo Bank, Aetna Life, Goodyear Tire & Rubber, Exxon, and Security Pacific Bank are just a few that not only have created the CIO position, but boast of saving countless millions of dollars in overall corporate functionality.

The key words here are "corporate functionality." It is no longer justifiable for MIS directors and CIOs to contribute after-the-fact analysis of accounting data only. Information officers also have a dramatic impact on how their companies sell and market their products. Companies that have realized computers can actually contribute to gaining a competitive advantage will also realize enhanced profits and growth. An example of this is the advantage Federal Express has gained in its sales and marketing because of its automation strategy. Federal Express literally uses computers as a competitive weapon encompassing everything from the handling of all internal corporate functions to its advertising campaigns.

When one company makes the move to use computers to achieve a strategic marketing advantage, competitors must follow or take on that adversary without all the resources available to them.

Most people filling the current positions of CIO are not strictly computer types. They have extensive business knowledge and experience. The experience one might get when using VAXes to develop products for sale or manufacturing. They must not only be capable of understanding and grasping the technologies, but more important, they must know *what works,* as opposed to *how it works.* The theories behind the software and applications are strategic, not the coding.

For the past year, *Hardcopy* has transitioned its editorial package to give you the foundation and information you "need to know" to harness the power of the current information and technologies offered. Those $250,000/yr. jobs can now be sought by Digital-oriented managers, and we intend it to be that way.



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The Silent 700™ Data Terminal Series from Texas Instruments.

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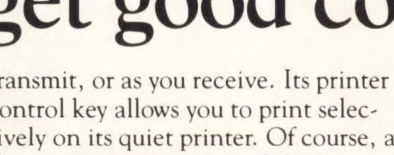

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For more information on TI's family of Silent 700 Series Portable Data Terminals, call toll-free **1-800-527-3500.**

TEXAS INSTRUMENTS

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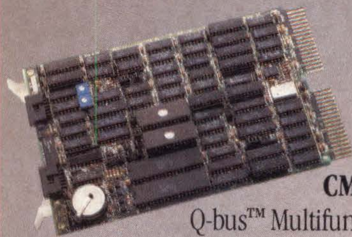
CALL FOR PAPERS

The editors at *Hardcopy* are interested in hearing about your unique computer-related experiences. We are issuing a call for papers to be published in the June, July, and August 1987 issues of *Hardcopy*. If you've successfully overcome any major roadblocks that have caused a serious problem for you or your company, we're interested in knowing how you dealt with the problem and the steps you took in finding the right solution. Your papers should deal with some aspect of any of the following topics:

- choosing a printer or plotter to do a specific job;
- combining workstations from a variety of vendors on a single LAN;
- selecting hardware and software for an integrated technical document production system;
- producing effective presentation graphics;
- using software based on AI concepts to develop application programs from a workstation;
- implementing a state-of-the-art graphics terminal for applications requiring extremely high resolution;
- breakthrough applications for image processing;
- supporting a VAX host with an array processor for computation-intensive processing;
- using micros in a mainframe environment;
- optimizing the performance of a VAXcluster;
- using layered software to build powerful networks and clusters; or
- achieving better performance with fiber optics.

Prospective authors are requested to submit a 200–500 word abstract (outline) no later than March 1, 1987. Send your abstract to: Dan Reese, Editor, *Hardcopy*, Seldin Publishing Inc., 1061 S. Melrose Ave., Ste. D, Placentia, CA 92670-7180. Please include a telephone number where you can be reached during the day.

Camintonn Announces Five New Products For Improved DEC™xterity.



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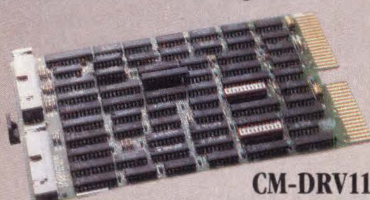

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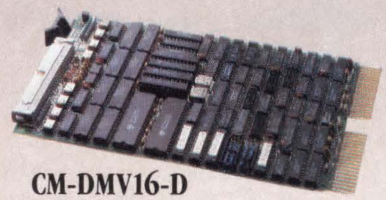

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LETTERS

ETHERNET

Ken O'Mohundro consistently underevaluated Ethernet in his recent series of articles on networking (*Hardcopy*, January 1986–October 1986). Ken's company, Able Computer (Costa Mesa, Calif.), markets an alternative (from my understanding a very good one) to the Ethernet terminal server solution. I will be the first one to admit that serving terminal I/O is not the best utilization of the Ethernet's high bandwidth, and that the protocol overhead can be a significant CPU burden, especially on a smaller machine (I would say this is the more serious problem). I think it is important for these issues to be brought up (Digital sure won't mention it).

However, he gives the impression that performance will immediately fall off the end of the Earth as soon as any servers are connected, and doesn't give equal time to the many undeniable conveniences of the servers (which is worth the performance price for many sites). I might add that in the future many functions (editing, screen, etc.) will no doubt be offloaded to the servers, making them actually a performance enhancement.

I would take issue with the statement in Ken's column that Ethernet throughput is 10% of bandwidth under DECnet. He has derived that figure from task to task transfer speeds between two 11/780s with DEUNAs (actually, the speed is 1300 Kbyte/sec., or 13%). The DEUNA's throughput is 1.4 Mbyte/sec., so it is clear where the bottleneck is. I have heard that the transceiver is also a performance limitation, not to mention the 780's processing of all the upper DECnet layers. I don't think the actual Ethernet is even breaking a sweat under these conditions. Yet, his assertion is made in a paragraph claiming to analyze contention network throughput! In order to realistically measure throughput, why not do task to task on an 8550 with BI interface and one of the newer transceivers, or better yet, six 8550s simultaneously transferring?

The point is that many machines can share in the Ethernet's high speed, not that a 780 only transferred data at 1.3 Mbyte/sec. under DECnet (which is quite fast; I note that the Ethernet's DECnet performance is actually superior to the CI's because of the larger packets; I'm not going to say the Ethernet is faster than the CI). When you add the possibility of isolating bandwidth with the LAN bridge, you could have 40 or more Mbits of aggregate speed.

I am not saying Ethernet is the ultimate network, and that two machines can transfer data over it at 40 Mbyte/sec. I'm just saying let's stop clouding the issues.

Tom O'Toole
Johns Hopkins School of Medicine
Dept. of Biophysics
Baltimore, Md.

In the April 1987 issue of Hardcopy, *Ken O'Mohundro will be addressing the issues presented in this letter as well as other Ethernet-related topics.*

—Ed.

RT-11 PERSPECTIVE

I was very disappointed to find that Milton Campbell's "RT-11 Perspective" has been discontinued. I found his discussions to be very useful in my work. Please consider returning the column for the many readers that find it so helpful.

Robert R. Wolfe
Professor
Rutgers University/Cook College
New Brunswick, N.J.

Many Hardcopy *readers have responded to the discontinuation of Milton Campbell's "RT-11 Perspective." In response, Mr. Campbell will be writing a quarterly department feature in which he will devote several pages to pertinent aspects and developments in RT-11. His first installment, which will explore RT-11 for the VAX, will appear in next month's issue as a software department feature. If you're having a problem with RT-11 or would like to share a unique solution to a problem, please send correspondence to Brad Harrison, technical editor,* Hardcopy *magazine, 1061 S. Melrose Ave., Ste. D, Placentia, CA 92670-7180. Your questions/solutions will be considered for publication in "Technical Support," a newly installed question and answer column devoted to searching out answers for any Digital-related hardware/software problems.*

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Ross Systems and Virtual Microsystems Merger

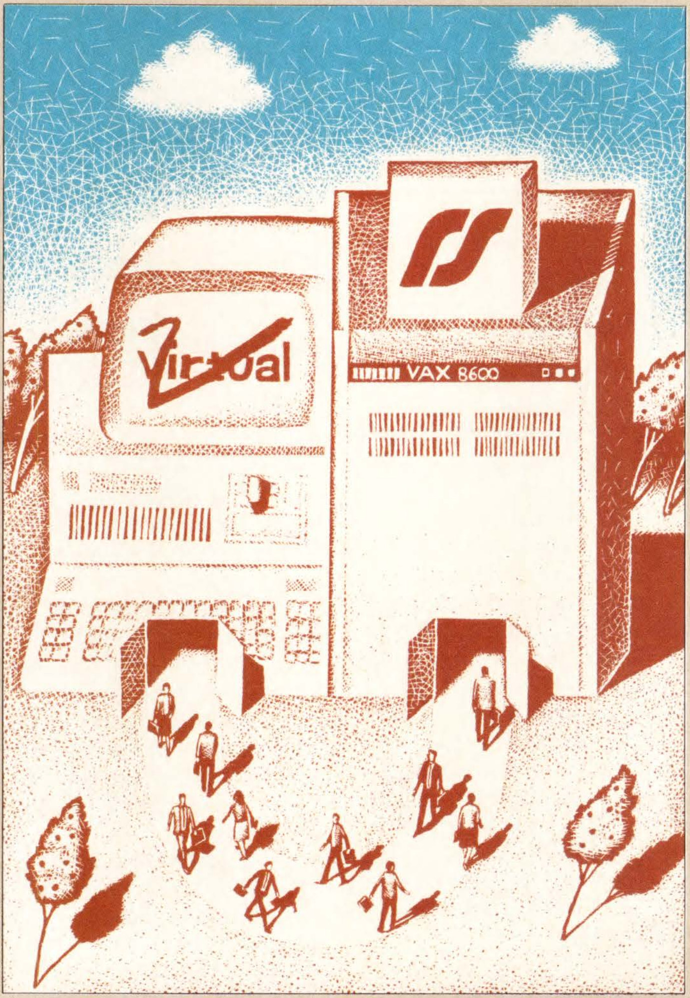
Ross Systems Inc. (Palo Alto, Calif.) and Virtual Microsystems Inc. (VMI-Berkeley, Calif.), two of the leading players in the Digital marketplace, have merged to form RossData Corp. The new company becomes one of the industry's largest suppliers of VAX applications software and IBM PC/VAX communications products, with an estimated combined sales of more than $17 million.

Kenneth Ross, formerly the president of Ross Systems, has accepted the post of president and chief executive officer of RossData. RossData will function as a parent to Ross Systems and VMI, which will otherwise maintain their separate identities. VMI is best known for its communications links that allow VAX users to run IBM PC software from their terminals, or let IBM PCs function as intelligent VAX terminals. Ross Systems offers a financial management applications software line for VAXes called Management Accounting and Planning Software (MAPS).

For VMI, the merger represents an opportunity to expand by getting into specific software applications and opening untapped marketing channels. For Ross Systems, it's a chance to interconnect its software with important new environments. "When we sell to a large corporation, we have found that all of the people want to use Lotus and IBM PC software," said Ross. "It was inevitable that we start looking into integrating with micros.

"There will also be a lot of synergy in terms of marketing and advertising," he added. "When our sales force goes out, all of our prospects are prospects of Virtual products."

There are two potential advantages of the merger to end users of products from each of the original firms. The users will be backed by a larger corporation with more economic clout. And RossData plans to announce an integrated product that combines the important capabilities of the two systems, according to Ross.



JOE CRABTREE

"In the long run, it (the merger) will give us more capabilities," explained Ron Feibusch of Integrated Device Technology Inc. (Santa Clara, Calif.), a semiconductor manufacturer that runs all of Ross' modules on a VAX-11/785, and also has several PCs. "Depending on what they come out with, we'll give it heavy consideration when the time comes."

The terms of the agreement were orchestrated by Broadview Assoc. (Fort Lee, N.J.), an independent investment bank that specializes in mergers and acquisitions of software companies.

Will the Ross-VMI merger spur further acquisitions and alliances in the Digital market? "It's difficult to know what the fallout will be," said Jim Bender, the president of Logicraft Inc. (Nashua, N.H.), a competitor of VMI. "Right now, we're self-sufficient and have no motivation for a merger."

But VMI President Gianluca Rattazzi sees a possible trend. "I still remain independent—I have my operation," said Rattazzi. "On the other hand, I'm now part of a public company." Rattazzi plans to create further ties with applications software firms in the form of business partnerships.

—Evan Birkhead

Optical Disks Look Like Tape Storage

Noticing similarities between optical disk and tape drives, Aviv Corp. (Woburn, Mass.) has built their optical disk system so that it emulates a tape drive, as compared to the common approach of emulating a magnetic disk drive.

The product, the Optical Storage System Model 2000, consists of three units, a tape controller, an optical disk controller, and the optical disks. Each of the systems can be set up with one to four optical disks, each disk holding approximately 1 Gbyte of information, or the equivalent of seven reels of tape.

"The throughput and the application reminded us of tape," explained Haim Brill, president of Aviv Corp. "The transfer rates are slow, relative to magnetic disk, like tape. The disks are write once read many and are not likely to be used as a random access disk. The typical application is archival or maintaining lots of data online. This sounds like tape."

The system includes the capability of converting tapes to optical disk without use of the computer. This is possible because all of the software for running the system is included in the memory for an onboard 68000.

NEWSLINE

Source Code Analyzer Improved

Digital is improving its Source Code Analyzer (SCA), a static development tool that allows a developer to examine an entire software system. When the SCA becomes available in early May, it will include extensive cross reference, analysis, validation, and search capabilities for software written in one of seven languages, as well as the VAX Language-Sensitive Editor (LSE) V. 2.0, also scheduled for May release.

The seven languages supported are: Ada, BASIC, BLISS-32, C, FORTRAN, Pascal, and PL/I. Other languages, most notably COBOL, will be added in the future, according to Larry S. Pearl, one of Digital's software product managers.

The SCA will allow the designer or programmer to examine an entire software system. Cross reference and search capabilities include the ability to locate variable, constant, and module names, references, declarations, initializations, locations, reads, and writes. Analysis capabilities include building trees of the relationship between routines called, including indicating recursive calls. Validation capabilities include checks on route calls, examination of the number and types of arguments passed, and examination of types of returned values. Powerful library features allow the programmer to create, load, use, and examine libraries of modules.

The Language-Sensitive Editor is a multilanguage, multiwindow, screen-oriented editor designed to assist the programmer in developing, writing, and maintaining source code. The new versions of the SCA and LSE are tightly coupled with each other. The LSE also will have new editing capabilities added.

These products are designed for static development work. Dynamic, runtime analysis will still be performed with the VAX Performance and Coverage Analyzer.

The SCA costs between $600 for VAXstation II and $12,000 for the VAX 8800. The LSE costs between $750 for the VAXstation II and $15,000 for the VAX 8800.

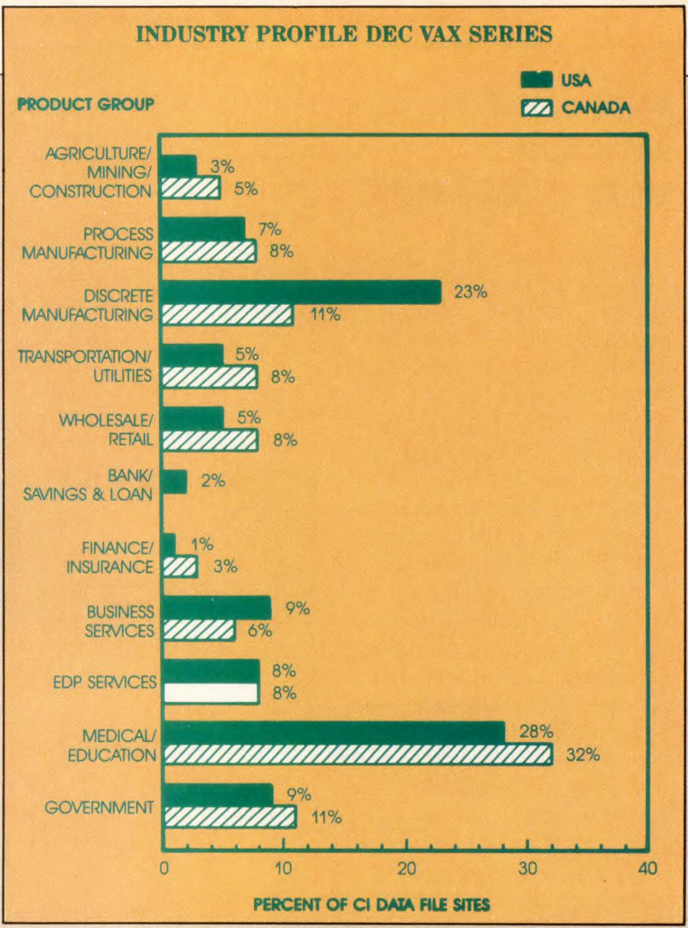
Electronics Employment

California continues to have the greatest employment of electronics workers (586,000), with more than double the next closest state (New York with 222,000). The recent downturn in the electronics business has resulted in national employment falling by 50,000 jobs, led by California (20,000 jobs lost), Massachusetts, and Illinois (12,000 each). The greatest gains were in Maryland and Michigan (5,000 new jobs each), and North Carolina (3,000).

—Information provided by the American Electronics Association.

Canadian VAX Market Orientation

The Canadian Digital VAX market has a much smaller emphasis on discrete manufacturing than the U.S. market, among other key differences noted in a study recently released by Computer Intelligence (CI) of La Jolla, Calif., a market research firm.



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These differences have important implications for marketing and sales forces, according to CI.

The study shows that discrete manufacturing is much more heavily represented among U.S. VAX sites than Canadian sites. In Canada almost ⅓ of all VAX sites are involved in either medical or education industries.

Canada has approximately 1/10 the number of VAX sites, as the U.S. CI estimates that there are 41,500 VAX systems within more than 25,000 sites in the United States, as compared to an estimated 4000 systems within more than 2500 Canadian sites.

Further differences show that the United States has a greater emphasis in engineering applications and that Canada has a greater emphasis in commercial and educational applications.

Approximately 46% of U.S. VAX system usage (as a percentage of total sites) is devoted to engineering applications, in contrast to 37% in Canada. A total of 63% of Canadian sites is devoted to commercial (53%) and educational (10%) applications, in contrast to American totals of 47% commercial and 7% educational (Figure 1).

The CI study showed that a significantly larger percentage of Canadian VAX sites (55%) have installed database management software than U.S. sites (46%). This trend shows up in most other product groups (Figure 2).

The Canadian VAX sites appear to purchase more software per site than U.S. VAX sites, the CI study concluded.

Biometric Data Entry

Typing patterns offer a new method of safeguarding computer data. The

Electronic Signature Lock Corp. (Ardmore, Pa.) has been granted a patent for a system that applies mathematical analysis to measure the timing between keystrokes compared to a statistical record of the user's typing to determine whether to grant access.

Each user has a different typing pattern, which can be used to uniquely identify the person attempting to gain access to the computer, according to the company's research. These typing patterns, the time between keystrokes for some phrase (such as the individual's name or password), are compared to a stored statistical record.

The system can be set to varying levels of security, with a trade-off between increased security and ease of access. At a typical setting, the user will sign in correctly on the first attempt about half the time, while unauthorized users will have a less than one in a million chance of access, even if he or she knows the access phrase. The system is claimed to work for typists of all skills, even though there is less consistency with novice typists.

The technique has a much lower cost than other current biometric methods, such as fingerprint or palm analysis, written signature analysis, or voice analysis. The use of a mathematical process and a standard keyboard or other data input device means that the method can be implemented in either hardware or software.

Time delays are measured between successive strokes of a keyboard as the individual enters his or her name. A timing vector, which is constructed from the time delays, is statistically compared with a stored timing vector derived from several sample attempts recorded earlier from the authorized user. If the timing vectors are statistically similar, the individual will be granted access to the resource.

Some users will have to re-enter their access phrase, but the company feels that this is not a serious drawback in a system that requires a great deal of security. Additionally, each user will have to spend some time becoming accustomed to the system before his or her signature stabilizes and an accurate set of reference signatures can be recorded. This time varies, being greatest with novice, one-finger typists.

Research showed that the most consistent and unique access phrase was the individual's own name, possibly due to familiarity and emotional involvement. The statistical methods applied were Mahalanobis distance function and empirical covariance matrix.

Optical System Emulates Magnetic Disk Drive

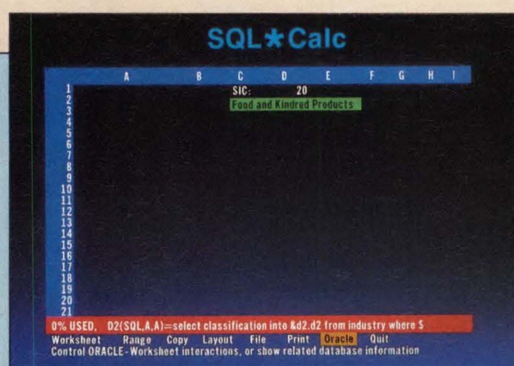
An optical disk system that emulates a normal magnetic disk drive is available from KOM Inc. (Ottawa, Ont.). The disk drive and its associated software (including the device drivers), called OPTIFILE II, is set up to exactly emulate a disk drive, allowing the use of all standard DCL commands and Q-IO calls. According to the company, the system should fully

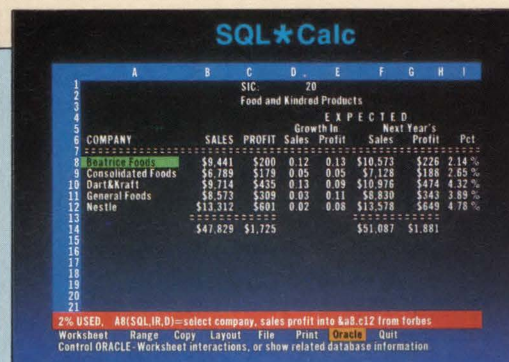
SQL Brings Together Lotus 1-2-3 And VAX/VMS RDBMS

Oracle Corp. (Belmont, Calif.) recently released a VAX/VMS version of SQL*Calc, a Lotus 1-2-3 compatible interface to Oracle's relational database management system (RDBMS).

According to Ken Cohen, Oracle's director of product marketing, SQL*Calc is the first product to combine the IBM/ANSI SQL interface with the Lotus spreadsheets interface.

"We released it initially in the PC-DOS environment and it's now being ported to other environments," explained Cohen, adding that a UNIX version should be available sometime in 1987. The VMS version appears to be identical to the PC version.





Querying with SQL—*The value of the SIC code is used in an SQL query* (left) *to retrieve the name of an industry group. Further querying* (right) *yields detailed information about a company in the group.*

For Oracle's users, the primary advantage of SQL*Calc (pronounced *Sequel*-Calc) will be that it lets the operator enter SQL commands into PC spreadsheet cells to directly access and modify data in the VAX database. This allows them to move spreadsheets and databases between the VAX and PC.

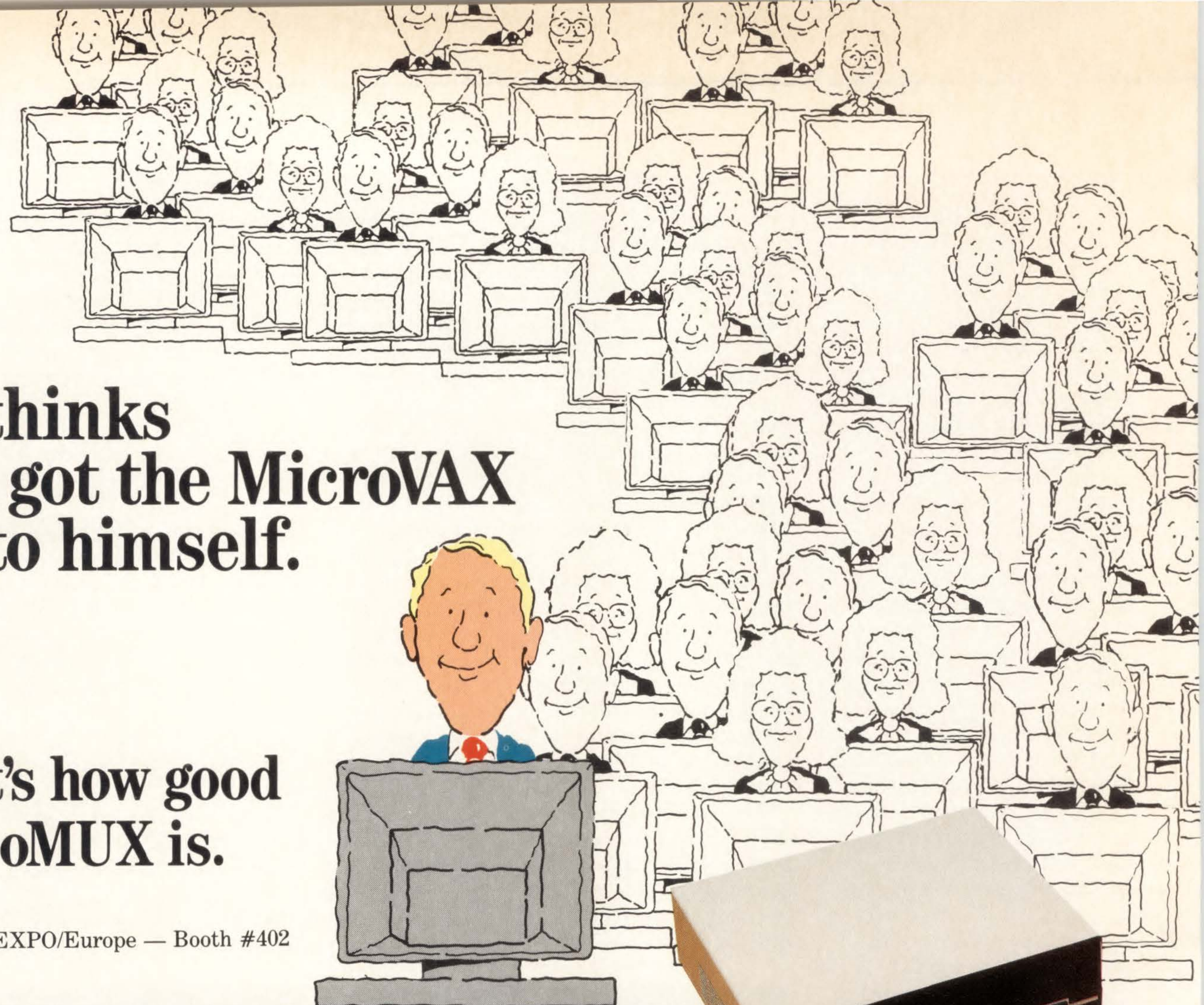
"More and more end users are finding themselves at workstations in front of a VAX," noted Cohen, "and most of them know how to use 1-2-3."

SQL*Calc should at least give VAX systems managers more flexibility. VT220 and VT240 users will now be able to run 1-2-3 spreadsheets from a dumb terminal, while IBM PCs and VAXmates can be configured to look like spreadsheet workstations.

The package also features relational retrieval, which allows changes made in each Lotus field to be reflected in related figures on each updated spreadsheet from the database.

For the MicroVAX, SQL*Calc is available in 9-track tape or cartridge. The price of the software ranges from $1,000 for the initial license on a MicroVAX to $18,000 on a VAX 8800.

Cohen predicts that the initial "flood of orders will come from our current end users." —*Evan Birkhead*



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Only one quad-sized board is plugged into the MicroVAX II backplane, and it cables into a desk-top or rack-mount terminal adapter unit which accommodates 32 terminals. Not only is backplane real estate conserved, but the desk-top unit *contains its own power.*

Up to eight adapter units can be slaved — *offering up to 256 channels* going to terminals, PCs, printers, and other serial devices.

One TurboMUX does the work of 32 eight-channel DHV boards — at an incredible cost per line of under $130.

TurboMUX is available with full modem control, supporting all the DEC baud rates from 50 to 38.4KB.

The terminal adapter units can be located up to 1000 feet away from the CPU. They support terminals up to 4000 feet away, with RS-232-C and RS-423-A compatibility. TurboMUX saves the headache and cost of long, multiple cables.

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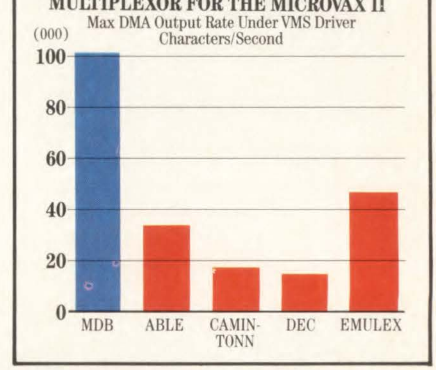

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support existing software.

The Canadian company has taken the approach of writing directory information directly onto the disk, eliminating magnetic disk caching of directory or other data. One result is that the platters can be transported between VAX/VMS and PDP/RSX systems, allowing upgrades and compatibility in a mixed-machine environment. On the other hand, disk space is used for directory information. The directory and data are interspersed on the disk, preventing the problem of overrunning preallocated directory space.

The system features a special high speed mode of operation for data acquisition. In this mode, verification of data writes is turned off, but the user gains high throughput, with write operations reaching a sustained transfer rate of 250 Kbytes/sec. in best case.

VT100 Look-alike Made

A VT100 look-alike has been introduced by CIE Terminals Inc. (Irvine, Calif.). The CIT 101XL terminal emulates the Digital VT100 and the CIT-101e.

The new product is being manufactured at a time when most other manufacturers have either dropped or are dropping a VT100 look-alike from their product line.

"We were approached by several customers requesting the terminal," explained John W. Knox, CIE's vice president of marketing. "A number of customers are accustomed to the layout and the keys of the VT100 or the CIT-101e (the company's previous VT100 look-alike).

"The VT100 replacement market is still fairly healthy," he continued. "We estimate that between 75,000 and 80,000 terminals will be sold in 1987."

VAX BASIC Improved

VAX BASIC V. 3.0, recently released, offers improvements including extensive graphics capabilities, structured error handling techniques, and other enhancements.

The language now supports the ANSI-standard Graphical Kernel System (GKS), allowing the programmer to use workstation graphics on any hardware supporting the GKS standard without learning complex interfaces.

Among the numerous graphics enhancements are: use of GKS libraries, convenient definition of values for attributes, the ability to write device independent programs, self-documenting statements, support of windows and viewports, input statements for interactive devices, pop-up menus, and the ability to build libraries of reusable routines .

The VAX BASIC now includes structured error handling capabilities of WHEN ERROR as specified in the ANSI-standard BASIC, as well as continuing to support the older ON ERROR for compatibility.

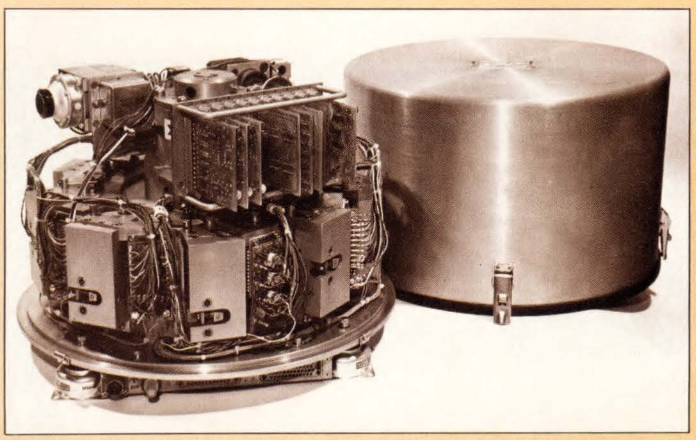
The new BASIC costs between $1,060 on a VAXstation II and $15,900 on a VAX 8800. It is available now.

Realtime Processing

In an effort to satisfy VAX users' persistent demands for increased processing responsiveness with minimal overhead, Digital Equipment Corp. has developed new hardware and software products that constitute an important step toward realizing true realtime performance on the VAX. The products are enhancements to the VAXELN programming environment, a VMS software toolkit that loads into a realtime target system and requires no disks.

With minimal resident memory, VAXELN is intended to maximize system performance and predictability with low overhead and a great deal of flexibility.

The announcement of VAXELN V. 3.2 coincided with the release of the KA620 single board computer, a 32-bit VAX board that is Digital's most advanced realtime



Highly reliable but out-of-date—*Drum storage devices implemented a separate read/write head for every data track.*

Drum Storage Ends

Vermont Research Corp. (North Springfield, Vt.) stopped manufacturing drum storage devices late last year, in what marks the end of an era. The company was probably the last manufacturer of the products, according to Evered W. Hinkley, manager technical communications.

Vermont Research had been building the fixed-head (head-per-track) drums since 1960, and had sales of more than $4½ million in fiscal year '86, primarily in drum storage. At press time, the company still had a limited number of orders on its books. The last order will go to Samsung, a Korean company.

Drum storage "is mighty reliable, but was getting costly to manufacture," Hinkley explained. "They are primarily used in telephone or telecommunications switch control, process control, in any application where medium to low capacity, fast access, and high reliability are needed."

With a read/write head for every data track, head-per-track storage retained a hold in the storage market because of its high performance and reliability, compared to moving-head disks, at a lower cost than solid-state storage. In recent years the cost of semiconductor memory has dropped dramatically.

The company will continue to support its drum systems, but is switching to the manufacture of dynamic RAM-based solid state storage devices.

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applications processor to date. The 8.4-in. x 10.5-in. board is Q-bus compatible, and was specifically designed for developing dedicated number crunching applications for realtime VAXes in both standalone and distributed installations.

In addition to supporting the KA620, VAXELN V. 2.3 supports three high end VAXBI-based CPUs—the VAX 8500, 8550, and 8700.

The VAXELN Toolkit provides tools that help the user create execute-only applications that run under the VAXELN kernel on dedicated systems.

It can reportedly be easily merged into Ethernet or DECnet LANs in a wide range of data collection and data processing applications.

—Evan Birkhead

CSPI Introduces Family Of Array Processors

CSP Inc. (Billerica, Mass.) has introduced a family of array processors with performance rated from 38 to 280 million floating point operations per second (MFLOPS). The processors, called the Mini-MAP XL, are targeted at signal processing applications.

The four models contain from one to four array processors. Each array contains three processors: an arithmetic processing unit, an integer processing unit, and a coprocessor.

A proprietary bus called the IOMV, transfers data between array processors at 2 Mbytes/sec. It also permits several processors to calculate a single problem in parallel. A library of routines is available for the bus.

Existing Mini-MAP users can upgrade to the XL version. The XL version includes from 38-280 MFLOPS capacity, FORTRAN compiler, a scientific subroutine library with 450 routines, and up to 64 Mbytes of data memory. List price of the Mini-MAP XL ranges from $32,000 to $138,000. Delivery is 90 days after receipt of order.

Salaries And Sales Down

A downtrend in the computer industry as a whole is evidenced by a drop in sales of electronics products and services last year and the slowest growth in data processing salaries in years.

Sales of U.S. domestically produced electronics products and services fell 1.8% during the first 9 mths. of 1986 from the comparable 1985 period, according to the American Electronics Association.

The association estimated that electronics sales in the first 9 mths. of last year were $165.3 billion compared with $168.4 billion a year earlier. However, 1986 third quarter electronics sales were $55.9 billion, up 1.3% from $55.2 billion for the same quarter the previous year.

Similarly, salaries for data processing professionals will grow at the slowest rate since 1979, despite continued stiff competition for trained staff, according to Edward Perlin Assoc., a New York City consulting firm. The firm predicts a national average growth of 6%, based on a survey of leaders in banking, communications, industry, and financial services.

The slower rate of salary growth comes in the face of high staff turnover, predicted to average more than 15% nationally.

"We have noted an effort to bring data processing professional salary growth rates more in line with non-DP employees in other areas of companies," explained Roger O'Connor, a spokesperson for Perlin Assoc. "This trend has proved frustrating to many corporate personnel directors who are painfully aware of the near record levels of DP professional staff turnover. It looks like high levels of turnover will continue unabated in 1987."

Removable disks—*Emulex introduces removable disks for Digital Equipment Corp. computers.*

Emulex' Removable Disk Subsystem

Emulex Corp. (Costa Mesa, Calif.) has introduced a modular, removable disk storage system called the Emulex Removable Winchester Disk Subsystem (EMR), which is aimed at markets where data security or remote data recording is important.

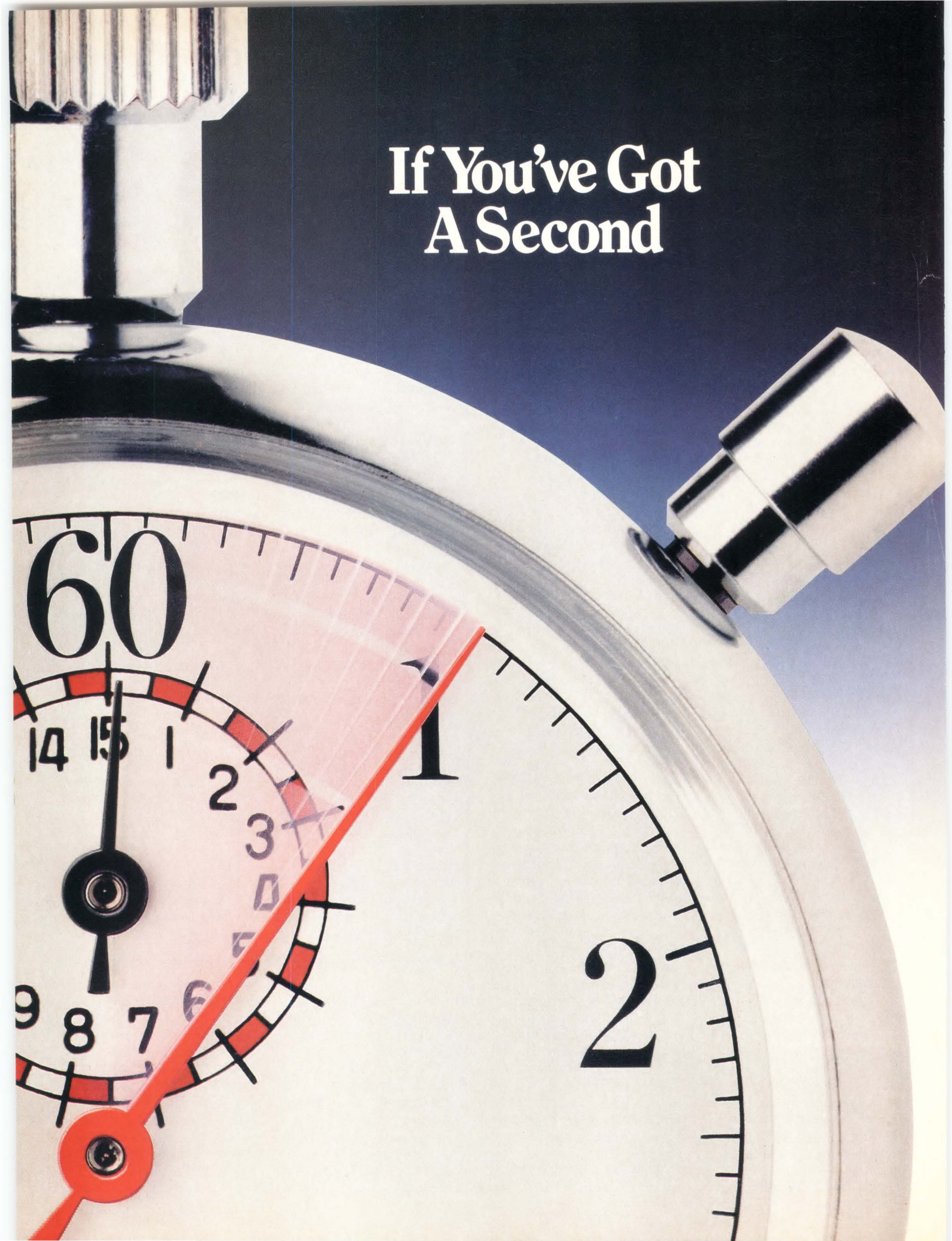
"The EMR packaged subsystem addresses the need for ultimate security," claimed Joe Traficante, director of product marketing, storage. "Because the user's removable Winchester disk drives can be secured in a safe overnight, one can ensure that top-level security needs are met. This advantage over permanently installed disks makes EMR subsystems very attractive to government intelligence and security agencies."

The system can also be used to provide workers with their own disk modules, allowing each individual to maintain data separately, removing it from the system every time they leave.

Because the system uses the Small Computer System Interface (SCSI), the system can be used to gather data at remote sites on a small personal computer, bringing the data to a central mini or mainframe for analysis. Q-bus and Unibus adaptors are available that will allow connecting the EMR to MicroVAX, VAX, PDP, MicroPDP, or LSI-11.

The system can store between 170 and 760 Mbytes of data. Daisy-chaining the devices can increase storage capacity to 3.0 Gbytes.

If You've Got A Second



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That's right! And look what else you can get with a 3-Mbyte/second disk transfer rate on your VAX-11/750* through VAX 8600/8650 computer:

- Higher throughput and much, much faster turnaround times on each disk access.
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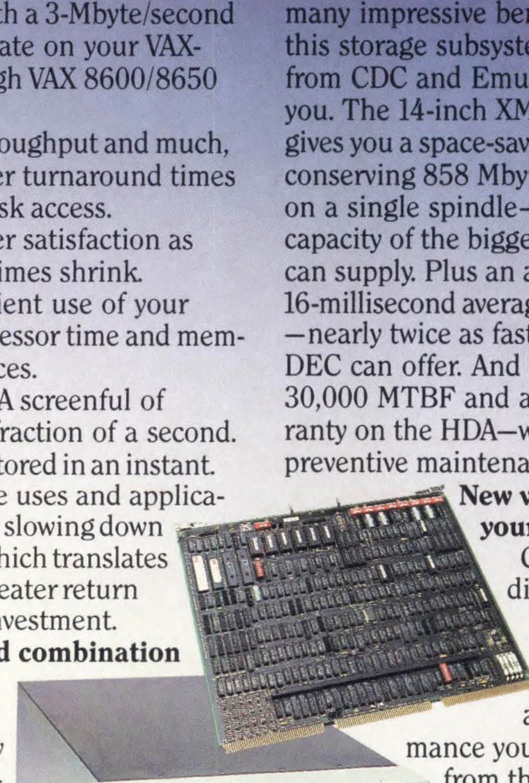

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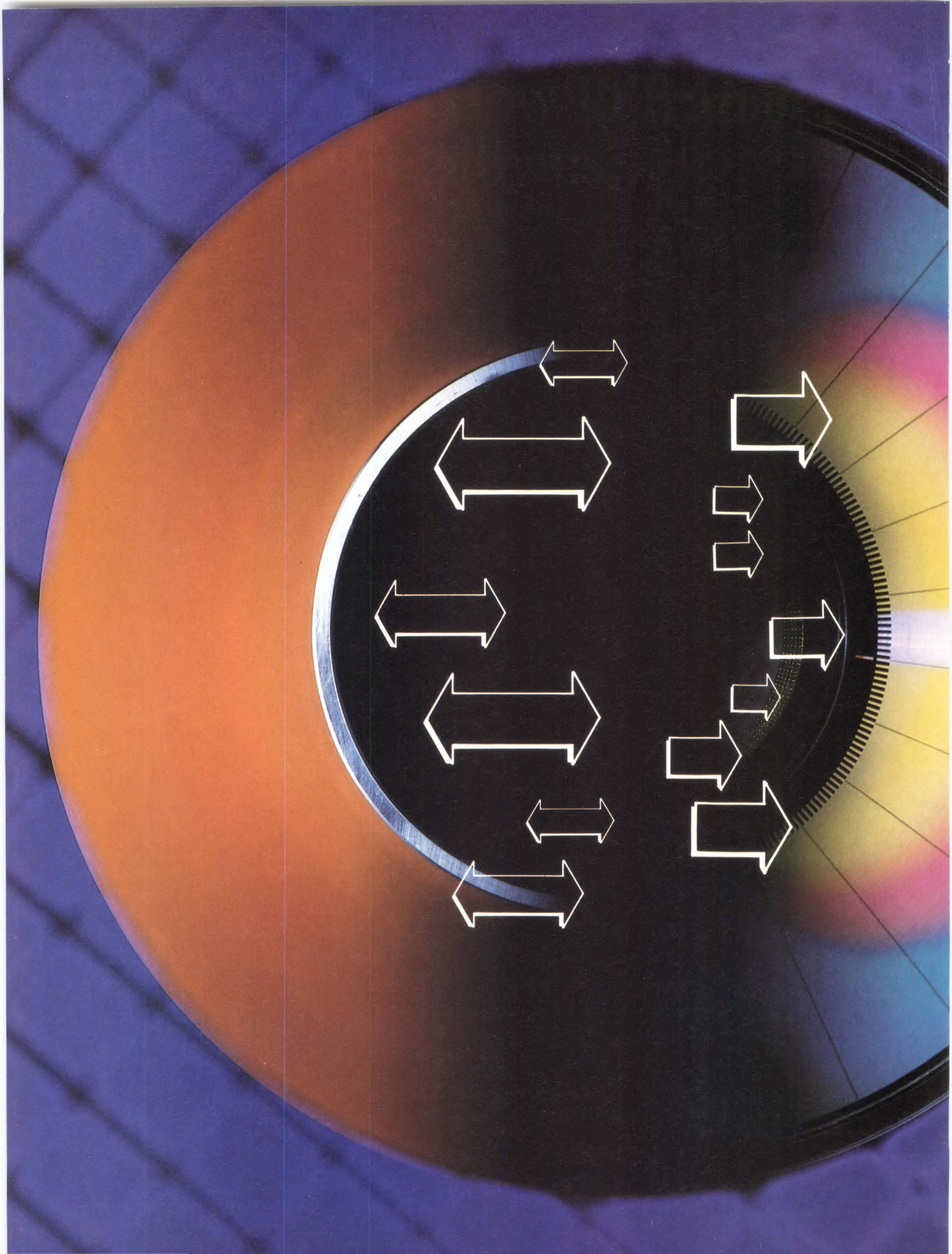
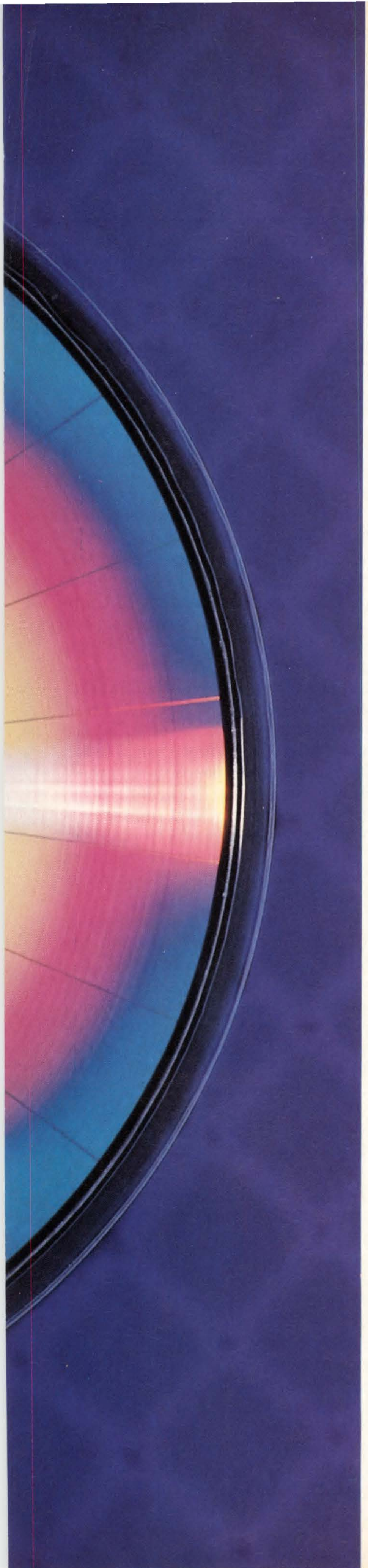




Magneto-optic technologies will eventually deliver erasable media, but meanwhile a combination of media and a special host file system layer can be used

SYSTEMS INTEGRATORS NEED PRACTICAL SOLUTIONS TO BRING WORM TECHNOLOGY ONLINE

by Chuck Dugwette
U.S. Design Corp.

Conny Johannesson Photography

Now that both compact disk, read-only memory (CD-ROM), and write-once read multiple (WORM) technologies are commercially available, the optical disk can be recognized as a genuine technological wonder. The raw specifications show why. A single 12-in. WORM disk stores up to 3.2 Gbytes of data. This is the equivalent of 12,000 floppy disks or 160 20-Mbyte hard disks. This is more than 1.4 million pages, almost 3000 books. Yet any piece of information on the disk can be located and retrieved within a few sec.

One of the key questions concerning the integration of WORM disks into computer systems is how to deal with the characteristic limitation of WORM disks—namely, their inability to erase, or to write data more than one time. Magneto-optic technologies will eventually deliver erasable media, but until that time, system integrators need practical solutions to bring WORM technology online.

File System Requirements

File systems based on magnetic disks form the backbone of most large capacity data applications. From commercial databases to manufacturing control systems, the magnetic disk and its associated file system pervade the data processing environment.

Certainly the most attractive way of integrating optical technology would be to add the optical devices into the file systems that already exist for magnetic disks. An immediate benefit from optical capacity would thus ensue. Native write-once technology cannot, however, suffice for the implementation of most file systems.

In order to implement the mechanisms of file access and storage allocation control, a disk file system typically requires the ability to perform multiple writes to the same location on the media. The file access mechanism provides the means to go from a particular filename to the physical storage location where the data for that file resides. The storage allocation control mechanism ensures that new files go in unused space and that space held by existing files remains secure. To the application environment, these functions are transparent, but both typically require the ability to rewrite the underlying media.

Chuck Dugwette, director of advanced technology and software development for U.S. Design Corp. (Lanham, Md.), holds a B.A. in mathematics from Georgetown University and an M.S. in computer science from John Hopkins University. He has 10 yrs. experience in the computer industry, and has pioneered numerous caching techniques.

"...the key argument against file system extensions for WORM drives is that the extension becomes a permanent part of the data retrieval mechanism."

Figure 1 shows the typical hierarchical structure of a file system. The file systems of VMS, UNIX, and MS-DOS all conform to this type of organization. A root directory provides the starting point for entry into the file system. Under a UNIX file system, the super block describes this structure; under a VMS Files-11 system, it is the master file directory at 000000.DIR. The path to any one file may follow directly from the root, or may follow through a number of directories and/or subdirectories. Each directory structure lists the names of files and provides a mapping between those names and the file locations.

Under MS-DOS, a file search ends at the directory where the physical location of the file itself can be found. Under VMS Files-11 and UNIX file systems, directories map to a secondary structure, that, in turn, contains the access information for the files. Under VMS Files-11, the system file called INDEXF.SYS contains file headers to hold file location information. Under UNIX, the system i-list links together a set of i-nodes, each of which performs the function of a file header.

As files are created and built under each of these operating systems, the directory structure, as well as any associated secondary structure, must be updated to reflect changes to the file system. Hence the need for multiple writes to the same locations—namely, the locations of the individual control files.

File system storage allocation control mechanisms also require multiple write support. VMS Files-11 uses BITMAP.SYS as a storage bit map file to control the available space on a volume, as well as an index file bit map in INDEXF.SYS to control the available space for file headers. UNIX employs a linked list to chain together all the free blocks in a file system. MS-DOS employs a file allocation table (FAT) to assign disk blocks from a list of available space in its files area. Each of these disk resident structures must be initialized and updated by the native file system.

On a WORM drive, the media can be written to only once. The requirement for multiple writes that is inherent in the file access and storage control mechanisms of magnetic-based file systems must be satisfied some other way if transparent operation with a WORM drive is desired.

General Multiple Write Mechanism

One way to achieve transparent operations under an existing file system would be to build an extension for WORM drives. Such an extension would emulate most of the standard file system structures on an optical volume, but would add an additional layer to allow the optical disk to be treated as a standard file system volume. The additional layer would comprise the intelligence necessary to transform updates into new writes to unused locations, and to provide the interface between the actual optical disk structure and the native file system.

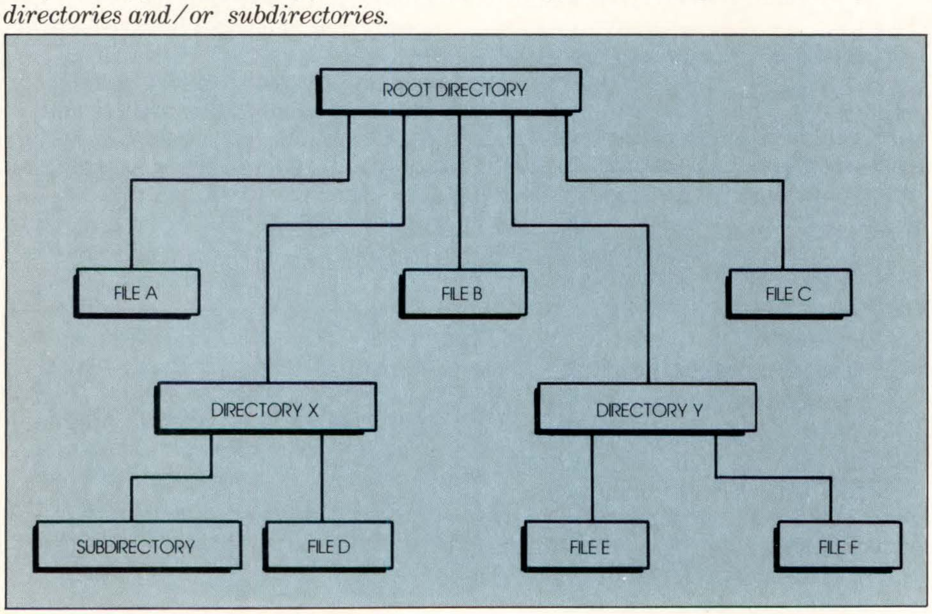
The problems inherent in building file system extensions to support WORM disks are twofold. First, there's the effort itself, which must be carried out for each file system implementation on each operating system that supports that file system. Second, there's the life expectancy of WORM disks. The most notable shortcoming of current optical technology is the inability to erase portions of the media in order to rewrite that area of the disk. Yet the optical industry does not intend to stay in the handicapped position. Erasable technology will come. In the long term, expect to see optical disks implementing rewritable file systems in their native mode—then file system extensions for WORM disks will become obsolete, or at best redundant.

But perhaps the key argument against file system extensions for WORM drives is that the extension becomes a permanent part of the data retrieval mechanism. While the extended file system exists to allow the building of WORM disk file systems, it must also be present in order to read data recorded in the extended format. This may lead to unwanted duplication of the extended file system at read-only sites.

So it's desirable to pursue a solution that is independent of modifications to any one particular file system, yet sufficiently powerful to allow the implementation of diverse file systems. Any particular file system implementation should be in exact conformance with the rules of that file system.

To this end, consider a sequence of disk sectors $\{s(i)\}$, $0 <= i < N$ addressed by a native file system. Let this sequence comprise the logical block address space made available by the device. The value N denotes the number of blocks available to the file system and is equal to the number of fixed size storage blocks on the device, less a frac-

Figure 1—*In the hierarchical structure of a typical file system, the path to any one file may follow directly from the root, or may follow through a number of directories and/or subdirectories.*



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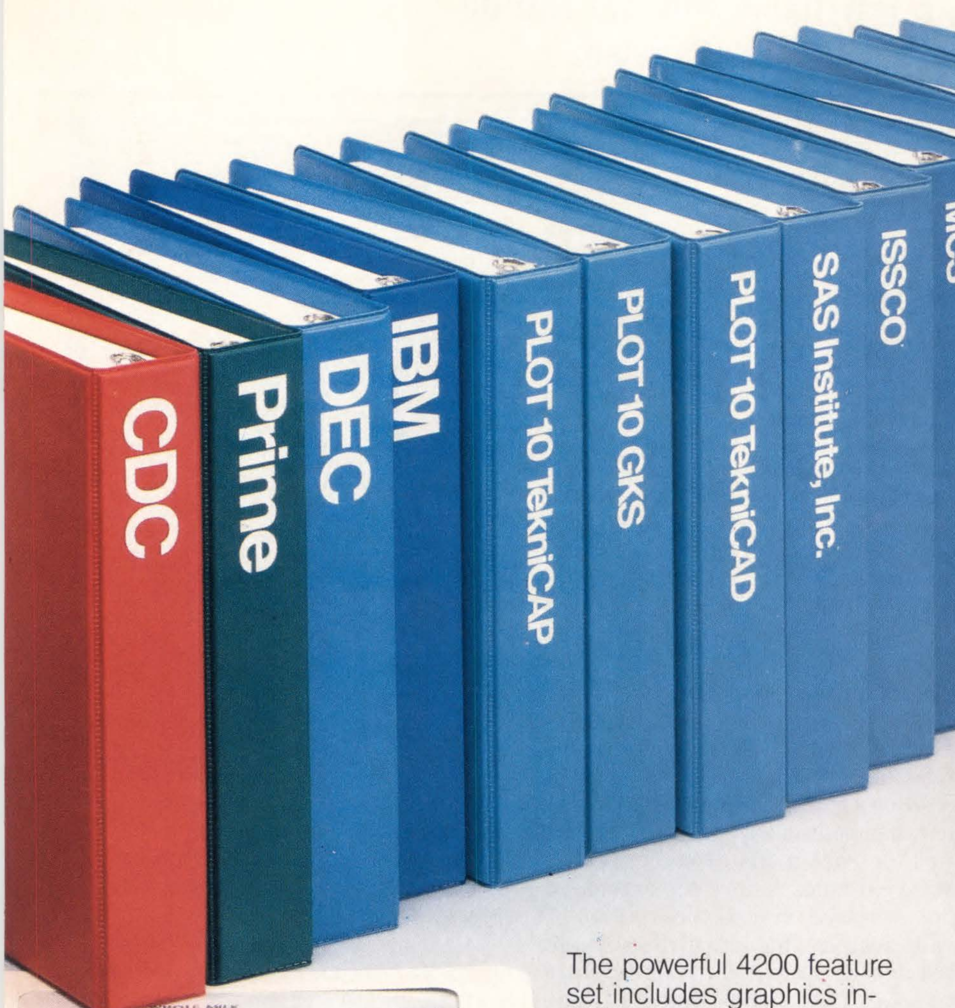
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"The definition of a multiple write interval can precede any file access to that interval — that is, a rewritable interval can be defined before it's used."

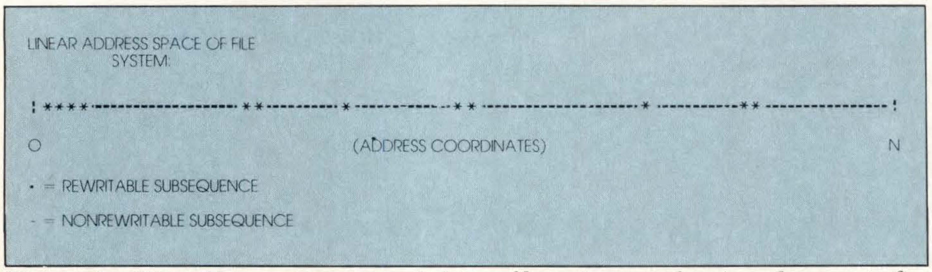


Figure 2—*The address space presented to a file system can be viewed as a set of rewritable subsequences plus a set of nonrewritable subsequences.*

tion devoted to media control.

Consider the properties of the address space in terms of multiple write characteristics. In the magnetic case, all elements of the sector sequence are automatically assumed to be rewritable. But to implement a file system, such universality isn't required. Rather (Figure 2), the address space can be viewed as consisting of a set of subsequences where multiple writes are required, plus a much larger set of subsequences where write-once characteristics would suffice. Roughly speaking, the first set corresponds to file system control areas, while the second set corresponds to actual data areas on the volume.

Following this line, a collection of subsequences can be derived:

[s,e](i) the ith rewritable subsequence with

s(i) = starting logical address in the subsequence

e(i) = ending logical address

= s(i) + x(i) - 1 with

x(i) = extent of the ith rewritable subsequence

where the collection of such intervals represents that portion of the file system that must allow multiple writes. This rewritable collection will consist of both static and dynamic intervals. Static intervals are defined when the device is initialized under the file system; dynamic intervals arise as the volume is used.

The definition of a multiple write interval can precede any file access to that interval—that is, a rewritable interval can be defined before it's used. This follows from the requirement that a file must be created before it can be opened, or that a file already created must be extended before the extension can be accessed. Hence those areas of the file system that require multiple writes can be identified prior to their being used. This means that files that require multiple writes can be stored on a different media—one on which rewritability is allowed.

Magnetic media could thus be used to maintain the rewritable portions of a WORM resident file system. Accordingly, let each definition of a multiple write interval by the native file system be associated with the assignment of a

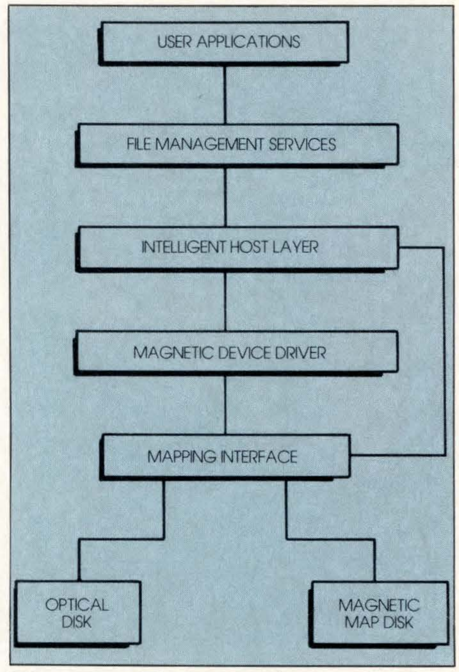


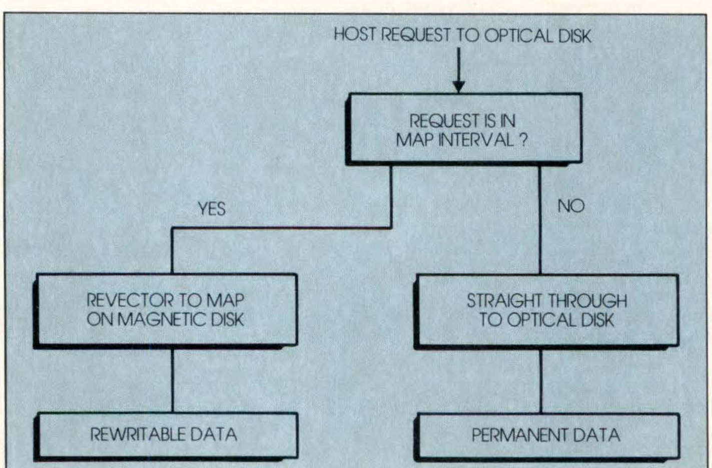
Figure 3—*The magnetic mapping for optical disk concept implements an intelligent layer that defines multiple write intervals to an associated mapping interface.*

magnetic segment to be mapped to the host file process. Each such magnetic segment consists of a contiguous range of defect free blocks, based at an arbitrary address on a magnetic disk. The set of magnetic segments substitutes for the WORM media where rewritability is required.

Figure 3 illustrates this concept. A user application delivers requests through a file management services system. This, in turn, generates file system requests to an added intelligence layer that has the singular responsibility of defining multiple write intervals to an associated mapping interface. Otherwise, requests are passed directly to the underlying magnetic device driver. The magnetic device driver communicates to the optical disk through the mapping interface. The mapping interface connects to the optical disk and also to a dedicated magnetic map disk.

Figure 4 illustrates the mapping interface. Essentially a caching machine, the mapping interface maintains a search structure to record what portions of the optical address space are

Figure 4—*The mapping interface allows for what appear as writes to an optical disk by supporting both optical and magnetic devices.*



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"When multiple writes are limited to the essential components of the file control system... less than 5% of the full optical capacity needs to be represented on magnetic disk."

mapped to multiple write intervals. The mapping interface acts as a device adapter for host accesses to the optical disk, while maintaining a concurrent data link to a magnetic map device. Accesses to the optical disk arrive at the mapping interface, where they are checked against the list of map intervals. A map hit causes the access to be revectored to the magnetic cache area. All manipulations of the file control system are thereby performed on magnetic media. Transfer of the magnetic cache data to the optical disk is done when the file control system is closed.

Implementation of this mapping scheme requires support for the creation of WORM-based file systems, but no support for the reading of the resulting disks, other than an optical device adapter. At each station where WORM disks are written, three support components are required. The first is an added layer of intelligence in the host system to communicate with the mapping interface. The second is the mapping interface itself, a programmable mapping intelligence that accepts map intervals as input and performs data revectoring as output. The third support component is the magnetic map device.

The use of magnetic media as cache memory for the portions of the optical file system that require multiple writes ensures complete conformance with the rules of the host file system. It has the further advantage of requiring a special WORM system only during the creation of the WORM disk files. Also, the file system so implemented on the WORM disk will, by virtue of its exact conformance with the native file system, be compatible with future file systems on erasable optical media.

Consider also the comparative cost of magnetic caching for WORM disks. When multiple writes are limited to the essential components of the file control system, and efficient use is made of the large optical data volume, then less than 5% of the full optical capacity needs to be represented on magnetic disk. At roughly $2/Mbyte for WORM disks and $10/Mbyte for magnetic cache, the combination station may cost $2.25 – $2.50/Mbyte for one-time use. But, as the magnetic cache can be reused, the cache cost is amortized over the creation of multiple WORM disks. ■

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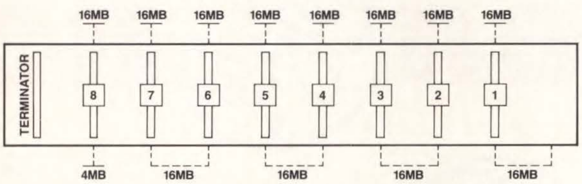

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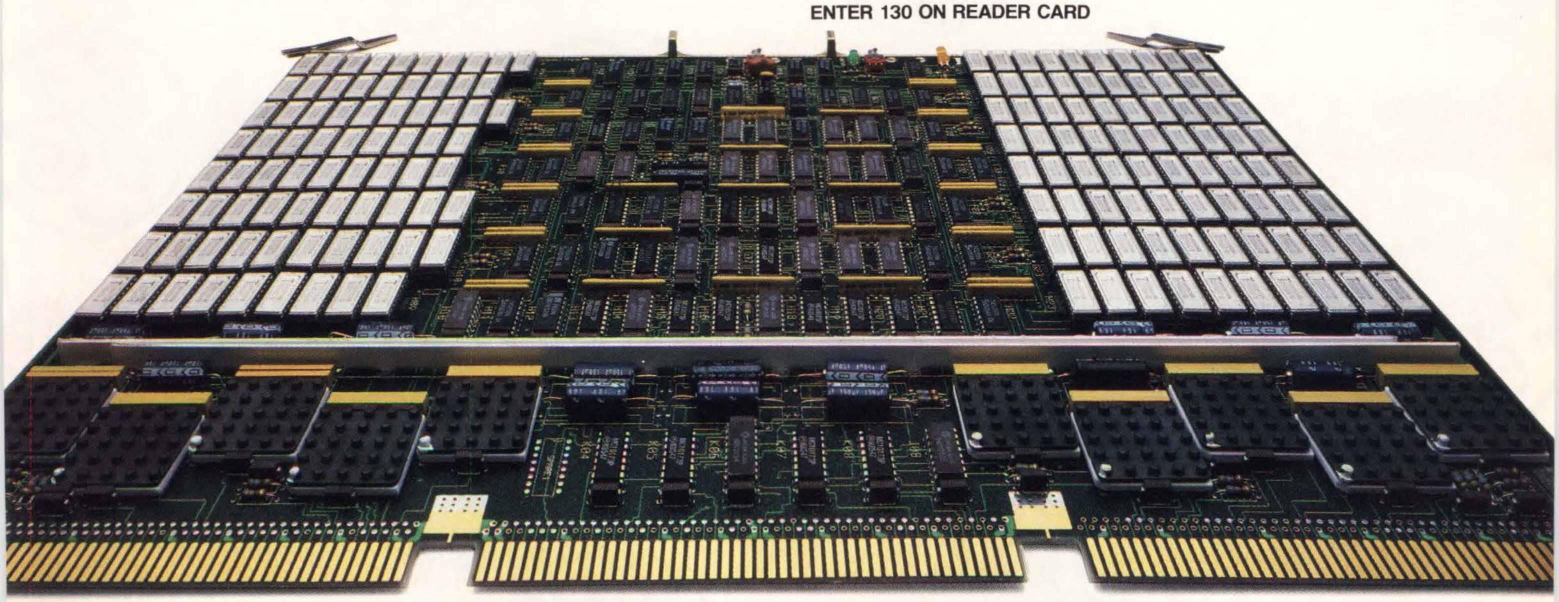

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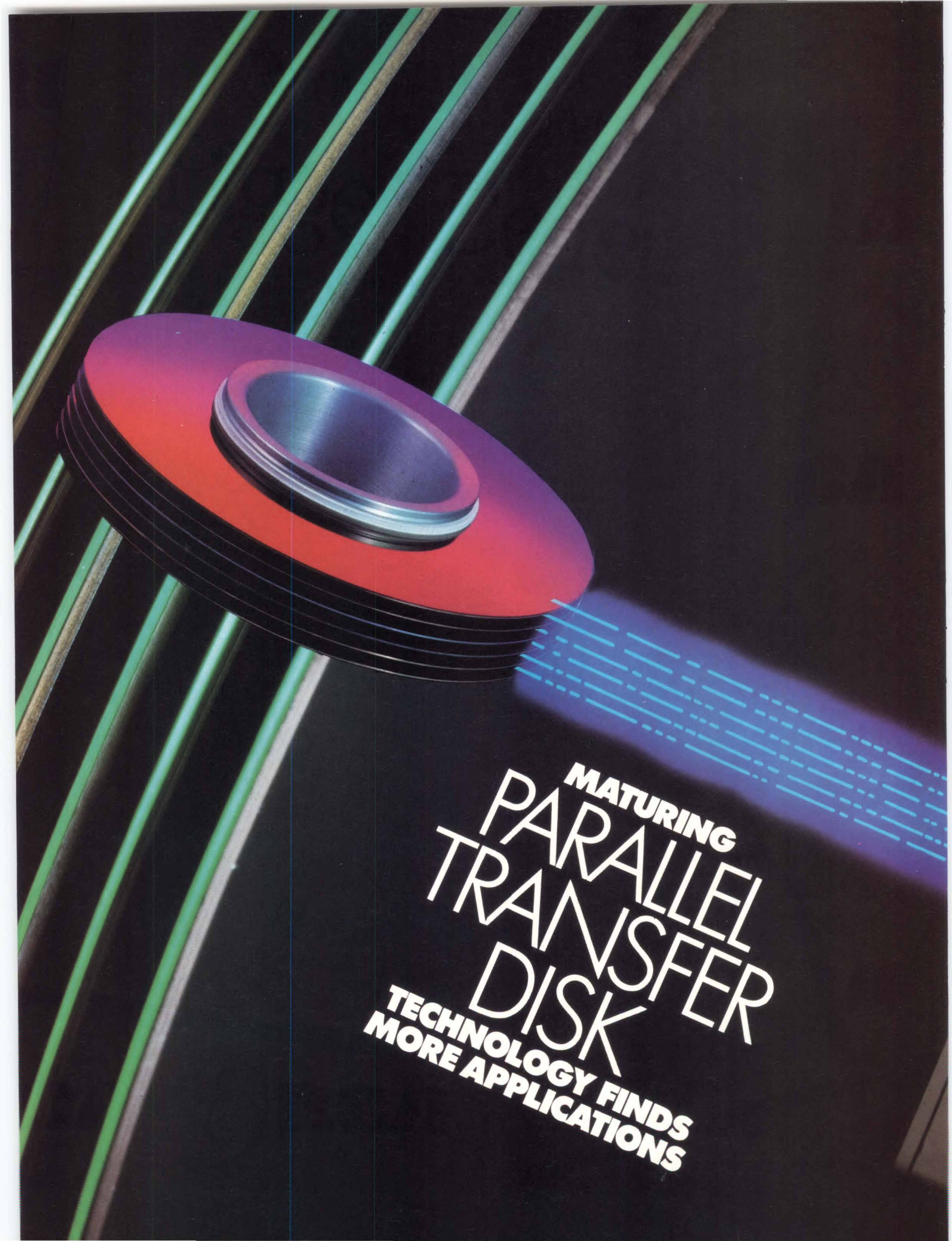
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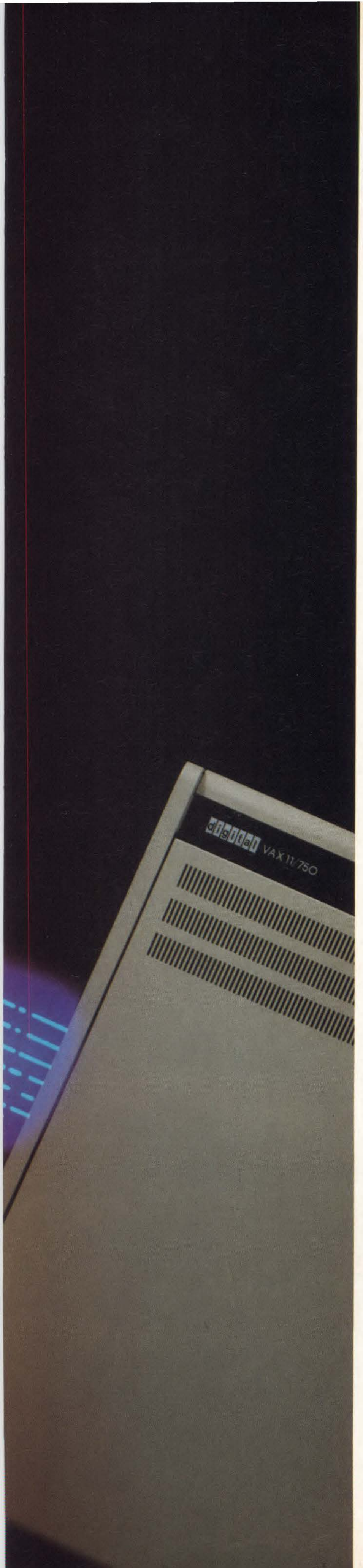

The bottleneck in many applications created by serial channel disk drives is overcome with PTDs, but the price/Mbyte is high and the technology is still being refined

by Michael Gamerl
Fujitsu America Inc.
Lee Karjala Photography

For many data-intensive applications, such as image processing or the large-scale computations of supercomputers and specialized parallel processors, the data transfer rate of serial disk drives isn't fast enough to keep up with computations.

Just a few years ago, the bottom line in benchmarking disk drive performance was access time. But with high performance drives all competing in the 15-20 msec average-access time range, incremental improvements to that specification will be slow to materialize.

Another factor is that the longer record lengths of digitized images de-emphasize the time spent finding a record. In such systems, seek time and latency are not the largest piece of the disk-access time problem. More importantly for these systems is how quickly the record can be transferred into the host system's memory once the heads are positioned over the data. The bottom line now is the data transfer speed.

Consider the problems of high resolution, image processing systems, such as those used in medical imaging. A flicker-free display requires that the entire image be refreshed at 30 frames/sec. To process a 512 x 512 pixel black and white image with 8 bits grey scaling at that uninterrupted rate requires that the system be able to handle sustained data transfer rates at a minimum of 7.8 Mbytes/sec. For processing an RGB (red-green-blue) color image, the necessary data transfer rate is closer to 24 Mbytes/sec. And this is just for medium resolution graphics. High resolution systems require 1024 x 1024 pixel images. You can't get close to the level of I/O performance required with Winchester drives that rely on a serial interface.

Parallel transfer drives (PTDs) are appropriate for such high speed operations. These drives feature multiple synchronized data channels that read and write data simultaneously to overcome the bandwidth limitations of serial disk drives. The most recent drives feature data transfer rates as high as 12 Mbytes/sec. in 4- or 5-channel operation.

American engineers haven't yet learned how to take full advantage of these powerful drives. But high performance PTDs have already been successful in solving many system performance problems.

Parallel Disk Basics

The basic design considerations and functionality of the PTD are the same as for a conventional serial drive. The differences lie in the configuration of read/write heads and data surfaces. In Fujitsu's 689-Mbyte (unformatted)

Michael Gamerl, product line manager for Fujitsu America Inc. (San Jose, Calif.) has dealt with PTD technology for 4 yrs., and worked as a support engineer on Fujitsu's first PTD. Currently he is researching and planning for future PTD products.

M2360A disk drive, for example, there are six 10½-in. platters and two heads for each of the 10 data surfaces—the top surface isn't used and one other surface is reserved for prerecorded continuous servo information (the servo surface has its own head). The high storage density of the drive (18,620 bits/in. linear density and 880 tracks/in. areal density) magnifies every tracking error, so continuous closed-loop servo tracking is imperative.

Because the drive has 20 independent read/write heads, there are theoretically 20 parallel read/write data channels. In practice, however, the limiting factor isn't the number of heads, but the number of independent positioning arms—in this case five. Although you can conceivably read and write simultaneously with all four heads on any given arm, you can't control the position of any one head relative to the other three heads. And seeking a new position in between read/write operations defeats the advantage of parallel data transfer. The diagram shown in Figure 1 illustrates the relationship between the logical head address and the physical read/write channel assignment for the heads on each of the five arms.

To support true parallel read/write operation for each arm (each set of four heads), the drive has separate preamplifiers, read/write circuits, and variable frequency oscillators (VFOs) as shown in Figure 2. Most of the other circuitry, such as the servo logic, motor control, and seek control is the same as you would find in any high performance serial Winchester drive.

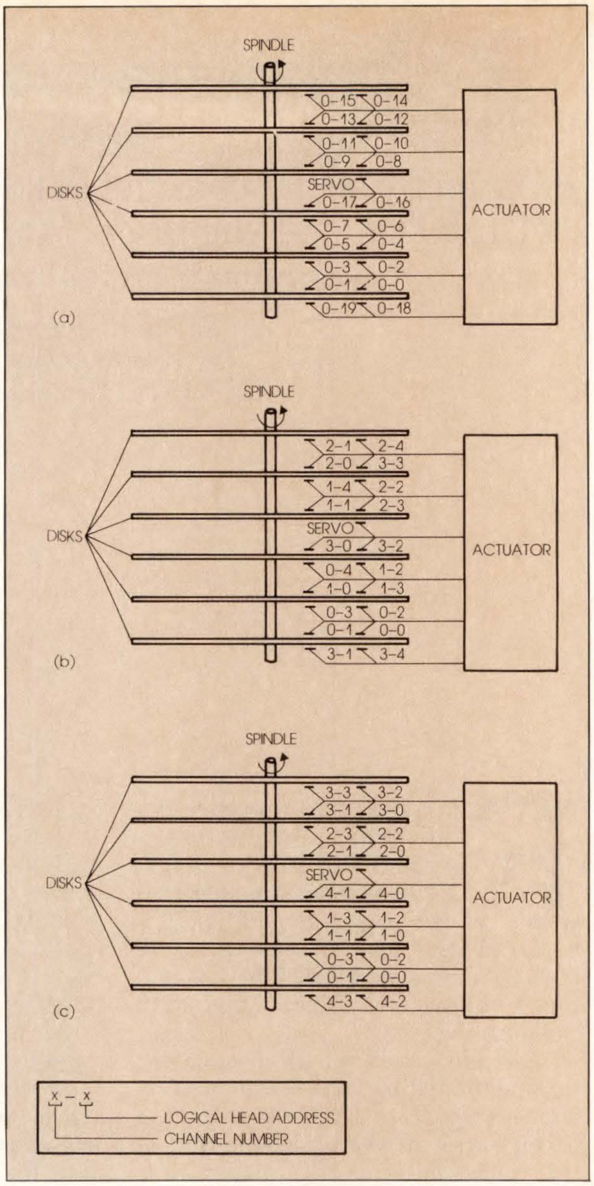

Figure 1—*The possible configurations of disks and heads in a 6-platter PTD include 1 channel/20-head groups* (a), *4 channel/5-head groups* (b), *and 5 channel/4-head groups* (c).

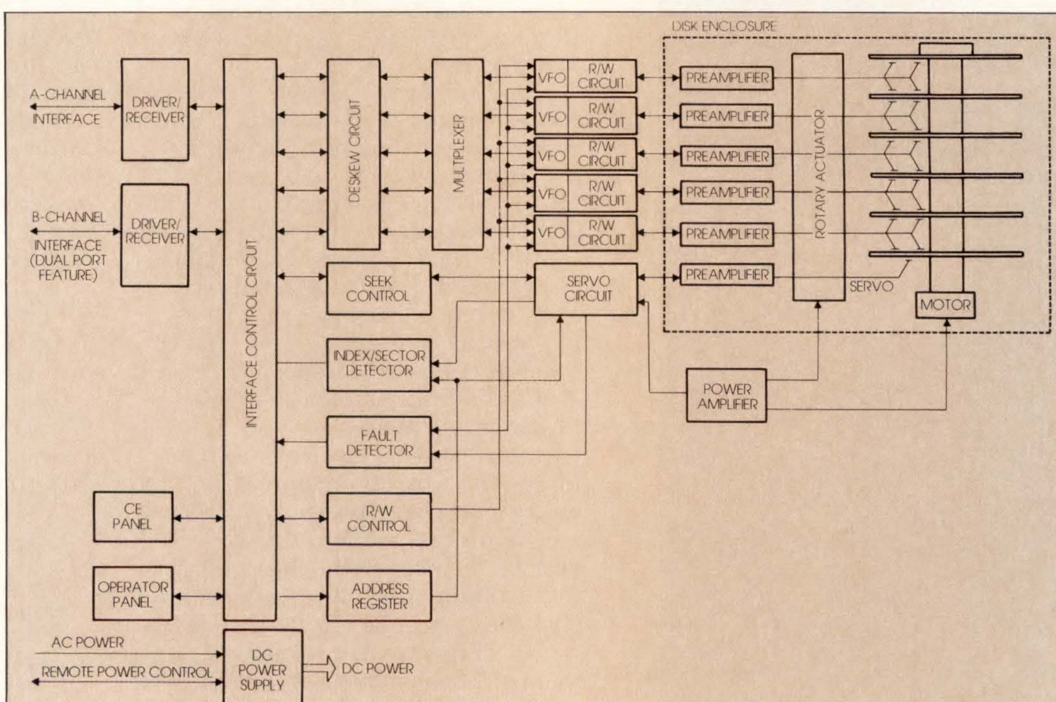

Figure 2—*To support each PTD arm separately, drive hardware is duplicated for each. Otherwise, the structure of a PTD is similar to high performance serial drives.*


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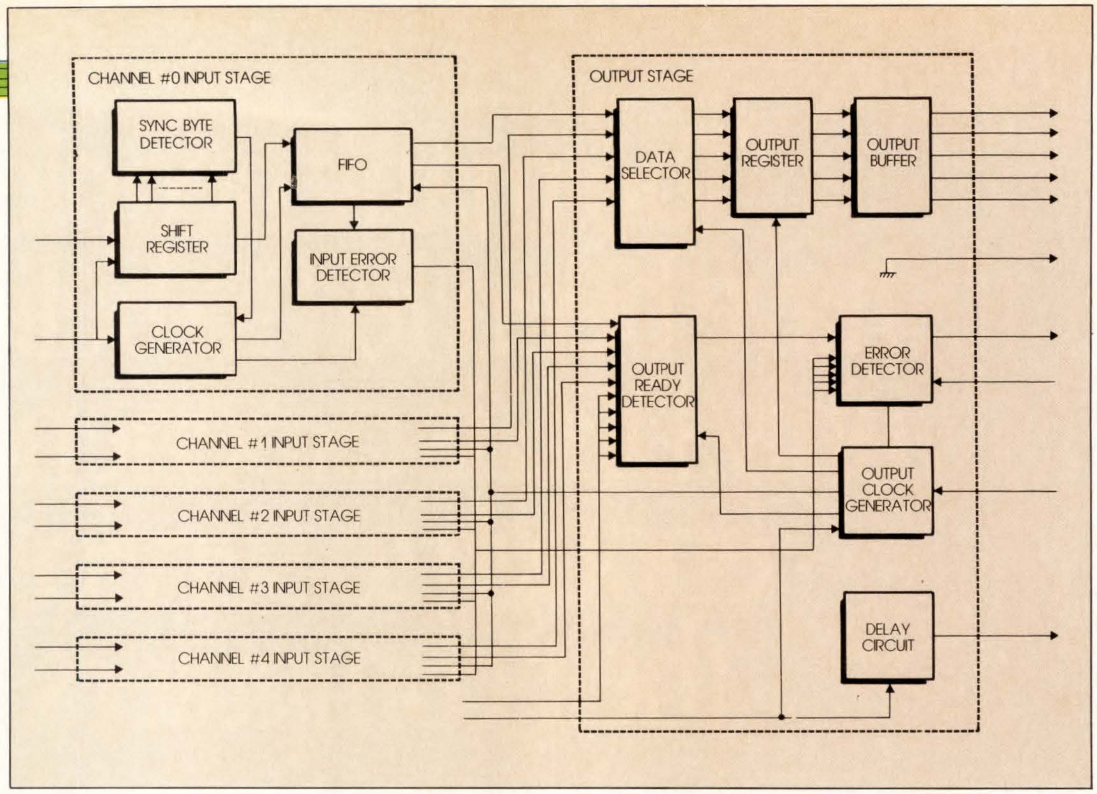


Figure 3—*De-skew circuitry eliminates data timing synchronization problems between channels that arise due to electrical or mechanical variances.*

Putting The Drives To Work

At the high data transfer rates that PTD drives reach, the data being read from four or five independent read/write channels can easily be skewed, or misaligned, by as much as 3 bytes. Skewing is caused by minor variances in the drive's components, including:

- mechanical factors (e.g., head alignment and tracking); and
- electrical characteristics (e.g., propagation delay and rise time).

These factors can be dealt with using optional plug-in de-skew circuitry. Some controller manufacturers also provide de-skew, or in the case of multiple drive subsystems, a specialized de-skew circuit to meet system requirements. Regardless of who provides the circuitry, the basic principles remain the same.

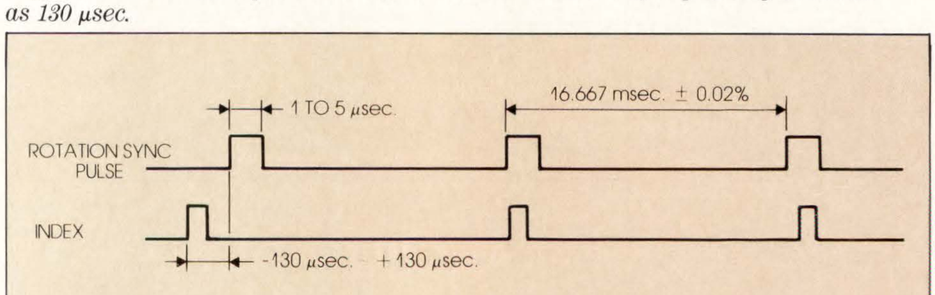
An optional de-skew circuit is shown in Figure 3. It will reduce bit skew to less than 1 bit, and the controller will be better able to handle incoming data. The five independent input channels accept data from the read channels and store it in a shift register, with data strobed by the clock signal. When the input channel detects the sync byte pattern in the incoming datastream, it begins to send the read data to the first-in-first-out (FIFO) buffer. The data moves to the final stage of the FIFO, automatically activating each channel's output ready signal.

When all of the input channels have activated their output ready signals, the de-skew circuitry can begin to synchronously output the data to the controller. A shift-out clock strobes the data in each FIFO into its output state. All data is now synchronous with the clock signal that triggers the output clock generator, which strobes data from the output buffer to the controller. Essentially all skewing has been absorbed by the shift register.

In some systems, designers want to combine multiple drives in parallel for even wider data transfers. A controller that uses four of the read/write channels from each of two drives, for example, provides a mass-storage subsystem configuration that can easily handle byte-wide data transfers. Strobing a byte of data at a time into a dual-ported video memory provides one of the fastest attainable methods of refreshing and updating video RAM. And for parallel processors capable of handling 32- or 64-bit data words, word-wide subsystems can be constructed by the addition of even more drives. The problems of synchronizing so many parallel channels make this configuration complex, but the payoffs in throughput can be exceptional.

To ensure the reliability of data transfers that involve more than one drive, some PTDs feature a rotation sync pulse that can be generated internally for single-drive subsystem configurations, or externally for multiple-drive systems. When the external pulse is selected, the controller sends each drive the same rotation sync pulse and each drive adjusts its spindle motor rotation so that the track index synchronizes with the rotation sync pulse's phase. Using a common rotation sync pulse for all of the drives in a subsystem will maintain rotation synchronization within ±130 μsec—this is the possible variation in time between the leading edge of the index pulse and the leading edge of the rotation sync pulse (Figure 4).

Figure 4—*The index pulse can lag or lead the rotation sync pulse by as much as 130 μsec.*



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MasterDisk®	***152 MB***	***7.26 msec***	***$42***
ADD-ON SUBSYSTEMS			
DEC RA81	456 MB	36.6 msec	$59
Eagle/QD32	370 MB	26.3 msec	$41
SI QDA50	960 MB	28.3 msec	$44
MasterDisk®	***607 MB***	***7.26 msec***	***$33***

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"In some applications, an intelligent interface— one that assumes the tasks of keeping track of the disk I/O operations and relieves the host computer of the overhead—makes sense."

If you consider the role of de-skewing circuits in managing multiple data paths, the effect of minimizing latency from individual drives is clear. The closer in time that the drives receive parallel data into the de-skew input buffers, the more regular the data flow out of the de-skew circuits—the buffers of some channels aren't waiting for the output ready signal from other channels. This translates directly into higher sustained data throughput rates.

Sharing A Drive

Another performance feature of PTDs that specifically supports high performance applications is a dual-ported architecture. This feature allows two independent disk controllers to directly access the same drive, providing two different systems access to one set of data. Thus, two specialized processors can have high speed access to images stored on disk without waiting for intersystem transfers.

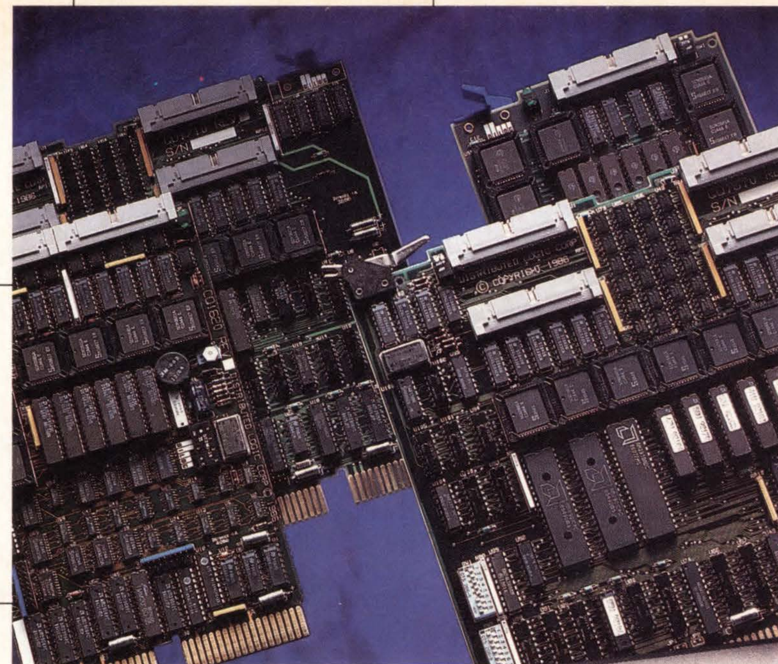
At the time of this writing, any applications implementing this function are unknown, but the potential for sharing the cost of a single high performance data storage device among two workstations should appeal to a variety of designers of turnkey image processing systems. This approach enhances and extends the basic architecture of high performance parallel processing engines by giving each processor direct access to data.

Combining the multiple drive configuration with system sharing via the dual porting feature, for example, lets a system integrator configure a system that updates 32- or 64-bit-wide data at high speed to multiple independent processors. Correlation, integration, and even formatting of the results of the two specialized image processors can be handled by a supervisory processor that doesn't require direct access to the raw data.

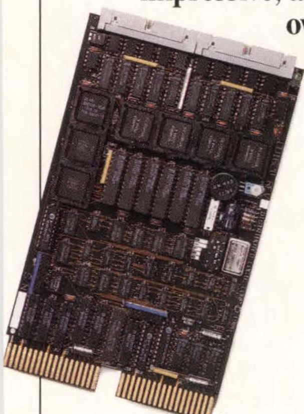
There are, however, system considerations that make it important for the drive to operate exactly like a serial drive. Although the drives are expressly designed for high speed 4- or 5-channel operation, under software control they can also transfer data via a single channel. This feature is important if the PTD is the only drive in the system, since it allows the I/O system to load the operating system (in serial mode) from a special partition on the disk. The parallel device driver, which is stored on disk, will then toggle the drive to parallel operation.

Because the operating systems of most of today's high end computers won't fit on a single floppy, a system

Dilog Gives You More In DEC-Compatible Communications.



Right now, DILOG is delivering the latest generation of asynchronous communications controllers for QBUS and UNIBUS systems. Highlighted in the table, these four advanced products offer impressive, across-the-board advantages over DHU11 and DHV11. Here's how we give you more...

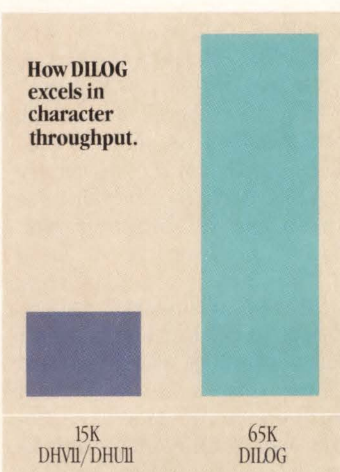


More Economy

DILOG's new generation communications controllers save from $40 to $90 per line. Multiply that by the lines in your system, and you'll see substantial bottom-line benefits.

More Useable Space

In every instance, DILOG uses a smaller board — typically dual-size — or puts more lines on the same size board.



More Throughput

Compare the competition's throughput to DILOG. Yes, we deliver an advantage of better than 400%! Results? Less load on the system and fewer pauses in data transfers. DILOG controllers feature 32 character transmit buffers on each channel and support data rates to 38.4K baud.

More Available Power

DILOG communications controllers draw far less wattage per line. This way, you don't have to sacrifice peripherals when you add communications to QBUS systems. And with UNIBUS, you can eliminate the need for an expansion chassis for controllers.

DHV11 compatibles for MicroVAX, MicroPDP-11, LSI-11

CQ1620 — dual board; 8 RS-423 channels; full DHV11 modem set.
CQ1622 — dual board; 8 RS-422 channels; data leads.
CQ1610 — quad board; 16 RS-423 channels; full DHV11 modem set.

DHU11 compatible for VAX and PDP systems

CU1710 — the only full-function 16-channel multiplexer on a quad board; RS-423 channels; full DHU11 modem set.

More Connectivity

A comprehensive choice of distribution panels simplifies installation, provides application flexibility, and assures easy migration to new configurations.

More Information?

Call today and see why DILOG has shipped over 60,000 controllers to some of DEC's best OEMs. Contact: DILOG Corporate Headquarters, 1555 S. Sinclair St., Anaheim, CA 92806; (714) 937-5700 TLX: 6836051. Eastern Regional Sales Office: 64-A White Street, Red Bank, NJ 07701; (201) 530-0044. UK Sales Office: Chester House, Chertsey Rd., Woking, Surrey GU21 5BJ; (4862) 70262 TLX: 859231. International Sales & Manufacturing: Route de Boudry 14, 2016 Cortaillod, Switzerland; (4138) 424454 TLX: 952751.

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"When PTDs were first introduced, they cost $75/ Mbyte; this year, in reasonable OEM quantities, the drives are priced at $17,500."

integrator would have to boot the OS from a standard serial Winchester disk drive if his PTD had no single channel capability. Then the PTD would be used only for storage of the data used in high speed operation. Certainly this approach works well, but it does little for a system's cost effectiveness to have a serial drive that does nothing once the system is booted.

Special serial-data partitions and serial data transfer capability make it possible to eliminate the requirement for a serial drive that isn't used after the system boots up.

The Interface: Intelligence Or Obedience?

The debate over the relative merits of intelligent interfaces rages at this end of the performance spectrum as strongly as it does at the low end. The Intelligent Peripheral Interface (IPI) is certainly a contender. Fujitsu's PTD comes with the modified Storage Module Drive (SMD) interface shown in Figure 5. The specific modifications support 4- or 5-channel parallel data transfers. In particular, the differences from the SMD specification are:

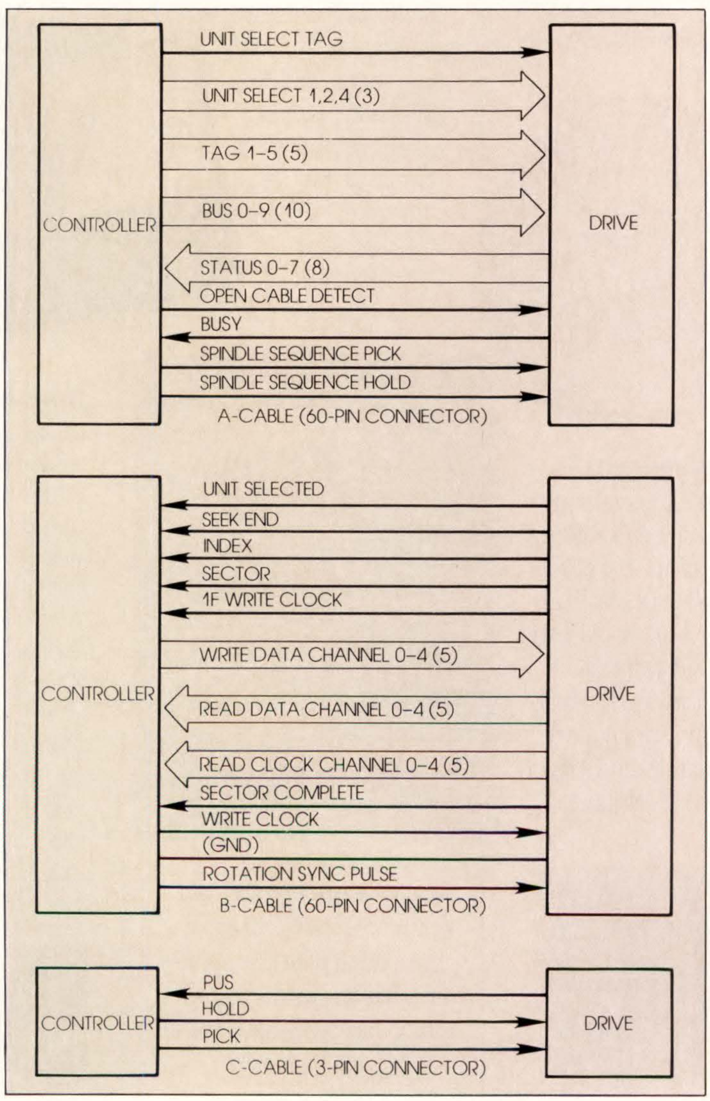


Figure 5—*The modified SMD interface uses two 60 pin cables to support 4- or 5-channel transfers. An optional C-cable provides AC power sequencing to the drives.*

- the data-transfer rate;
- track capacity (40,960 bytes);
- timing of read/write operations;
- addition of new tags; and
- set sector/read sector.

The SMD interface offers integrators the advantage of relative simplicity (compared to more intelligent interface designs) and benefits from widespread acceptance in existing high performance computer systems.

For some applications, however, an intelligent interface makes more sense—one that assumes some tracking of the disk I/O operations and relieves the host computer of the overhead. But the overhead of an intelligent controller usually means lower data throughput. These different goals have to be reconciled before there is a widespread application of intelligent parallel-transfer drives.

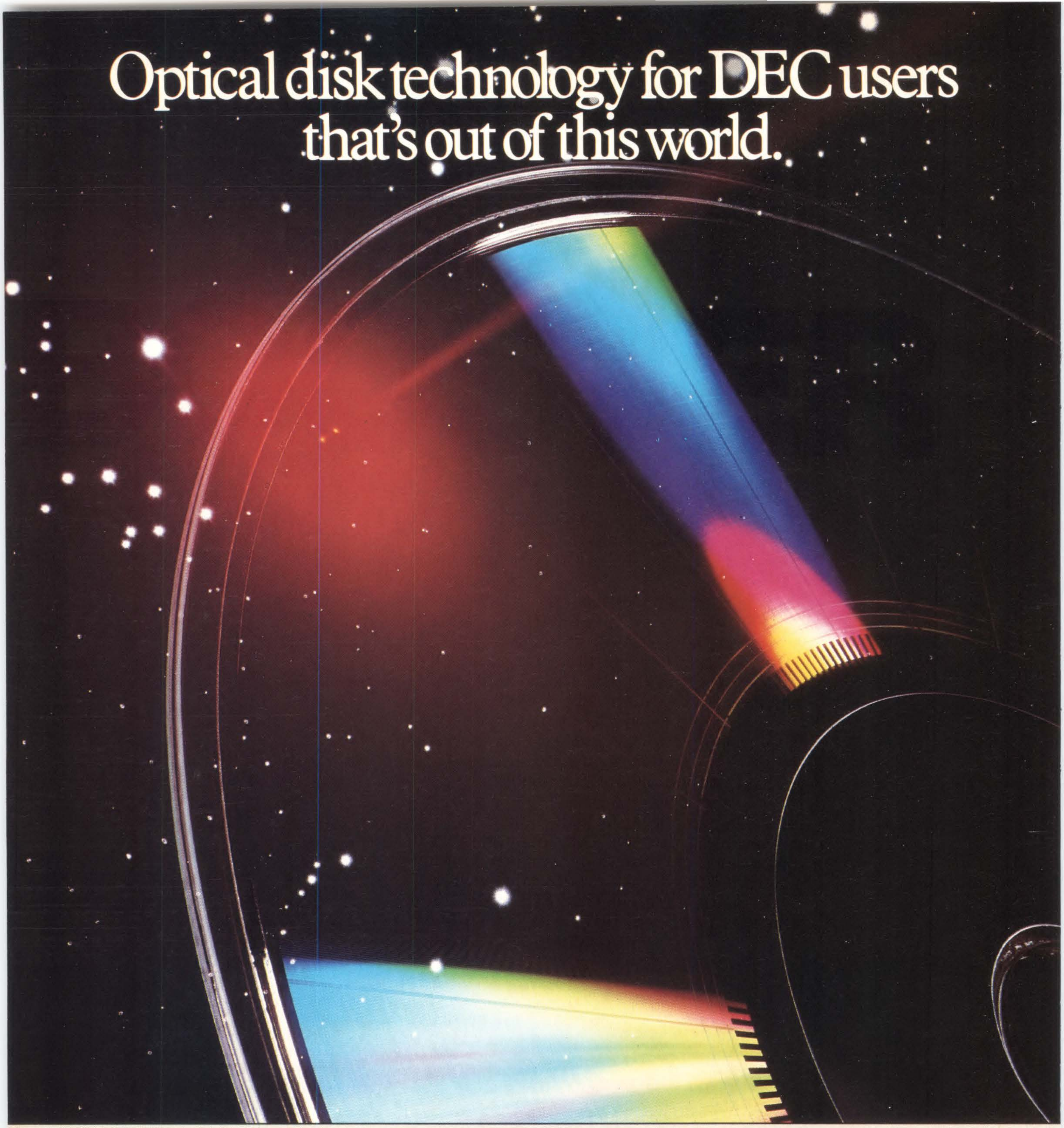
The Price Of Storage

Perhaps the major stumbling block to the widespread application of PTDs to workstations and high end computational engines such as parallel processors has to do with the way engineers view the price of mass storage. The current rule of thumb is to assume that high performance mass storage will cost a system manufacturer in the range of $10/Mbyte. But PTDs inherent complexity will always put it at a purchase price disadvantage compared to serial drives. However, as we have seen, PTDs don't compete directly with serial drives any more than conventional Winchester drives compete with tape drives (which offer significant savings over disks in terms of dollars/Mbyte).

When PTDs were first introduced, they cost $75/Mbyte; this year, in reasonable OEM quantities, the drives are priced at $17,500. As high performance disk storage in the 700-Mbyte range, PTDs still appear expensive. It is in their creative application to problems, where data rates are a concern, that engineers will recognize that PTDs aren't just another version of the standard disk drive. They offer a new approach to mass storage that provides the designer with a way of efficiently and directly contending with critical system bottlenecks. And, as designers begin to use PTDs in higher volumes, their prices will decrease accordingly. ■

How would you rate the technical information in this article?

Too complex	**Enter No. 656**
Just right	**Enter No. 660**
Too simplistic	**Enter No. 664**



Finally, an optical disk file server for DEC users. Optifile is a multiuser file server peripheral for PDP-11 and VAX systems. Optifile uses large capacity "Write-once" removable optical disks and provides high level file and volume related commands (such as mount, dismount, read, write, insert, append). Optifile runs now under RSX-11M/PLUS and VMS and a DECnet option turns the system into a file server node. For more information call 1-800-267-0443 or write KOM Inc.

Optifile

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FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fixed	Type: Removable	Host Bus	Controller** Model	Controller** DEC Emulation	Drive**	Capacity (Mbytes, formatted)
ADV COMPUTER SYSTEMS INC. 250 Prospect St. Waltham, MA 02154 617-894-3278 **Enter No. 900**	MicroVAX II Disk Subsystem	$7,495	•		Q-bus	D MV210	MicroVAX II	NEC D2268H	300
	Q-bus Disk Subsystem-DU	$7,495	•		Q-bus	D DQ226	MSCP	NEC D2268H	300
	Q-bus Disk Subsystem-RM05	$7,495	•		Q-bus	D DQ228	RM05	NT 8212X	300
ALPHA DATA INC. 20750 Marilla St. Chatsworth,CA 91311-4488 818-882-6500 **Enter No. 901**	Atlas 520	$10,850	•		Q-bus, Unibus	D, SL	Most	Atlas 520	400 +
AMERICAN DATA SYS. MKT. INC. 53 Elderwood Dr. Stoughton, MA 02072 617-341-0171 **Enter No. 902**	Concept 21 PTD	$42,200	•		Q-bus, Unibus	SC Concept 21	N/A	F M2350A	462
	Concept 31 PTD	$48,900	•		Q-bus, Unibus	SC Concept 31	N/A	F M2360A	672.8
	DCM2351	$17,000	•		CMI	E SC700X	RM05/80/ex.	F M2351A	413.8
	DCM 2361	$17,500	•		CMI	E SC700X	RM05	F M2361A	551.8
	DQV2351	$11,900	•		Q-bus	E QD32	MSCP	F M2351A	367.8
	DQV2361	$12,900	•		Q-bus	E QD32	MSCP	F M2361A	538.9
	DUX2351	$12,950	•		Unibus	E SC31	RM80 ex.	F M2351	405.2
AMERICAN DIGITAL SYSTEMS INC. 75 Union Ave. Sudbury, MA 01776 617-443-7711 **Enter No. 903**	MasterDisk/MDE607-A*	$6,450	•		Q-bus	W ADS/ MDC001	MSCP	C Wren III (1–4)	152/drive
APTEC COMPUTER SYSTEMS INC. P.O. Box 6750 Portland, OR 97228 503-626-9000 **Enter No. 904**	DSS-1412 Aptec Disk Subsystem	$118,000	•		Q-bus, Unibus, BI-bus	Aptec Ibis Disk Adaptor	N/A	I 1400	1200
AVIV CORP. 26 Cummings Pk. Woburn, MA 01801 617-933-1165 **Enter No. 905**	DFS 904-1182	$6,450	•		Q-bus	DFC 904	MSCP	C Wren III	152
	DFS 904-1380	$7,900	•		Q-bus	DFC 904	MSCP	M 4380	319
	DFS 904-2182	$12,150	•		Q-bus	DFC 904	MSCP	C Wren III (2)	152/drive
	DFS 904-2380	$14,350	•		Q-bus	DFC 904	MSCP	M 4380 (2)	319/drive
	DFS 904-3182	$16,050	•		Q-bus	DFC 904	MSCP	C Wren III (2)	152/drive
	DFS 904-3380	$19,000	•		Q-bus	DFC 904	MSCP	M 4380 (3)	319/drive
	DFS 904-4182	$19,950	•		Q-bus	DFC 904	MSCP	C Wren III (4)	152/drive
	DFS 904-4380	$23,650	•		Q-bus	DFC 904	MSCP	M 4380 (4)	319/drive
	DFS 917-2333	$10,800	•		Q-bus	DFC 917	MSCP	F 2333	280
	DFS 917-2351	$12,500	•		Q-bus	DFC 917	MSCP	F 2351	402
	DFS 917-2361	$13,700	•		Q-bus	DFC 917	MSCP	F 2361	573
	DFS 917-9772	$14,550	•		Q-bus	DFC 917	MSCP	C 9772	725
CHRISLIN INDUSTRIES INC. 31352 Via Colinas #101 Westlake Village, CA 91362 818-991-2254 **Enter No. 906**	CI-70-WC	$3,750	•		Q-bus	A UDC11	MSCP	F 2334	70
	CI-120-WC	$4,450	•		Q-bus	A UDC11	MSCP	M 1140	120
	CI-550-10WF*	$2,895	•		Q-bus	A UDC11	MSCP	S	10
	CI-550-20WF*	$3,095	•		Q-bus	A UDC11	MSCP	S ST225	20
	CI-550-45W	$3,450	•		Q-bus	A UDC11	MSCP	R 204E	45
	CI-820-20*	$3,895	•		Q-bus	A UDC11	MSCP, RX02/03	S ST225	20
	CI-820-45*	$4,494	•		Q-bus	A UDC11	MSCP, RX02/03	R 204E	45
	CI-820-70*	$5,495	•		Q-bus	A UDC11	MSCP, RX02/03	F 2334	70
	CI-820-120*	$5,950	•		Q-bus	A UDC11	MSCP, RX02/03	M 1140	120
	CI-1340-MB	$8,295	•		Q-bus	E QD32	MSCP	P 807-23	300
	CI-1340-MBB	$13,295	•		Q-bus	E QD32	MSCP	P 807-23 (2)	300/drive
	CI-1340-MD	$19,000	•		Q-bus	E QD32	MSCP	T	900
DAX 3868 Carson St. #310 Torrance, CA 90503 213-540-2639 **Enter No. 907**	Special 1-MV2*	$12,590	•		Q-bus	SL Spectra 25	RM, TS	F M2333	337
	Special 2-MV2	$22,090	•		Q-bus	SL Spectra 25	RM, TS	F M2361A	689

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable. The vendors listed in this buyers guide responded to a survey conducted by *Hardcopy*. To be included in the *Hardcopy* hard drives database, please contact Cindy Grant-Thurman at 714-632-6924.

FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fi	Type: Re	Host Bus	Controller** Model	Controller** DEC Emulation	Drive**	Capacity (Mbytes, formatted)
DIGITAL CONSULTANTS 246 Knollwood Dr. Newbury Park, CA 91320 805-498-4577 **Enter No. 908**	9900/2361, 9900/2351, 9900/2333	$20,400, $17,000, $14,800	•		SBI, CMI	SI 9900	All: RH 750/780, RM05 (2351-ex.)	F 2361/2351/2333	512.2, 413.8, 256.2
	QD/2361, QD/2351, QD/2333	$13,300, $10,900, $8,700	•		Q-bus	All: E QD32	MSCP KDA50	F 2361, 2351, 2333	INP
	SC7XXX/2361, SC7XXX/2351, SC7XXX/2333	$17,245, $13,995, $12,500	•		CMI	E SC7003	All: RH750, RM05 (2351-ex.)	F 2361, 2351, 2333	512.2, 413.8, 256.2
	VM2361, VM2351, VM2333	$18,615, $16,200, $13,445	•		SBI	E V-Master	All: RH780, RM05 (2351-ex.)	F 2361, 2351, 2333	512.2, 413.8, 256.2
DIGITAL DYNAMIC SYSTEMS INC. 11285 Elkins Rd., Ste. F2 Roswell, GA 30076 404-442-8747 **Enter No. 909**	MAX2-85/95*	$6,822	•		Q-bus	E QD01	MSCP	C 9415-5	72
	MAX2-140/95*	$7,500	•		Q-bus	E QD01	MSCP	M 2140	116
	MAX2-190/95*	$9,822	•		Q-bus	E QD01	MSCP	M 2190	165
	MAX2-380/0	$10,316	•		Q-bus	E QD01	MSCP	M 2190 (2)	165/drive
	MAX2-382/95*	$11,287	•		Q-bus	E QD21	MSCP	M 4380	322
	MAX2-764/0	$13,300	•		Q-bus	E QD21	MSCP	M 4380 (2)	322/drive
EAKINS ASSOCIATES INC. 67 E. Evelyn Ave. Mountain View, CA 94041 415-969-5109 **Enter No. 910**	As configured	POR	•		CMI, SBI	E 7003	RH	F 2361	585
	As configured*	POR	•		Q-bus	SL 25M	RM	F 2361	585
	As configured*	POR	•		Q-bus	E DM01	MSCP	F 2243	68
	As configured*	POR	•		Q-bus	E DM02	MSCP	M EXT 4380	323
	As configured	POR	•		Q-bus	E QD32	MSCP KDA50	F 2333 (1–2)	286
	As configured	POR	•		Q-bus	E QD32	MSCP KDA50	F 2361 (1–2)	585
	As configured	POR	•		Q-bus	E QD33	MSCP KDA50	F 2361, 2333	585, 286
	As configured	POR	•		Q-bus	SL 15	RM	P DX548	465
	As configured	POR	•		Q-bus	SL 501	MSCP	F 2361, 2333	585, 286
THE 11 CONNEXION 1105 Pamplona Ave. Davis, CA 95616 916-758-2943 **Enter No. 911**	11X-MSCP-5W/XX	$2,800–$9,900	•		Q-bus	MT, W, E	MSCP	F, M	10–1200
	11X-RL02-5W/XX	$2,200–$3,000	•		Q-bus	MT MLVIIM	RL02	F	10–40
EMULEX CORP. 3545 Harbor Blvd. Costa Mesa, CA 92626 714-662-5600 **Enter No. 912** (Note: All subsystems are available with one or two drives; prices given are for single drive subsystems)	R0310/BX	$9,895		•	Q-bus	SC03/BX	RM02/03	C 9710	67.4
	R0310/XX	$10,095		•	Q-bus	SC03/MS	MSCP	C 9710	65.2
	R0366/BX	$17,020		•	Q-bus	SC03/BX	RM05	C 9766	256.2
	R0366/XX	$17,220		•	Q-bus	SC03/MS	MSCP	C 9766	247.8
	R3110/J	$11,350		•	Unibus	SC31/BX	RM02/03	C 9710	67.4
	R3110/V	$11,500		•	Unibus	SC31/BX	RM02/03	C 9710	67.4
	R3166/J	$17,750		•	Unibus	SC31/BX	RM05	C 9766	256.2
	R3166/V	$17,900		•	Unibus	SC31/BX	RM05	C 9766	256.2
	R3210/XX	$10,295		•	Q-bus	QD32	MSCP	C 9710	67.0
	R3266/XX	$17,420		•	Q-bus	QD32	MSCP	C 9766	246.7
	R4110/J	$11,950		•	Unibus	SC41/MS	MSCP	C 9710	62.5
	R4110/V	$11,950		•	Unibus	SC41/MS	MSCP	C 9710	65.2
	R4166/J	$18,350		•	Unibus	SC41/MS	MSCP	C 9766	247.8
	R4166/V	$18,350		•	Unibus	SC41/MS	MSCP	C 9766	247.8
	R7210/BX	$15,000		•	Unibus	SC72/BX	RM02/03	C 9710	67.4
	R7266/BX	$21,400		•	Unibus	SC72/BX	RM05	C 9766	256.2
	R7510/BC	$14,500		•	CMI	SC7002/RC	RM03	C 9710	67.4
	R7566/BC	$20,900		•	CMI	SC7002/BC	RM05	C 9766	256.2
	R7810/BC	$14,500		•	SBI	SC7002/BS	RM03	C 9710	67.4
	R7810/BS	$18,550		•	SBI	V78/DI/BS	RM03	C 9710	67.4
	R7866/BC	$20,900		•	SBI	SC7002/BS	RM05	C 9766	256.2
	R7866/BS	$24,950		•	SBI	V783/DI/BS	RM05	C 9766	256.2
	W0315-340/BX	$13,100	•		Q-bus	SC03/BX	RM05	C 9715-340	256.2
	W0315-340/XX	$13,300	•		Q-bus	SC03/MS	MSCP	C 9715-340	270.4

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

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- MSCP command queuing – up to 32 commands
- Selectable seek optimization
- Dynamic bad block replacement and ECC
- Block mode or normal DMA
- Multi-device on-board boot
- Front panel Write Protect functions

...plus additional features for ESDI and SMD controllers...

- Drives can have different data transfer rates up to 3 MB/sec
- On-board 1 MB cache
- Shortened access time (down to 2.5ms)
- Up to six controllers per system
- Disk drive logical partitioning
- Drive shadowing
- Manufacturer's media defect map
- Look-ahead algorithm and statistics recording
- ESDI version supports up to four drives per controller

OEM discounts available

Sigma Information Systems

3401 E. La Palma Ave., Anaheim, CA 92806
(714) 630-6553 TLX 298607 SGMA

CA	(714) 633-0652	MO	(314) 532-3035	GREECE	(01) 9520 589
	(714) 771-7320	NM	(505) 294-5423	ISRAEL	052-552494
	(714) 633-1545	TX	(713) 890-8011	ITALY	(02) 445-9351
	(408) 241-3770		(214) 790-2777		(02) 445-0131
CO	(303) 528-8893	WA	(206) 451-7966	N. ZEALAND	(09) 59 02 49
FL	(305) 682-4084	AUSTRALIA	(02) 728-2622	NORWAY	(02) 68 52 30
IL	(312) 490-0700	BENELUX	(02) 720-9038	SPAIN	(03) 204 2099
MA	(617) 938-1310	DENMARK	(08) 57 46 10	SWEDEN	(08) 235 540
MD	(301) 921-8898	FINLAND	(00) 523 722	SWITZ.	(056) 87 11 51
MI	(313) 227-3010	FRANCE	(01) 4786 2504	U.K.	(0372) 37 88 11
MN	(612) 435-6550	GREECE	(01) 9514 944	W. GERMANY	(02202) 520 42

ENTER 227 ON READER CARD

FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fi	Type: Re	Host Bus	Controller** Model	Controller** DEC Emulation	Drive**	Capacity (Mbytes, formatted)
EMULEX CORP. (cont.)	W0315-500/BX	$14,750	•		Q-bus	SC03/BX	RM05 ex.	C 9715-500	436.8
	W0315-500/XX	$14,950	•		Q-bus	SC03/MS	MSCP	C 9715-500	427.3
	W0351/BX	$14,600	•		Q-bus	SC03/BX	RP06/ex., RM02 ex./80 ex.	F M2351	348.8–413.9
	W0351/XX	$14,800	•		Q-bus	SC03/MS	MSCP	F M2351	370.1
	W0371/BX	$17,985	•		Q-bus	SC03/BX	RM05/ex.	C 9771	512.4–704.6
	W0371/XX	$18,185	•		Q-bus	SC03/MS	MSCP	C 9771	678.1
	W0398/BX	$14,100	•		Q-bus	SC03/BX	RM05/ex.	F M2298	268.4–512.2
	W0398/XX	$14,300	•		Q-bus	SC03/MS	MSCP	F M2298	525.5–527.5
	W3115-340/J	$13,900	•		Unibus	SC31/BX	RM05/ex.	C 9715-340	256.2–279.6
	W3115-340/V	$14,050	•		Unibus	SC31/BX	RM05/ex.	C 9715-340	256.2–279.6
	W3115-500/J	$15,600	•		Unibus	SC31/BX	RP06, RM02 ex./ 05 ex.	C 9715-500	348.8–436.8
	W3115-500/V	$15,750	•		Unibus	SC31/BX	RP06, RM02 ex./ 05 ex.	C 9715-500	348.8–436.8
	W3151/J	$14,550	•		Unibus	SC31/BX	RP06, RM02 ex./ 80 ex.	F M2351	348.8–413.9
	W3151/V	$14,700	•		Unibus	SC31/BX	RP06, RM02 ex./ 80 ex.	F M2351	348.8–413.9
	W3171/J	$17,850	•		Unibus	SC31/BX	RM05/ex.	C 9771	512.4–704.6
	W3171/V	$18,000	•		Unibus	SC31/BX	RM05/ex.	C 9771	512.4–704.6
	W3198/J	$14,850	•		Unibus	SC31/BX	RM05/ex.	F M2298	512.4–570.4
	W3198/V	$15,000	•		Unibus	SC31/BX	RM05/ex.	F M2298	512.4–570.4
	W3215-340/XX	$13,500	•		Q-bus	QD32	MSCP	C 7915-340	286.3
	W3215-500/XX	$15,150	•		Q-bus	QD32	MSCP	C 9715-500	442.8
	W3233/XX	$12,000	•		Q-bus	QD32	MSCP	F M2333	280.7
	W3251/XX	$15,000	•		Q-bus	QD32	MSCP	F M2351	403.0
	W3261/XX	$18,000	•		Q-bus	QD32	MSCP	F M2361	574.5
	W3271/XX	$18,385	•		Q-bus	QD32	MSCP	C 9771	718.2
	W3298/XX	$14,500	•		Q-bus	QD32	MSCP	F M2298	567.9
	W4115-340/J	$14,500	•		Unibus	SC41/MS	MSCP	C 9715-340	270.4
	W4115-340/V, W4115-500/V	$14,500, $16,200,	•		Unibus	SC41/MS	MSCP	C 9715-340 9715-500	270.4, 427.3
	W4115-500/J	$16,200	•		Unibus	SC41/MS	MSCP	C 9715-500	427.3
	W4133/J	$14,700	•		Unibus	SC41/MS	MSCP	F M2333	265.0
	W4133/V	$12,903	•		Unibus	SC41/MS	MSCP	F M2333	265.0
	W4151/J	$15,150	•		Unibus	SC41/MS	MSCP	F M2351	370.1 or 404.5
	W4151/V	$15,150	•		Unibus	SC41/MS	MSCP	F M2351	370.1 or 404.5
	W4161/J	$20,700	•		Unibus	SC41/MS	MSCP	F M2361	525.5 or 527.5
	W4161/V	$20,700	•		Unibus	SC41/MS	MSCP	F M2361	525.5 or 542.2
	W4171/J	$18,450	•		Unibus	SC41/MS	MSCP	C 9711	525.5–643.7
	W4171/V	$18,450	•		Unibus	SC41/MS	MSCP	C 9771	525.5–643.7
	W4198/J	$15,450	•		Unibus	SC41/MS	MSCP	F M2298	525.5 or 527.5
	W4198/V	$15,450	•		Unibus	SC41/MS	MSCP	F M2298	525.5 or 527.7
	W7215-340/BX	$17,550	•		Unibus	SC72/BX	RM05/ex.	C 9715-340	256.2–279.6
	W7215-500/BX	$19,250	•		Unibus	SC72/BX	RP06, RM02 ex./ 05 ex.	C 9715-500	348.8–436.8
	W7251/BX	$18,200	•		Unibus	SC72/BX	RP06, RM02 ex./ 80 ex.	F M2351	348.4–413.9
	W7271/BX	$21,500	•		Unibus	SC72/BX	RM05/ex.	C 9771	512.4–704.6
	W7298/BX	$18,500	•		Unibus	SC72/BX	RM05/ex.	F M2298	512.4–570.4
	W7515-340/BC	$17,050	•		CMI	SC7002/BC	RM05/ex.	C 9715-340	256.2–279.6
	W7515-500/BC	$18,750	•		CMI	SC7002/BC	RM02 ex./05 ex.	C 9715-500	436.8
	W7533/BC	$17,750	•		CMI	SC7002/BC	RM05/ex./02 ex.	F M2333	256.2–269.7
	W7551/BC	$17,700	•		CMI	SC7002/BC	RM02 ex./05 ex./ 80 ex.	F M2351	405.2–413.9

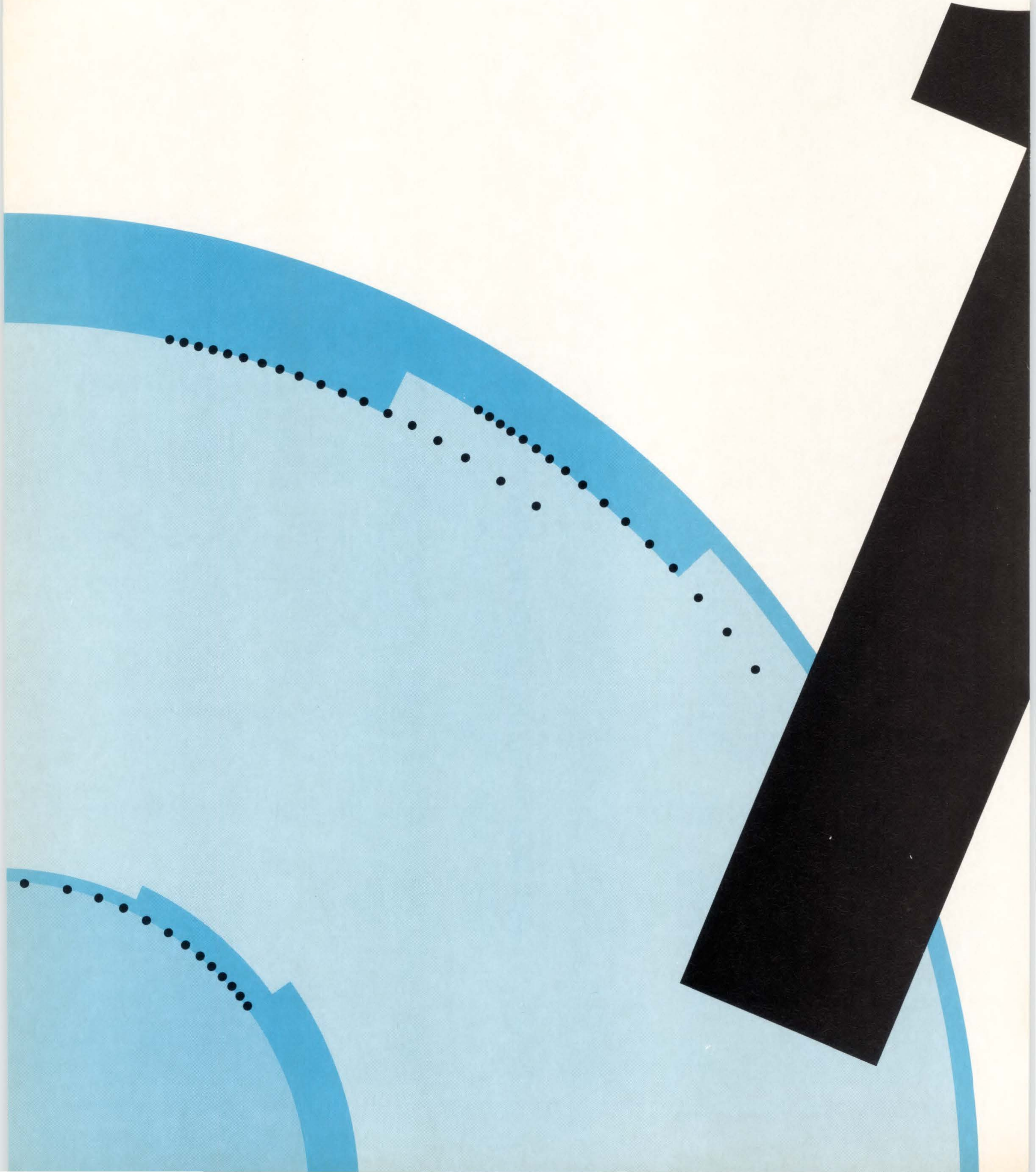
*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fi	Type: Re	Host Bus	Controller** Model	Controller** DEC Emulation	Drive**	Capacity (Mbytes, formatted)
EMULEX CORP. (cont.)	W7561/BC	$23,750	•		CMI	SC7002/BC	RM05/ex./02 ex.	F M2361	512.4–551.8
	W7572/BC	$25,750	•		CMI	SC7003/BC	RM05/ex./02 ex./ 80 ex.	C 9772	512.4–697.3
	W7598/BC	$18,000	•		CMI	SC7002/BC	RM05/ex.	F M2298	512.4–570.4
	W7815-340/BC	$17,050	•		SBI	SC7002/BS	RM05/ex.	C 9715-340	256.2–279.6
	W7815-340/BS	$21,100	•		SBI	V783/D1/BS	RM05/ex.	C 9715-340	256.2–279.5
	W7815-500/BC	$18,750	•		SBI	SC7002/BS	RM02 ex./05 ex./ 80 ex.	C 9715-500	428.1–436.8
	W7815-500/BS	$22,800	•		SBI	V783/DI/BS	RM02 ex./05 ex./ 80 ex.	C 9715-500	428.1–436.8
	W7833/BC	$17,750	•		SBI	SC7002/BS	RM02 ex./05 ex./ 80 ex.	F M2333	256.2–269.7
	W7833/BS	$21,800	•		SBI	V783/DI/BS	RM05/ex./02 ex.	F M2333	256.2–269.7
	W7851/BC	$17,700	•		SBI	SC7002/BC	RM02 ex./05 ex./ 80 ex.	F M2351	405.2–413.9
	W7851/BS	$21,750	•		SBI	V783/DI/BS	RM02 ex./05 ex./ 80 ex.	F M2351	405.2–413.9
	W7861/BC	$23,750	•		SBI	SC7002/BS	RM05/ex./02 ex.	F M2361	512.4–551.8
	W7861/BS	$27,800	•		SBI	V783/DI/BS	RM05/ex./02 ex.	F M2361	512.4–551.8
	W7872/BC	$25,750	•		SBI	SC7003/BC	RM05/ex./02 ex./ 80 ex.	C 9772	512.4–697.3
	W7872/BS	$29,800	•		SBI	V783/DI/BS	RM05/ex./02 ex./ 80 ex.	C 9722	512.4–697.3
	W7898/BC	$18,000	•		SBI	SC7002/BS	RM05/ex.	F M2298	512.4–570.4
	W7898/BS	$22,050	•		SBI	V783/DI/BS	RM05/ex.	F M2298	512.2–570.4
GENERAL ROBOTICS CORP. 23 S. Main St. Hartford, WI 53027 414-673-6800 **Enter No. 913**	MWD67	$2,850	•		Q-bus	MWV22	RL02, RM02	C 9415, F 2243	67.5
	WDD270	$6,665	•		Q-bus	SMV22	RM02, RM05	NT 8310	270
GROUP III ELECTRONICS 2613 Manhattan Beach Blvd. Redondo Beach, CA 90278 213-643-6997 **Enter No. 914**	Guardian 3175	$4,955	•		Q-bus	D DQ686	MSCP	M 4175	155
	Guardian 3380	$7,730	•		Q-bus	D DQ686	MSCP	M 4380	319
	Guardian 3422	$7,263	•		Q-bus	D DQ226	MSCP	F M2322	130
	Guardian 3450	POR	•		Q-bus	D DQ226	MSCP	F M2351	358
	Guardian 3460	$16,495	•		Q-bus	D DQ262	MSCP	F M2361	588
	Guardian 3483	$9,055	•		Q-bus	D DQ226	MSCP	F M2333	260
	As configured	POR	•		Q-bus	D MV210	MSCP	F M2351	404
	As configured	POR	•		Q-bus	D MV210	MSCP	F M2322	143
	As configured	POR	•		Q-bus	D MV230	MSCP	F M2361	590
	As configured	POR	•		Q-bus	D MV230	MSCP	F M2333	290
	As configured	POR	•		Unibus	D DU215	MSCP	F M2351	358
J.P. HERNE & ASSOCIATES 2426 Townsgate Rd. Westlake Village, CA 91361 805-497-4442 **Enter No. 915**	JPH380	$7,980	•		Q-bus	W WQESD	MSCP	M EXT-4380	320
MCS COMPUTER PRODUCTS INC. 2599 White Bear Ave. St. Paul, MN 55109 612-770-5232 **Enter No. 916**	SMS 1000 Model 60*	$4,220–$16,010	•		Q-bus	SM 0107	MSCP	INP	INP
MDB SYSTEMS INC. 1995 N. Batavia St. Box 5508 Orange, CA 92613-5508 714-998-6900 **Enter No. 917**	MLSI-D-SMD-512	$23,591	•		Q-bus	MLSI-DK11-RM	RM05	F M233K (2)	512/drive
	MLSI-S-SMD-134	$9,640	•		Q-bus	MLSI-DK11-RM	RM03	F 2322	134
	MLSR-S-SMD256	$12,850	•		Q-bus	MLSI-DK11-RM	RM05	F M2333K	256
	MV-D-SMD-540	$23,795	•		Q-bus	MLSI-DK11-RM	RM05 (custom driver from vendor)	F 2333K (2)	540/drive
	MV-S-SMD-134	$9,747	•		Q-bus	MLSI-DK11-RM	RM03 (custom driver from vendor)	F 2322	134
	MV-S-SMD-270	$12,957	•		Q-bus	MLSI-DK11-RM	RM05 (custom driver from vendor)	M 2333K	270
	RCS-P-1	$19,070		•	Q-bus	DEC RQDX3	MSCP	DEC RD53	51
	RCS-P-2	$21,320		•	Q-bus	MSCI-ESDI-RM	RM03	F 2246E	134.84

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

SYSTEM INDUSTRIES



FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fi	Type: Re	Host Bus	Controller** Model	Controller** DEC Emulation	Drive**	Capacity (Mbytes, formatted)
MDB SYSTEMS INC. (cont.)	RCS-P-6	$25,160		•	Q-bus	MLSI-ESDI-RM	RM05	F 2246E (2)	134.84/drive
	RCS-P-7	$29,210		•	Q-bus	MLSI-ESDI-RM	RM05	SE 1300 (2)	256/drive
	RMS-A-1	$12,450		•	Q-bus	RQDX3	MSCP	DEC RD53	51
	RMS-A-2	$18,040		•	Q-bus	RQDX3	MSCP	DEC RD53 (2)	51/drive
	RMS-B-1	$9,670		•	Q-bus	MLSI-ESDI	RM03	F 2246E	171.7
	RMS-C-1	$14,525		•	Q-bus	MLSI-ESDI-RM	RM05	SE 1300	256
	RMS-C-2	$23,100		•	Q-bus	MLSI-ESDI-RM	RM05	SE 1300 (2)	256/drive
MICRO TECHNOLOGY INC. (MTI) 1620 Miraloma Ave. Placentia, CA 92670 714-632-7580 **Enter No. 918**	MD4910	$4,800		•	Q-bus	MLV11M	RL02	RI 5130 (2)	10/drive
NISSHO ELECTRONICS (USA) CORP. Inwood Park #200 17310 Red Hill Ave. Irvine, CA 92714 714-261-8811 **Enter No. 919**	N1700	$4,500	•	•	Q-bus	1700Q	RL02	Custom (both)	31.2 (f), 10.4 (r)
PLESSEY PERIPHERAL SYSTEMS 17466 Daimler Ave. Irvine, CA 92714 714-261-9945 **Enter No. 920**	1X1Q*	$2,085+	•		Q-bus	N/A	N/A	R 202E (add on)	21
	1X2Q*	$2,589+	•		Q-bus	N/A	N/A	R 204E (add on)	42
	1X3Q*	$4,318+	•		Q-bus	N/A	N/A	M XT1085 (add on)	67.1
	1X4Q*	$7,042+	•		Q-bus	N/A	N/A	M XT1140 (add on)	112.8
	1X6Q or U*	$6,599+	•		Q-bus, Unibus	N/A	N/A	F M2312 (add on)	84
	1X7Q or U*	$7,317+	•		Q-bus, Unibus	N/A	N/A	F M2322 (add on)	INP
	2351Q or U	$13,141+	•		Q-bus, Unibus	E SC03/BX, SC31/BX	RP06	F M2351A	352
	2X1Q*	$3,070+	•		Q-bus	PM-FCV21	RL02	R 202E	21
	2X2Q*	$3,620+	•		Q-bus	PM-FCV21	RL02	R 204E	42
	3X2Q*	$3,620+	•		Q-bus	PM-DCV51	MSCP	R 204E	42
	3X3Q*	$4,979+	•		Q-bus	PM-DCV51	MSCP	M XT1085	67.1
	3X4Q*	$7,796+	•		Q-bus	PM-DCV51	MSCP	M XT1140	112.8
	4X6Q or U*	$7,838+	•		Unibus, Q-bus	PM-DCO2B, PM-DCV03	RM02, RM03	F M2312	INP
	4X7Q or U*	$8,556+	•		Unibus, Q-bus	PM-DCO2B, PM-DCV03	RM02, RM03	F M2322	INP
	5X6Q or U*	$9148+	•		Q-bus, Unibus	E QD32, SC41/MS	MSCP	F M2312	INP
	5X7Q or U*	$9,866+	•		Q-bus, Unibus	E QD32, SC41/MS	MSCP	F M2322	INP
	9710Q or U	$9,151+		•	Q-bus, Unibus	PM-DCV03, PM-DC02B	RM03, RM02	C 9710-80	67
	9762Q or U	$10,232+		•	Q-bus, Unibus	PM-DCV03, PM-DC02B	RM03, RM02	C 9762	67
	9766Q or U	$17,000+		•	Q-bus, Unibus	PM-DCV03, PM-DC02B	RM03, RM02	C 9766	256
	9771Q or U	$14,507+	•		Q-bus, Unibus	E SC03/BX, SC31/BX	RP06	C 9771	512
QUALOGY INC. 2241 Lundy Ave. San Jose, CA 95131 408-434-5200 **Enter No. 921**	D934GL	$5,495	•		Q-bus	Cyclone	MSCP	M XT1140	120
	D938GL	$5,795	•		Q-bus	Cyclone	MSCP	M XT2190	160
	D964GL	$8,495	•		Q-bus	Cyclone	MSCP	M XT1140	240
	D968GL	$8,695	•		Q-bus	Cyclone	MSCP	M XT2190	320
	D998GL	$14,595	•		Q-bus	Cyclone	MSCP	M XT2190	640
	D1120-023	$3,995+	•		Q-bus	Cyclone	MSCP	M XT1140	120–240
	D1120-123	$3,995+	•		Q-bus	Cyclone	MSCP	M XT1140	120–480
	D1160-023	$4,695+	•		Q-bus	Cyclone	MSCP	M XT2190	160–320
	D1160-123	$4,695+	•		Q-bus	Cyclone	MSCP	M XT2190	160–640
	D885-8-L*	$6,575	•		Q-bus	8836	RL01/02	Q Q2010	7.8
	D885-30-L*	$8,575	•		Q-bus	8836	RL02	Q Q2040	31.2
	D885-8-P*	$6,575	•		Unibus	8830	RL01/02	Q Q2010	7.8

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

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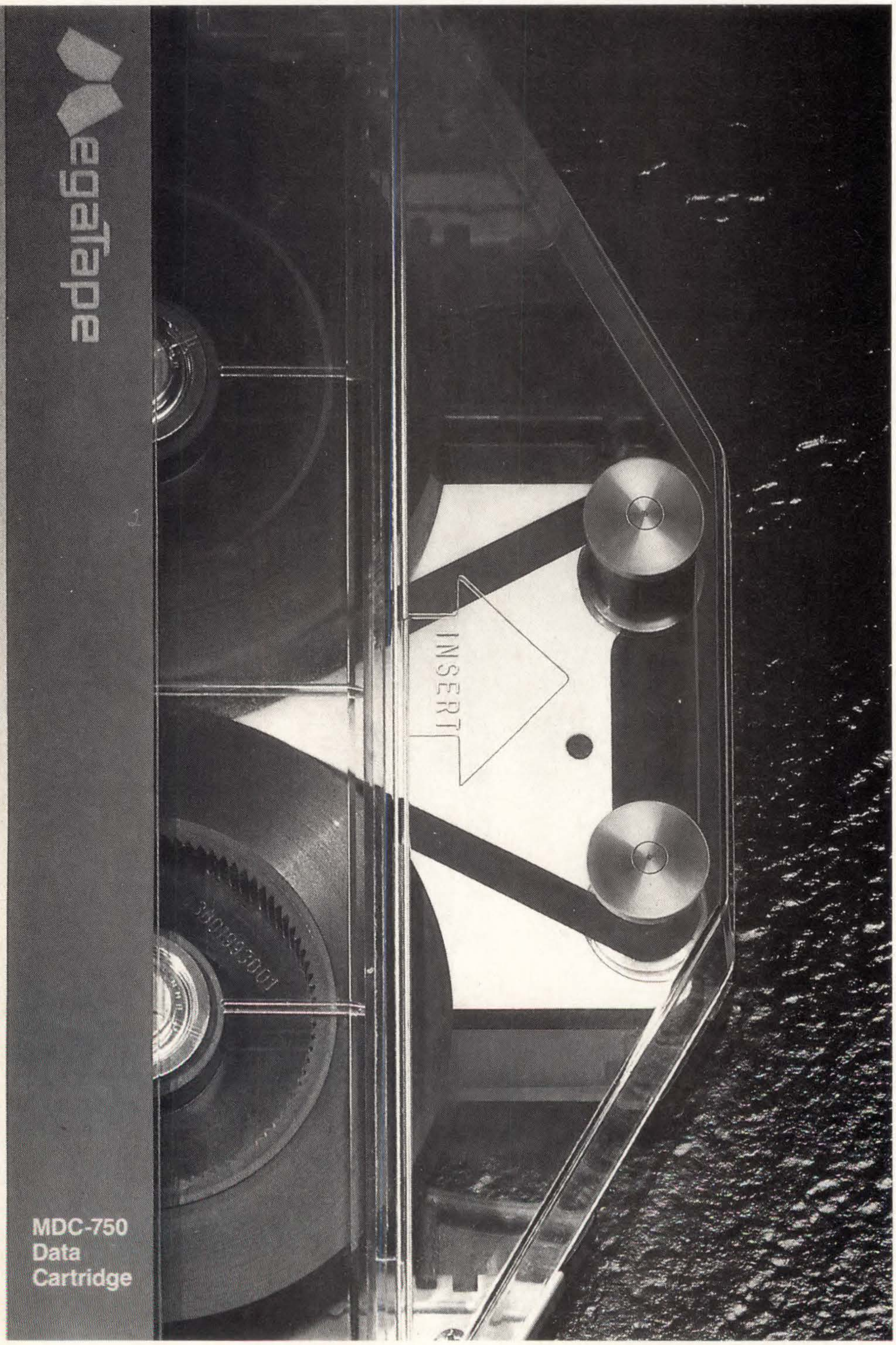
ENTER 228 ON READER CARD

FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Type: Fi	Type: Re	Host Bus	Controller**: Model	Controller**: DEC Emulation	Drive**	Capacity (Mbytes, formatted)
QUALOGY INC. (cont.)	D885-30-P*	$8,575	•		Unibus	8830	RL02	Q Q2040	31.2
	D2310-023	$7,195+	•		Q-bus	QE-2	MSCP	M EXT4380	310–620
	D2310-123	$7,195+	•		Q-bus	QE-2	MSCP	M EXT4380	310–1240
	D2140-023	$3,295+	•		Q-bus	QE-2	MSCP	F M2246E	140–280
	D2140-123	$3,495+	•		Q-bus	QE-2	MSCP	F M2246E	140–560
	QE2100	$5,995	•		Q-bus	QE-2	MSCP	F M2246E	140
	QE2200	$9,290	•		Q-bus	QE-2	MSCP	F M2246E	280
	QE2400	$15,880	•		Q-bus	QE-2	MSCP	F M2246E	560
	QE2150	$8,995	•		Q-bus	QE-2	MSCP	M EXT4380	310
	QE2250	$16,095	•		Q-bus	QE-2	MSCP	M EXT4380	620
	QE2450	$30,295	•		Q-bus	QE-2	MSCP	M EXT 4380	1240
	D924GT *	$5,095	•		Q-bus	Cyclone	MSCP	Q Q540	36
	D930GT *	$6,395	•		Q-bus	Cyclone	MSCP	M XT1105	88
	D934GT *	$6,895	•		Q-bus	Cyclone	MSCP	M XT1140	120
	D938GT *	$7,195	•		Q-bus	Cyclone	MSCP	M XT2190	160
	D964GT *	$9,795	•		Q-bus	Cyclone	MSCP	M XT1140	240
	D968GT *	$10,095	•		Q-bus	Cyclone	MSCP	M XT2190	320
SCIENTIFIC MICRO SYSTEMS (SMS) 777 E. Middlefield Rd. Mountain View, CA 94043 415-964-5700 **Enter No. 922**	SMS 1000 Model 60*	$4,000–$10,000	•		Q-bus	0107	MSCP	ST506 interface drives	10–240
	SMS 1000 Model 68*	$4,000–$20,000	•		Q-bus	0108 Triple Function	MSCP	ESDI or ST506 interfaces	25–700
STORAGE CONCEPTS INC. 3198-G Airport Loop Dr. Costa Mesa, CA 92626 714-557-1862 **Enter No. 923**	Concept 21 Real Time Disk System	$42,000	•		Q-bus, Unibus	QB21, UB21	Driver supplied for VMS	F M2350 PTD (1–4)	474/drive
	Concept 31 Real Time Disk System	$48,000	•		Q-bus, Unibus	QB31, UB31	Driver supplied for VMS	F M2360A PTD (1–4)	689/drive
SYSTEM INDUSTRIES 560 Cottonwood Dr. Milpitas, CA 95035 408-942-1212 **Enter No. 924**	9733 Fixed	POR	•		Unibus, Q-bus, CMI, SBI	9900, SDA50, QDA50	RM, MSCP	F M2X33	244–256
	9733 Removable	POR	•		Unibus, Q-bus, SBI, CMI	9900, SDA50, QDA50	RM, MSCP	F M2333	244–256
	9751		•		Unibus, Q-bus, SBI, CMI	9900, SDA50, QDA50	RM, MSCP	F M2351	340–414
	9751/C	POR	•		Unibus, Q-bus, BI, CI	DEC HSC50, HSC70, UDA50, KDA50, KDB50	RA8X	F M2351	360
	9761	POR	•		Unibus, Q-bus, SBI, CMI	9900, SDA50, QDA50	RM, MSCP	F M2361	502–551
	9761C	POR	•		Unibus, Q-bus, BI, CI	DEC HSC50, UDA50, KDA50, KDB50, HSC70	RA8X	F M2361	522
	9798	POR	•		Unibus, Q-bus, SBI, CMI	9900, SDA50, QDA50	RM, MSCP	F M2398	497–536
TRIMARCHI & ASSOCIATES P.O. Box 560 State College, PA 16804 814-234-5659 **Enter No. 925**	RD53AE	$3,350	•		Q-bus	DEC RQDX3	MSCP	RD53E (custom)(1–4)	72/drive
	RD54AE	$5,350+	•		Q-bus	DEC RQDX3	MSCP	RD54E (custom)(1–4)	159/drive
	As configured	$3,150+	•		Q-bus	W SRQD11-B	MSCP	MI 1325 (1–2)	72/drive
	As configured	$4,300+	•		Q-bus	W, D	MSCP	MI 1370 (1–2)	155/drive
UNITRONIX CORP. 50 County Line Rd. Somerville, NJ 08876 201-231-9400 **Enter No. 926**	System 4000*	$6,800+	•		Q-bus	E DQ32, DQ132	RA80/81	F Eagle I, II	360–580
U.S. DESIGN CORP. 5100 Philadelphia Way Lanham, MD 20706 301-577-2880 **Enter No. 927**	HCS 175 Series	$6,500–$15,250	•		Q-bus, Unibus	1108, 1158	MSCP	M 4175 (1–4)	140/drive
	HCS 380 Series	$10,500–$31,000	•		Q-bus, Unibus	1108, 1158	MSCP	M 4380 (1–4)	300/drive
	VIP Series*	$8,500–$34,500	•		Q-bus, Unibus	1108, 1158	MSCP	M 4175, 4380 (1–4)	140–300/drive
WINCHESTER SYSTEMS INC. 400 W. Cummings Pk. Woburn, MA 01801 617-933-8500 **Enter No. 928**	1xRL02-1R	$5,400		•	Q-bus	Custom	RL02	Custom	10.4
	2xRL02-1R	$5,800		•	Q-bus	Custom	RL02	INP	21
	2xRL02-2R	$7,700		•	Q-bus	Custom	RL02	INP	21

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

Any disk backup system can save your data. This one can save your life.



Most people would agree that life is too short to spend sitting in front of a tape drive, swapping reels or cartridges while disk backup grinds on and on.

It's boring, error-prone, and expensive.

It's also unneccessary.

Just get an inexpensive MegaTape drive. Plug it in right where your 9-track was (your system won't know the difference). Pop in a cartridge. Push the button.

Then turn out the lights and go home.

When you come back in the morning, all your data—up to an amazing *630 megabytes*—will be safe and sound on a single book-size cartridge. That's an entire RA-81 or Fujitsu Eagle, with room to spare. *Room enough even for the next generation of ultra-high capacity drives.*

No other tape backup system—existing, rumored or announced—offers anything close to this kind of convenience. And we've been delivering it for over two years.

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MegaTape

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AND TWO IS TOO MANY.

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FIXED AND REMOVABLE HARD DISK SUBSYSTEMS ***

Company	Product	Price (Quantity One)	Fi	Re	Host Bus	Controller**		Drive**	Capacity (Mbytes, formatted)
			Type			Model	DEC Emulation		
WINCHESTER SYSTEMS INC. (cont.)	3xRL02-1R	$6,600	•	•	Q-bus	Custom	RL02	INP	21 (f), 10.4 (r)
	4xRL02-1R	$6,950	•	•	Q-bus	Custom	RL02	INP	31 (f), 10.4 (r)
	4xRL02-2R	$8,600	•	•	Q-bus	Custom	RL02	INP	42
	DataSafe 11R + 11R	$7,700		•	Q-bus	Custom	MSCP	Custom	22
	DataSafe 11 + 11R	$8,850	•	•	Q-bus	Custom	MSCP	Custom	44
	DS 11R	$5,600		•	Q-bus	Custom	MSCP	Custom	11
	DS 70 + 11R	$8,700	•	•	Q-bus	Custom	MSCP	MI, custom	70 (f), 11 (r)
	DS 90 +11R	$7,100	•	•	Q-bus	Custom	MSCP	MI, custom	90 (f), 11 (r)
	DS 110 +11R	$11,150	•	•	Q-bus	Custom	MSCP	MI, custom	110 (f), 11 (r)
ZOLTECH CORP. 7023 Valjean Ave. Van Nuys, CA 91406 818-780-1800 **Enter No. 929**	VCQ-16/53 *	$2,950	•		Q-bus	DCW-RL02	RL02	WDD-5F-53 (4)	41 10.25/drive
	VCQ-16/85 *	$4,540	•		Q-bus	DCW-MSCP	MSCP	WDD-5F-85	71
	VCQ-16/190 *	$8,395	•		Q-bus	DCW-MSCP-B	MSCP	WDD-5F-190	160
	VCQ-16/380 *	$10,395	•		Q-bus	DCW-MSCP-ESDI-4	MSCP	WDD-5F-380-ESDI	310
	VHQ-16/1.6G	$34,529	•		Q-bus	DCW-MSCP-ESDI-4	MSCP	WDD-5F-380-ESDI (4)	310/drive
	VHQ-16/600TF*	$22,795	•		Q-bus	DCW-MSCP-ESDI-4	MSCP	WDD-5F-380-ESDI (2)	310/drive

*Product additionally includes a tape and/or floppy device. **See key to codes on page 63. Controllers and drives without codes are manufactured by subsystem vendor. ***Product listings for many companies aren't comprehensive — contact vendors for complete information on subsystem integration possibilities. POR — price on request; INP — information not provided; N/A — not applicable.

Key To Disk Controller And Drive OEMs

A — Andromeda Sys. Inc.
9000 Eton Ave.
Canoga Park, CA 91304
818-709-7600
Enter No. 930

C — Control Data Corp. (CDC)
8100 34th Ave. S.
Minneapolis, MN 55440
612-931-3131 Ext. 3422
Enter No. 931

D — Distributed Logic Corp. (DILOG)
1555 S. Sinclair
P.O. Box 6270
Anaheim, CA 92806
714-937-5700
Enter No. 932

DEC — Digital Equip. Corp.
146 Main St.
Maynard, MA 01754-2571
617-897-5111
Enter No. 933

E — Emulex Corp.
3545 Harbor Blvd.
Costa Mesa, CA 92626
714-662-5600
Enter No. 912

F — Fujitsu America Inc.
Storage & Peripheral Div.
3055 Orchard Dr.
San Jose, CA 95134-2017
408-946-8777
Enter No. 934

I — Ibis Systems Inc.
5775 N. Lindero Cnyn. Rd.
P.O. Box 5082
Westlake Village, CA 91362
Enter No. 935

M — Maxtor Corp.
150 River Oaks Pkwy.
San Jose, CA 95134
408-942-1700
Enter No. 936

MI — Micropolis Corp.
21123 Nordhoff St.
Chatsworth, CA 91311
818-709-3300
Enter No. 937

MT — Micro Tech. Inc.(MTI)
1620 Miraloma Ave.
Placentia, CA 92670
714-632-7580
Enter No. 918

NEC — NEC Info. Sys. Inc.
1414 Massachusetts Ave.
Boxborough, MA 01719
617-264-8000
Enter No. 938

NT — Northern Telecom Inc.
2100 Lakeside Dr.
Richardson, TX 75081
214-437-8000
Enter No. 939

P — Priam Corp.
20 W. Montague Expwy.
San Jose, CA 95134
408-946-4600
Enter No. 940

Q — Quantum Corp.
1804 McCarthy Blvd.
Milpitas, CA 95035
408-262-1100
Enter No. 941

R — Rodime Inc.
901 Broken Sound. Pkwy. N.W.
Boca Raton, FL 33431
305-994-6200
Enter No. 942

RI — Ricoh Systems Inc.
2071 Concourse Dr.
San Jose, CA 95131
408-946-6200
Enter No. 943

S — Seagate Technology
920 Disc Dr.
Scotts Valley, CA 95066
408-438-6550
Enter No. 944

SC — Storage Concepts Inc.
3198-G Airport Loop Dr.
Costa Mesa, CA 92626
714-557-1862
Enter No. 923

SE — Siemens Info. Sys.
5655 Lindero Canyon Rd.
Ste. 325 Westlake Village,
CA 91362
818-706-8872
Enter No. 945

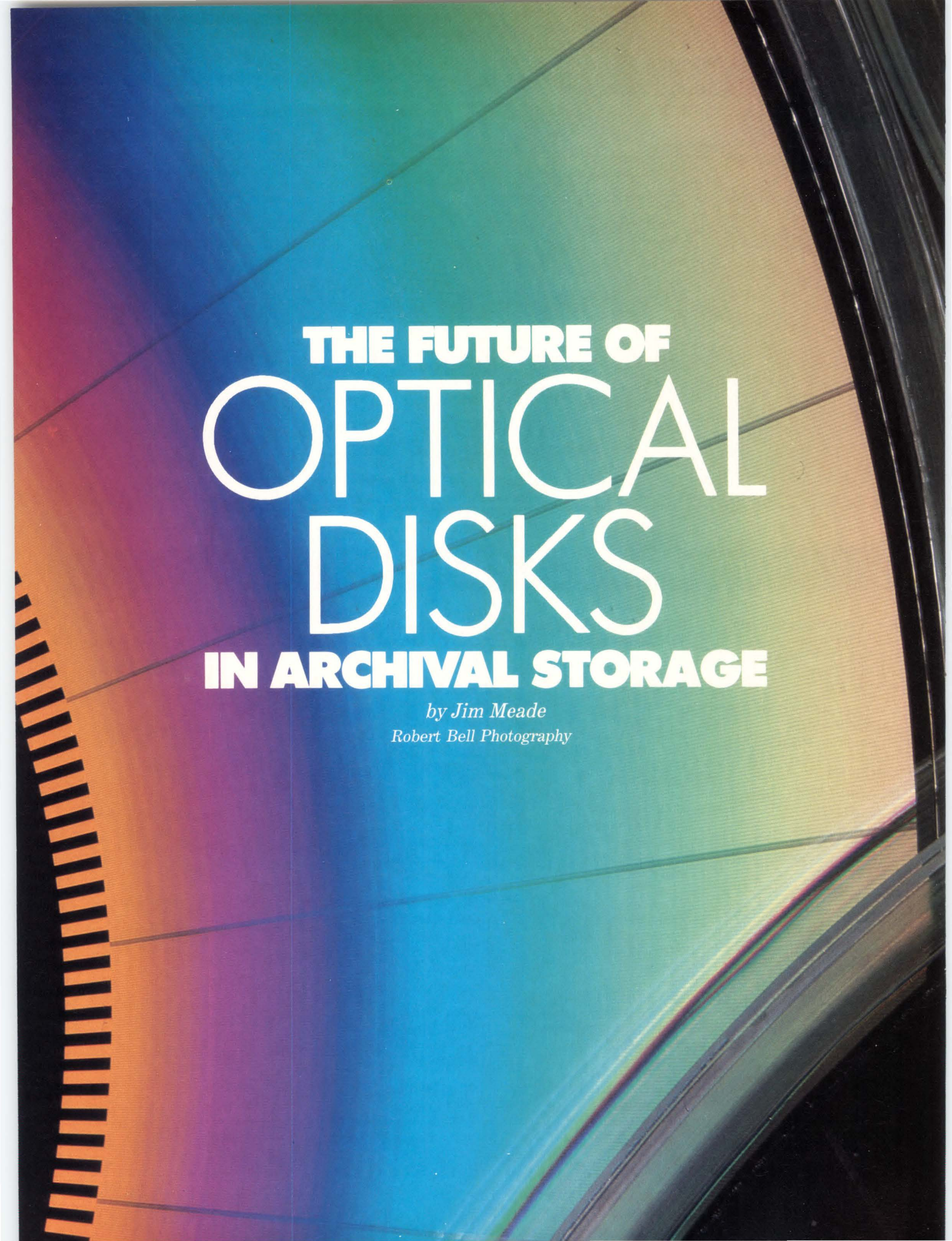
SI — System Industries
560 Cottonwood Dr.
Milpitas, CA 95035
408-942-1212
Enter No. 924

SL — Spectra Logic Corp.
297 N. Bernardo Ave.
Mountain View, CA 94043
415-964-2211
Enter No. 946

SM — Scientific Micro Systems (SMS)
777 E. Middlefield Rd.
Mountain View, CA 94043
415-964-5700
Enter No. 922

T — Toshiba America Inc.
Information Systems Div.
2441 Michelle Dr.
Tustin, CA 92680
714-730-5000
Enter No. 947

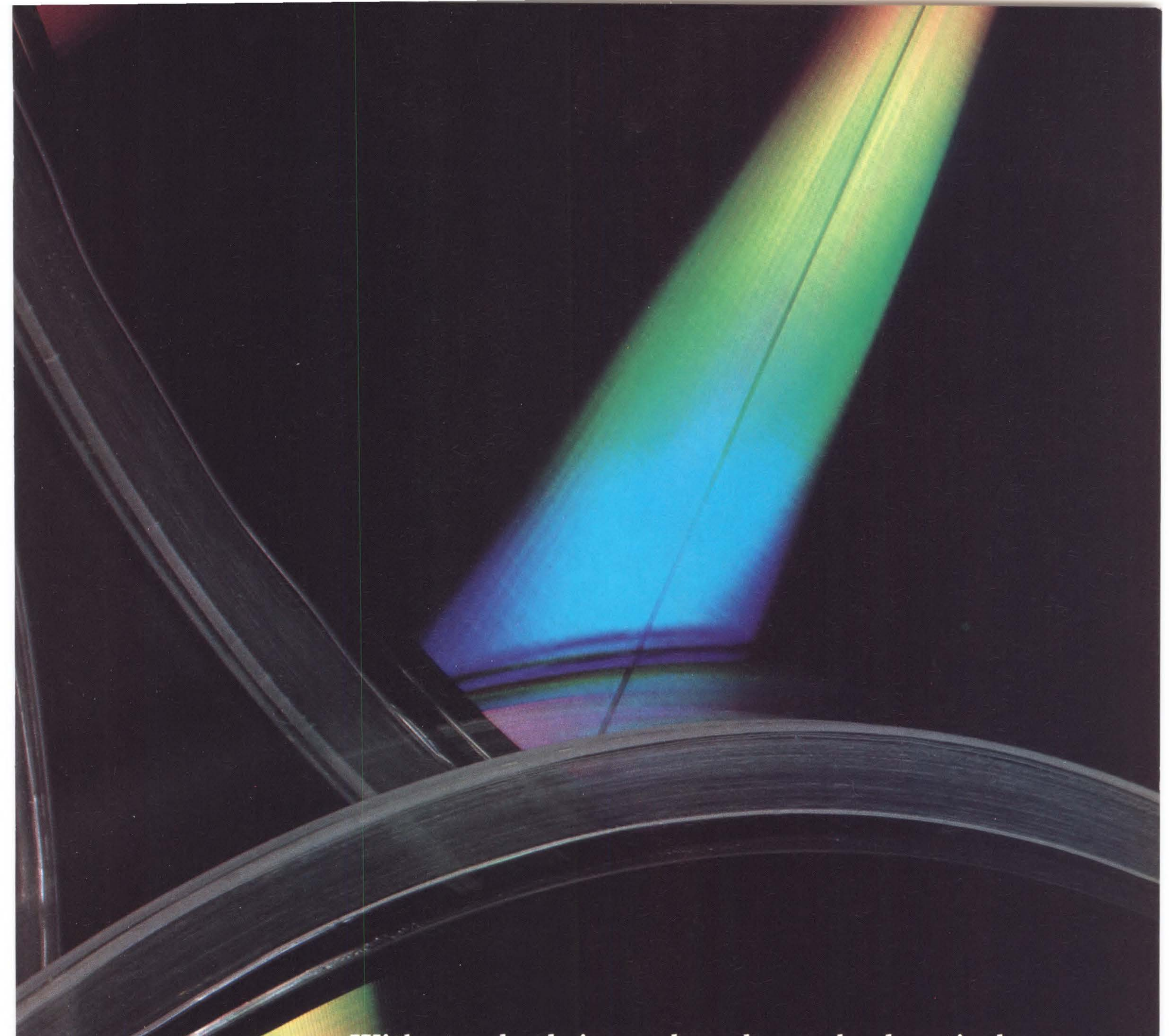
W — Webster Comp. Corp.
1037 N. Fair Oaks Ave.
Sunnyvale, CA 94089
408-749-0660
Enter No. 948



THE FUTURE OF OPTICAL DISKS IN ARCHIVAL STORAGE

by Jim Meade

Robert Bell Photography



With standards issues largely resolved, optical storage is now expected to fulfill its potential

Optical disk technology today is in some respects like videocassette recorder technology of the 1970s. Almost everyone believes the technology has a bright future. But it has problems, too. The biggest problem has to do with standards—the standardization of the storage method for optical platters.

Optical disk is an "emerging" technology. The field belongs, for the most part, to daring innovators and pioneers, while computers used in the field tend to be Digital Equipment Corp. and IBM. And the actual storage media may come from known giants as well—3M, Eastman Kodak, Hitachi. But the true optical disk technology, the interface between the optical disk and the CPU is not yet available from the giants.

Neither Digital nor IBM has announced a product in the write once read many (WORM) technology that makes up most archival storage. (Digital has announced a product in CD ROM—compact disk read only memory—used primarily for information distribution rather than storage. But it is not currently marketing the product aggressively.) WORM technology is coming from system integrators and third party manufacturers like TECEX (Placentia, Calif.), KOM (Ottawa, Can-

Most experts feel that optical production can surge ahead, even without a standard for the media.

ada), U.S. Design (Lanham, Md.), and Emulex Corp. (Costa Mesa, Calif.).

For an emerging technology, optical disk has emerged quite far in the past 2 yrs. Mike Befeler, who works for third party integrator Reference Technology (Boulder, Colo.), characterizes 1985 as the "Year of Education" in optical disk, 1986 as the "Year of Prototypes," and 1987 as the "Year of Production and Applications." While he is referring primarily to CD ROM, the characterization is almost equally true for write-once technology. Optical disk is moving from the drawing board to the computer room.

Freeman Assoc. (Santa Barbara, Calif.), projected in 1984 that by 1990 sales of optical disk drives would top $7.4 billion. In revised projections (see Table), Freeman now estimates sales of only $2 billion by 1991. Though lower than the forecasts of 1984, the new forecasts reflect a solid industry that has been learning from experience, reports Lee Elizer, vice president of Freeman Assoc.

People expected too much too soon from optical, says Elizer. "It took a while to get the systems integration issues resolved just in general," he explains, "because optical doesn't really look like a disk and it doesn't really look like a tape drive." And, of course, in-place storage systems are disks and tapes. Optical disk, though, is not magnetic at all. It uses a laser beam to scan and read the holes or bumps on plastic media, much as batch computers read punch cards.

Because optical disk isn't magnetic media, it offers a number of distinct advantages over the established form of storage—primarily the ability to store much more data within the same space. A laser beam can read and write much smaller—orders of magnitude smaller—than a read-write magnetic head. Emulex Corp. summarizes the storage capacity of a current 12-in. optical disk by saying, "Each removable 12-in. cartridge typically holds 1 Gbyte of data. That means you could store 240,000 pages of single-spaced text or 4800 uncompressed digital images on one cartridge. It would take approximately 26 magnetic tapes at 1600 bits per in. (bpi) or 3200 floppy disks to do the same job."

For all its advantages, though, people initially expected too much of the glamorous-sounding technology. Optical disk proved to be no simple replacement for magnetic disk. Both optical and magnetic devices were storage technologies, but the similarity ended there. And, as developers soon discovered (if they didn't know it already), the problems began there as well.

There are four main components in an optical disk system, just as in a magnetic storage system—a controller, a disk drive, and the storage media itself. There's also the operating system software that interfaces between the CPU and the controller and manages the files on the media.

When optical systems first began to appear in the marketplace 2 yrs. ago, there were no existing standards for any of the media itself or for interfaces in an optical storage system. "It has been pretty much a free-for-all," says one third party integrator.

Magnetic tape storage systems never had to go through such infighting. IBM set the standard early, and everyone went along with it. The big, open reels of tape were interchangeable from an IBM to a Burroughs to a Univac to a Digital system. The IBM standard became an ANSI standard.

Table 1—Projected Worldwide Revenue All Optical Disk Drives

($ Million at OEM If-Sold Level)	1984	1985	1986	1987	1988	1989	1990	1991
Read-Only	2.6	16.8	40.0	70.8	104.8	131.4	153.6	174.0
Write-Once	5.2	40.2	180.7	340.3	561.7	855.9	1144.6	1488.6
Erasable	—	—	—	0.7	17.5	79.1	192.0	347.5
TOTAL	7.9	57.0	220.7	411.7	684.0	1066.4	1490.2	2010.1
Growth From Previous Year		624%	288%	87%	66%	56%	40%	35%

Introducing the most reliable DEC™-compatible terminal ever built. The TeleVideo 9220.

"Why do we want thousands of TeleVideo® terminals? Because we can't afford thousands of problems."

Susan Kennedy should know. She's a product analyst at Leasametric, a company that rents, sells, and services DP equipment all over the country. Including thousands of terminals. And since reliability is crucial to Leasametric, they tear each evaluation unit apart piece by piece. Then, they give it a series of tests that make MIT exams look easy.

"Too many terminals just don't measure up," says Susan. "I've seen machines with questionable ergonomics...keyboards that flex in the middle when you type... even cheap little diodes that could drop off.

"But TeleVideo starts with solid engineering, and follows through with every detail. Overall, they've built the same quality into the 9220 that's made all their other terminals last so long."

And there's more to the 9220 than quality and reliability. There's also an extended feature set, including full VT-220 compatibility. A super-dark 14" amber screen. A tilt and swivel base. 30 programmable function keys. Plus the best thought-out ergonomics around. All for exactly $619.

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"Digital ... seems to enjoy a strong advantage in optical disk, because many of its computers are already in environments best suited to optical disk applications."

But IBM hasn't yet set a standard for optical disk media, and most players now believe there may never be a standard for the media itself. Some optical disks are single-sided, some dual-sided. The disks range in size from 5¼, 8, 12, and 14 in. Some are available as a single removable platter, and some come in "jukebox" arrangements, with up to 50 platters online and accessible under program control. There is also no standard yet for the file structures on the disk.

Standardization Problems

Although the media itself hasn't been standardized, almost all the other "systems integration issues" Elizer mentioned have been solved. "Those issues appear to be resolved right now, across the board," says Elizer.

As Befeler explains, there are four areas of standardization: 1) the physical media itself, 2) the interfaces, 3) the file manager, and 4) the applications software. While standards have not been set for all four, most feel that the "necessary" standards have been set.

The biggest problem to have been effectively resolved has been the need for a standard interface between the controller and the optical disk drive itself. Most products now support the Small Computer Systems Interface (SCSI). Disks from Toshiba, CDC, Optimem, OSI, Alcatel Thompson, and Hitachi—for example—all now work with the SCSI interface.

For the file manager, a standard known as the "High Sierra Standard" was set by a committee whose members included Digital and IBM. Most expect it to become an ANSI standard. Applications software, says Befeler, will always allow room for innovation.

That leaves only the physical media to be standardized. "If IBM were to announce a standard-size platter today, everyone would probably follow it," says Eva March of Cygnet Technologies Inc. (Sunnyvale, Calif.). But, with the other standards established, most experts feel that optical production can surge ahead, even without a standard for the media. If the software and interfaces are standardized and work with a variety of disks, that is all the "standard" users need.

Optical Disk Vendors

Digital itself is known to be developing a WORM product, but the product is not announced. A number of third parties, though, have concluded that write once technology is indeed ready for the marketplace, and Digital's absence makes the market all the more inviting. The marketplace is responding well, say the vendors.

TECEX, for example, offers a complete archiving subsystem called TEC-OAS/1 (Figure 1). The optical disk system operates with MSCP and Files-11. According to TECEX, it requires no patches or changes to a company's existing Digital software device driver or utility packages. TEC-OAS/1 connects to the host CPU via a Q-bus or Unibus adapter emulating a standard UDA50 magnetic disk controller. There has been a growing momentum in the marketplace after a slow start, according to TECEX spokesman Michael P. Johnson. TECEX sold more than 100 drives in 1986, and has been active in the market for 18 mths.

KOM Inc. is likewise finding a growing enthusiasm in the marketplace. KOM's OPTIFILE is a software/host adapter package that allows most of the major optical disk drives to run in both the VAX and PDP-11 Digital environments. Perceptics Corp. (Knoxville, Tenn.) sells optical disk operating software for VMS too, packaging it with hardware from other vendors.

Figure 1—*The TEC-OAS/1 Optical Archiving Subsystem for VAX architectures from the Q-bus to the Unibus was configured by TECEX.*

U.S. Design Corp. also offers optical disk products for the Digital environment. Its 1108 (Q-bus) and 1158 (Unibus) SCSI host adapters have been firmware "tailored" for support of all major manufacturers of optical disk drives, including OSI, Sony, Hitachi, Alcatel Thompson, and Optimem. In addition, it offers an archival software utility package called OPUS that performs archival backup and restore functions for optical disks. A third product is Virtual Optical Storage (VOS), which Manager Jeff Lessner de-

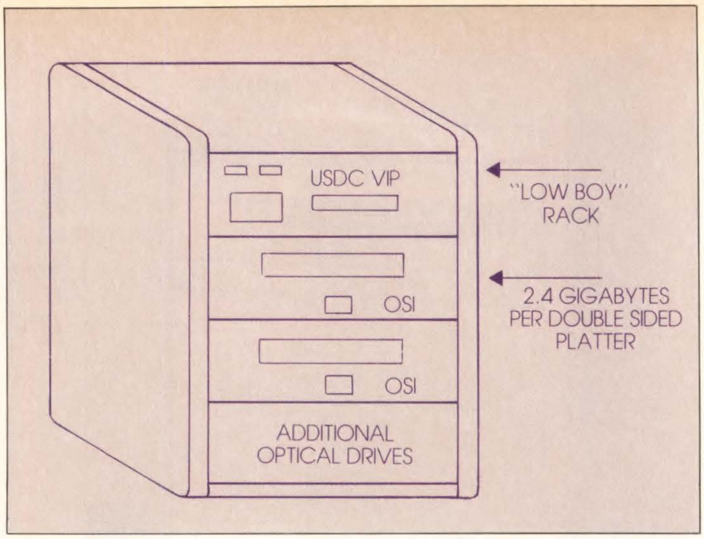


Figure 2—*The VOS drive configuration, designed by U.S. Design Corp., incorporates multiple optical disks and a VIP subsystem to supplement the WORM technology with magnetic media.*

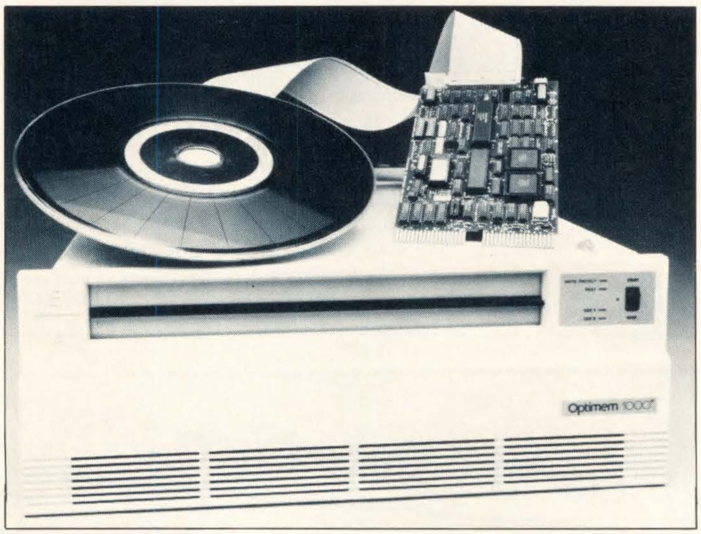


Figure 3—*Emulex's Laser Optical Subsystem (LX400 Series) uses the UC04/UC14 host adapters and is designed for both Q-bus and Unibus computers.*

scribes as "a complete turnkey system that brings the optical disk WORM technology completely into the Digital, MSCP, Files-11 environment" (Figure 2). The USDC Virtual Information Processor (VIP) additionally allows the use of magnetic media to supplement the optical storage.

There are other players in the Digital marketplace as well. TD Systems (Lowell, Mass.) offers SCSI host adapters for optical support. Its TDL-12 connects to the Q-bus, says Vice President of Engineering Don Brickman, and its UHA-11 connects to the Unibus. A new product, the Viking, Model QSC, is available for the Q-bus, while a Unibus version is forthcoming.

Emulex Corp. offers a Laser Optical Subsystem (LX400 Series) that uses the Emulex UC04/UC14 host adapters to provide what spokesman Larry Tashbook calls "a complete optical solution for the Q-bus and Unibus systems" (Figure 3).

Adept Digital Systems also offers a complete subsystem. While most third parties pride themselves on making an optical disk look like a magnetic disk, Adept has taken a different approach. "We feel that the optical disks are unique," says President Fred Huebner. "They're not magnetic tapes and they're not magnetic disks. We've found our greatest success with the optical disk with imaging type applications, where large contiguous files are put on the optical disk."

Other activity reaching the Digital marketplace is aimed not at end users,

Vendors Directory

Adept Digital Systems Inc.
1430 Koll Cir., #111
San Jose, CA 95112
408-287-2331 **Enter No. 500**

Alcatel Thompson
470 Totten Pond Rd.
Waltham, MA 02154
617-890-6801 **Enter No. 501**

Control Data Corp.
8100 34th Ave. S.
Minneapolis MN 55440
612-931-3131 **Enter No. 502**

Cygnet Technologies Inc.
1296 Lawrence Station Rd.
Sunnyvale, CA 94089
408-734-9946 **Enter No. 503**

Eastman Kodak's Co.
Business Systems Markets Div.
343 State St.
Rochester, NY 14650
716-724-4000 **Enter No. 504**

Emulex
3545 Harbor Blvd.
P.O. Box 6725
Costa Mesa, CA 92626
714-662-5600 **Enter No. 505**

Hitachi America Ltd.
950 Benicia Ave.
Sunnyvale, CA 94086
408-773-8833 **Enter No. 506**

KOM Inc.
145 Spruce St.
Ottawa, Ontario
Canada, K1R 6P1
613-238-7766 **Enter No. 507**

Optical Storage International
3333 Scott Blvd.
P.O. Box 58063
Santa Clara, CA 95052
303-593-7900 **Enter No. 508**

Optimem
435 Oakmead Pkwy.
Sunnyvale, CA 94086
408-737-7373 **Enter No. 509**

Perceptics Corp.
Pellissippi Center
Knoxville, Tenn. 37932
615-966-9200 **Enter No. 510**

Reference Technology Inc.
5700 Flatiron Pkwy.
Boulder, CO 80301
303-449-4157 **Enter No. 511**

Scientific Micro System
777 E. Middlefield Rd.
Mountain View, CA 94943
415-964-5700 **Enter No. 512**

Sony Corp. of America
Information Products Div.
One Sony Dr.
Park Ridge, NJ 07656
210-930-6585 **Enter No. 513**

TECEX
1061 S. Melrose Ave.
Placentia, CA 92670
714-632-6672 **Enter No. 514**

TD Systems Inc.
24 Payton St.
Lowell, MA 01853
617-937-9465 **Enter No. 515**

Toshiba America Inc.
Information Systems Div.
2441 Michelle Dr.
Tustin, CA 92680
714-730-5000 **Enter No. 516**

U.S. Design Corp.
5100 Philadelphia Way
Lanham, MD 20706
301-577-2880 **Enter No. 517**

but at the systems integrators themselves. Scientific Micro Systems (Mountain View, Calif.), for instance, has developed a chip to interface between a controller and the SCSI interface. Its NG 8510 chip, says Advanced Development Manager Gary Lee, drops the raw error rates on optical disk drives to one in 10^{-13}. SMS hopes the chip will become an industry standard.

Cygnet Technologies sells only to OEMs, VARs, and system integrators and provides high performance optical disk jukeboxes and subsystems for imaging and data management. Jukeboxes hold many optical disks—up to 50—and make it possible to access data online in seconds that might take days or weeks to locate on stored magnetic tapes.

Market Advantages

The marketplace itself, then, tends to confirm projections like those of Freeman Assoc. Activity is no longer simply in the prototype stage. Optical disk is surging into the market from both systems integrators and suppliers to those integrators. Digital and IBM may be behind for now, but the market will undoubtedly surge even more when they announce their products.

Digital, in particular, seems to enjoy a strong advantage in optical disk, because many of its computers are already in environments best suited to optical disk applications. Applications most often mentioned for optical disk are archival files; audit trails for all industries; banking, insurance, and legal documents; CAD/CAM graphics; engineering drawings; medical imaging; satellite data capture; seismic, oil, and gas explorations; and government and military applications.

"I am aware of a lot more activity in integrating optical storage to Digital VAXes and PDP-11s than I am to IBM minis and mainframes," observes Les Cowan of Rothchild consultants in San Francisco. "Although there are some people doing it with IBM, those are higher end systems, highly specialized." In applications for the personal computer, IBM, of course, dominates.

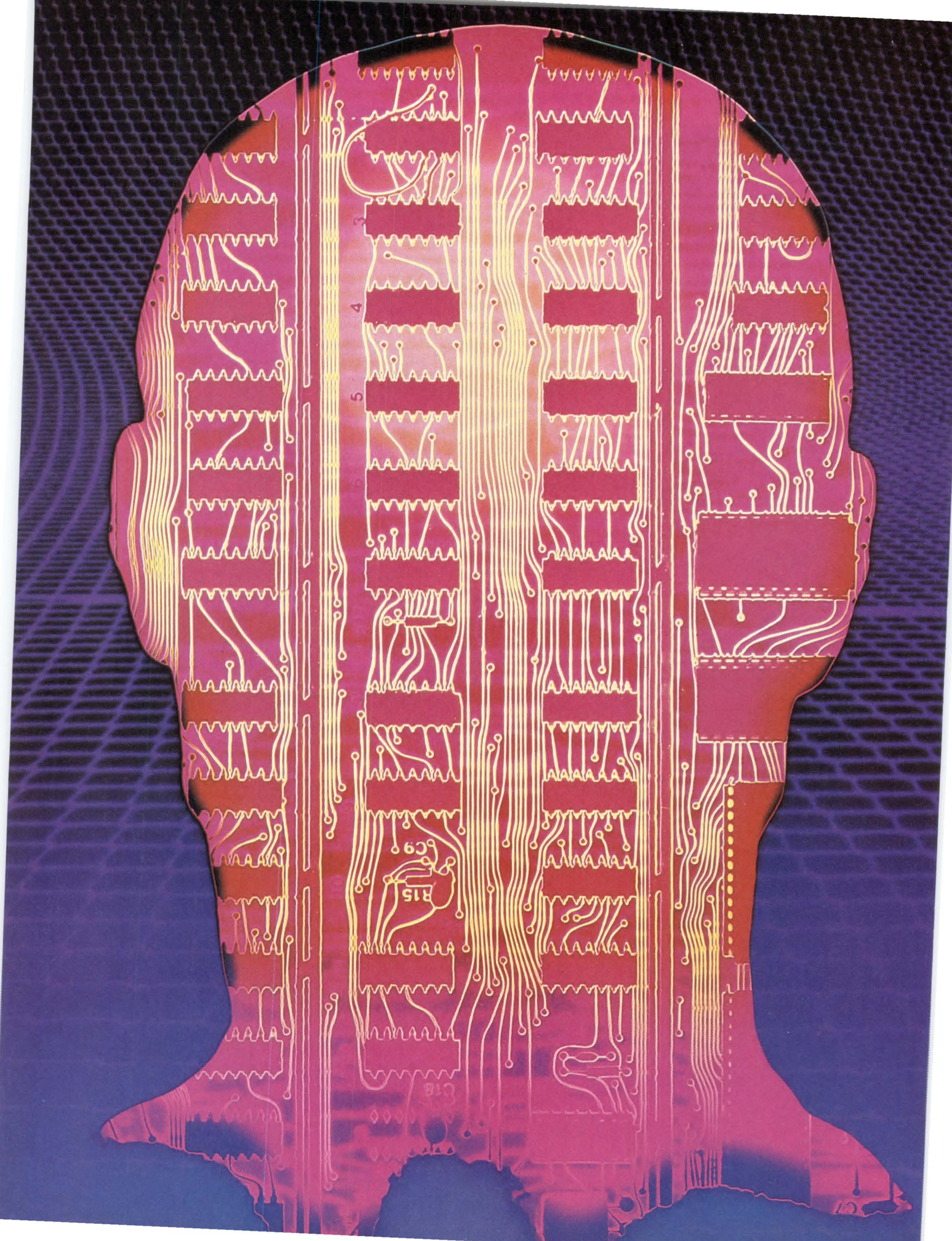
Aside from being in the right place at the right time, Digital enjoys other advantages in the optical marketplace. "Digital has all the pieces in place already," says TECEX's Michael P. Johnson. "Integrated office automation, DECslide and DECgraph, desktop publishing, connectivity. They're ready for large storage."

Optical disk may not yet have solved all of its problems. It is still more expensive than tape storage. Though defenders argue that the cost per bit is competitive, most people do not buy by cost per bit but by cost per media. And optical disk costs much more than tape. Optical disk, too, is not erasable, though at Comdex in November, Eastman Kodak's Verbatim division announced what may be the first erasable optical disk.

Whatever problems remain, optical disk's biggest problems apparently lie behind it. With the systems integration problems solved, the other problems seem minor. Solutions for them are certain to develop over time.

The future for optical disk, then, looks bright indeed. And it looks particularly bright within the Digital marketplace. The technological pioneers have done their work. No one is certain when the technology will fully come into its own—perhaps by 1990, perhaps not until 1995. No one knows either whether it will be a $1 billion market or $2 billion or larger. But few who are familiar with it doubt that it will indeed come into its own and that it will be big.

Jim Meade is a Hardcopy *contributing author.*



From expert system programming languages to shells to complete environments, the VAX user has many tools for developing management and decision support applications

EXPERT SYSTEM DEVELOPMENT TOOLS FACILITATE THE CREATION OF AI APPLICATION SYSTEMS

by Clyde W. Holsapple and Michael D. Gagle
Micro Data Base Systems Inc.

Expert systems are rapidly emerging from a specialized and experimental niche into the practical computing mainstream. With their abilities to emulate the reasoning behavior of human experts, these systems allow computers to offer advice about a wide variety of problems facing their users. When a human expert is unavailable, a user can consult an expert system for recommendations and justifications of those recommendations. The benefits of expert system technology are further amplified when it is integrated with other computing techniques for the construction of management information systems, decision support systems, and even robotic systems that embody human reasoning.

Expert system technology can be used in many areas including engineering, accounting, finance, manufacturing, marketing, operations management, and strategic planning. The technology is delivered to systems developers through a growing arsenal of software tools. Regardless of whether a developer is building expert systems or the more ambitious artificially intelligent (AI) application systems for information management, decision support, or robotic behavior, the choice of an appropriate development tool is crucial. The tool will determine what can and cannot be developed, the speed of development, the ease of development, and the development cost. There is a continuing trend among producers of expert system development tools to make improvements along these lines. Today, tools exist that do not require extensive formal training in AI as a prerequisite to rapid construction of interesting expert systems.

Following an introduction to the basics of expert systems, this article identifies three types of expert system development tools. VAX-based representatives of each are examined with respect to such issues as knowledge representation, the treatment of uncertainty, inference controls, and user interfaces. The central objectives are to emphasize the distinction between expert systems and the tools with which they can be built, provide a framework for understanding available tools, and suggest factors that should be kept in mind when assessing a tool.

Clyde W. Holsapple, associate professor of management at Krannert Graduate School of Management, Purdue University, holds a Ph.D. in management science from Purdue. His teaching and research interests are in the areas of database management, decision support, AI, knowledge management, and software integration. Michael D. Gagle, senior vice president of research and development for Micro Data Base Systems Inc., holds a Ph.D. in management information systems from Purdue. He has a long-standing interest in AI as applied in the business world.

"Expert system technology can be used in many areas...."

The Basics

Simply put, an expert system is a computer based consultant. When a user faces a problem, an expert system is able to accept a request for advice, draw on its knowledge of the problem area, interact with a user to further clarify the specifics of the problem, infer a solution to the problem, present the solution as a recommendation to the user, and explain the line of reasoning used in reaching the solution.

In principle, the derived advice is comparable to what a human expert in the problem area would recommend. The benefit of expert systems is increased productivity for those who seek advice, for those who give advice, and for the organizations that use expert systems. While the benefits can be substantial, they should not be overestimated. Though an expert system is able to reason logically, it doesn't have creative imagination or exhibit intuition.

The raw material for an expert system's reasoning activities consists of reasoning knowledge that has been elicited from a human expert and stored as part of the expert system. This knowledge is typically represented in the guise of rules. Though many syntactic variations are possible when stating a rule, it has at least two basic parts: a premise and a conclusion. If the situation described by a rule's premise can be determined to be true, then the actions specified in its conclusion can be deemed valid.

The active software component of an expert system is traditionally called an inference engine. This software supports one or more user interfaces and allows problems to be posed. When a user requests advice about some problem, the inference engine uses the rules to try to reach a conclusion that solves the problem. During this reasoning process, the inference engine may prompt the user to provide further details about the problem and, in turn, provide explanations about why it is asking for additional details. When a solution is inferred, it is presented as advice to the user who can then interrogate the inference engine to explore the rationale for that advice.

The way in which an inference engine uses rules as it reasons about problems can be designed to proceed along any of many possible avenues. The processing of two inference engines can differ, not only in terms of the sorts of rules they can process, but also in terms of their strategies for selecting what rule to examine next, evaluating multiple conditions in a rule's premise, timing interactions with the user, reusing rules, and assessing when a consultation has become sufficiently rigorous to report its results. However, at the most elementary level, inference processing takes some variant of a forward or backward chaining approach to using rules.

In forward chaining, a selected rule's premise is evaluated. If the premise evaluates to true, then the inference engine fires the rule, which means the actions in its conclusion are performed. This process continues with each selected rule until the inference engine detects that a sufficient degree of reasoning rigor has been achieved. At that point, the results of rule firings serve as a solution to the consultation problem, provided it's possible to infer a solution from the available set of rules.

In backward chaining, an inference engine processes rules by first examining a rule's conclusion and then its premise. The inference engine begins by selecting a rule with a conclusion that might directly solve the problem. It then tries to determine whether that rule's premise is true or false. If it is true, then the rule is fired to yield a solution. If the premise is false, the engine selects another rule with a conclusion that could solve the problem, and proceeds to test its premise.

There is a third possibility. The premise may be neither true nor false. In this case, the premise's unknown variables become new subproblems. The inference engine works to solve each of these subproblems (i.e., establish values for the unknown variables) by the same backward chaining process. This may, of course, involve many levels of recursion before the originally selected rule's premise can be determined to be either true or false.

Regardless of whether it uses some variant of forward or backward chaining (or both), an inference engine may also be able to cope with uncertainty. Just as human experts are able to reason about uncertain situations, so too can an expert system. This is typically accomplished by the inference engine's ability to process certainty factors. A certainty factor is a numeric indicator of the degree of certainty that exists about a piece of information provided by the user (or some other source), or about the applicability of an action in a rule's conclusion. The way in which multiple certainty factors are combined during a reasoning process is called a certainty factor algebra. The inference engine uses such an algebra to calculate what degree of certainty it should attach to the advice it offers.

Like a human expert, an expert system's advice may consist of multiple, alternative solutions to a problem. Rather than a single, definitive answer, there is a multivalued, fuzzy answer in which each value has an associated degree of certainty. The inference engine of such an expert system is able to manipulate fuzzy variables in the course of its reasoning. These are variables that can simultaneously have multiple values, each of which is subject to modification as rules are fired. The certainty of each fuzzy value is calculated just as the certainties of single-valued variables.

When a consultation's inference process terminates, the expert system presents the derived advice. The presentation may take many guises ranging from line-oriented output of variable values to more elaborate forms-oriented and graphical portrayals. In response to user requests, the inference engine can explain how it arrived at a particular result (i.e., what rules were fired and in what sequence) and why particular rules were used (i.e., what values were established to make their premises true).

To the extent that an information management system or a decision support system can be designed to incorporate the foregoing expert system capabilities, it becomes artificially intelligent. In addition to the other kinds of knowledge with which it traditionally deals, it becomes able to accommodate and process reasoning knowledge as well. Expert system technology is not limited to building standalone expert systems, but can also be applied to dramatically enhance the behaviors of more conventional kinds of systems.

Development Tools

One of the most important factors in the practical application of expert system technology is the choice of a development tool that is appropriate to the tasks at hand. Historically, there has been a progression through three types of tools, all of which are available today for the VAX. The earliest expert systems were built with programming languages such as LISP. A second type of development tool is an expert system shell. The forerunner of today's commercial shells was EMYCIN in the late 1970s. More recently, a third type of tool has appeared. Tools in this category are environments that integrate expert system development and consultation capabilities with other computing capabilities.

When a programming language serves as the development tool, it is used to devise the inference engine software. With such a tool, a developer has a great deal of flexibility in defining an expert system's user interface, rule representation mechanism, and inference process. The ability to handle certainty factors, fuzzy inference variables, and post-inference explanations can all be programmed into the inference engine software. The disadvantage of programming an expert system is the extensive time and effort required for development and maintenance of nontrivial expert systems.

Expert system shells were a significant advance, in that they eliminated the need for programming during the development of expert systems. With a shell, the developer can concentrate on eliciting and specifying human experts' reasoning knowledge. This is because a shell furnishes a ready-made inference engine that is able to process any set of rules specified according to the rule representation protocols supported by the shell. Instead of writing programs, the developer states rules. This may be accomplished with a general purpose text editor. Alternatively, some shells provide software for rule set management, including the creation, maintenance, and analysis of rules.

While a shell's inference engine and rule set manager can facilitate expert system development, they also provide less flexibility than programming languages. Although a typical shell doesn't allow developers to significantly alter its inference strategy, the primary source of shell inflexibility comes from limitations in knowledge representation. A shell supports one knowledge representation method (some syntactic variation of rule specification) and focuses on reasoning knowledge. Of course, a developer may want to use multiple representation methods and store other types of knowledge, in addition to reasoning knowledge. Because this is not readily possible with a shell, the developer is (at best) forced into various mental gymnastics in an attempt to overcome the limitations it imposes on knowledge representation.

Expert system environments are tools that break down the knowledge representation limits of shells without requiring developers to resort to programming. Like a shell, an environment provides ready-made inference and rule set management capabilities. Unlike a shell, they are not provided as isolated tools. Instead, these capabilities are integrated with other computing capabilities (such as database management and spreadsheet processing) to yield a single tool. Each of these other capabilities supports a different knowledge representation method. All of the knowledge representation methods can be used as desired when developing an expert system. For instance, a rule could reference databases and spreadsheets in its premise and conclusion. This implies that the environment software blends database management and spreadsheet analysis capabilities with inference engine capabilities.

Unlike the other two kinds of tools, an environment can be directly used by end users, as well as developers. Not only is it a tool for development, it is also an environment for consultation and other end user activities, such as database management or spreadsheet processing. End users can freely exercise any of the integral capabilities as desired, and can customize the environment's behavior to suit their own tastes and needs.

Figure 1 suggests that a continuum exists among the three types of tools. Specific VAX-based tools effectively cover this continuum. There are the pure programming languages such as C and LISP. These and other programming languages can also be used to create software that is not an expert system. For instance, these two programming languages are commonly used to create the shells and environments that are used to develop expert systems. Though PROLOG and OPS5 are often described as programming languages, it is also, in many respects, fair to regard them as shells. In the VAX world, KES is perhaps the best commercial example of a pure shell. The KEE, Knowledge Craft, ART, and S.1 tools go a step beyond shells by supporting programmatic and frame-oriented knowledge representations in addition to rules. A more full-blown realization of an environment is Guru, which synergistically integrates a variety of knowledge representation methods including rules, relational databases, spreadsheets, text, programmatic models, and forms.

Although other tools exist for the VAX (Figure 1), these are among the most prominent and are representative of what is available today for building VAX-based expert systems. Selecting an appropriate development tool is arguably one of the most important determinants of successful expert system projects. The overviews provided here are intended to give a basic familiarity with available possibilities. More detailed examination is advisable when actually selecting a tool. For example, Chapter 12 of *Business Expert Systems* (C. Holsapple and A. Whinston, Irwin, Homewood, IL) contains an extensive checklist of tool selection criteria.

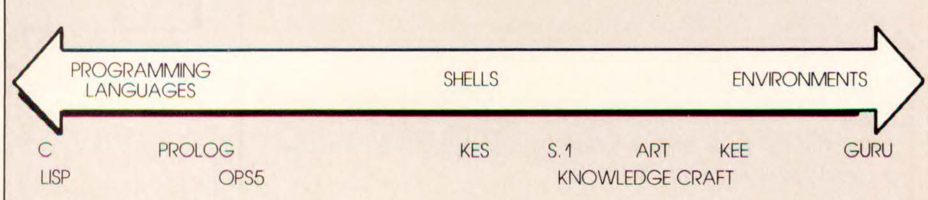
Logic Programming

PROLOG is billed as a language for "logic programming." It implements a subset of first-order predicate calculus, allowing knowledge to be represented in terms of Horn clauses. A Horn clause can be regarded as a rule that may have multiple conditions in its premise and, at most, one action in its conclusion. All conditions and actions are specified as predicates [e.g., as GT(SALARY,20000] rather than SALARY>20000). It is traditional to state a PROLOG rule's conclusion before its premise.

In addition to this facility for representing reasoning knowledge, PROLOG also allows descriptive knowledge to be represented. Each descriptive fact (e.g., Jack is an employee with salary of 22000) is specified as a predicate [e.g., EMP(Jack,22000)] that stands on its own apart from rules. These singleton predicates are legitimate Horn clauses and may be thought of as premiseless conclusions or assertions. Collectively, they are sometimes called a "data-

continued on page 80

Figure 1—*VAX-based expert systems development tools effectively cover the continuum of all types of expert system development tools.*



INDUCTIVE EXPERT SYSTEMS TECHNOLOGY USES HISTORICAL DATA TO GENERATE BEHAVIOR GUIDELINES

by Ken Begbie
BBJ Computers International

An expert system can acquire its knowledge base by being given a set of rules by an expert. It can also, if appropriately programmed, develop its own set of behavior guidelines by looking at the patterns and histories of past events. Expert systems that look at past histories to create their own rule base exist today, and are commonly called inductive expert systems.

Much of the original theoretical work in this area was done by Professor Ross Quinlan, chairman of the Department of Computer Science at the New South Wales Institute of Technology. In 1977, he developed and published an algorithm for transforming raw historical data into decision trees (Figure 1). The methodology has become known as ID3, an abbreviation for iterative dichotomizer three.

ID3 is now a public domain algorithm. It has spawned a number of commercial software products, a few of which are fairly well known—Rulemaster, KDS, and Expert-Ease. Professor Quinlan's contribution to this field continues, however, and in 1986 he announced a new generation of the algorithm—C4. C4 supports a number of real-world requirements—including the handling of "noisy" data—that were omitted from the more theoretically based ID3.

The underlying concept of inductive expert systems is both interesting and subtle. Given that experts learn by experiencing past events (causes and effects) in various combinations, might not it be possible to go directly to records of past events (i.e., historical data) and do something worthwhile with that information?

If so, the time, tedium, and expense of teaching rules to an expert system could be virtually eliminated. Costs of constructing usable expert systems for specific business situations, such as banking, finance, or insurance, would drop significantly. The rule gathering would actually be accomplished by the expert system.

There have been many successes, and observations in the field indicate that the fundamental ID3 technology and its algorithm work. ITT has used the technology for diagnosing circuit board faults and has, in published statements, referred to a savings of more than $1,000,000/yr. Westinghouse has applied the technology to nuclear fuel processing process control.

Experience has shown that—for certain classes of business application situations (i.e., those where there already exists a large base of historical computer-readable data)—the inductive methodology is an almost perfect solution. What then, does the process look like (Figure 2)?

The first step is a selection process in which key data elements and their

Ken Begbie, president of BBJ Computers International (Santa Clara, Calif.), holds a B.S. from the University of Melbourne and is a member of the Australian Computer Society. In addition to his work with inductive expert systems, Begbie was project coordinator for MARLOWE, a PROLOG-based research effort conducted during 1985 at the University of Melbourne. MARLOWE was the prototype for a rule-based expert system designed to detect white-collar computer crime.

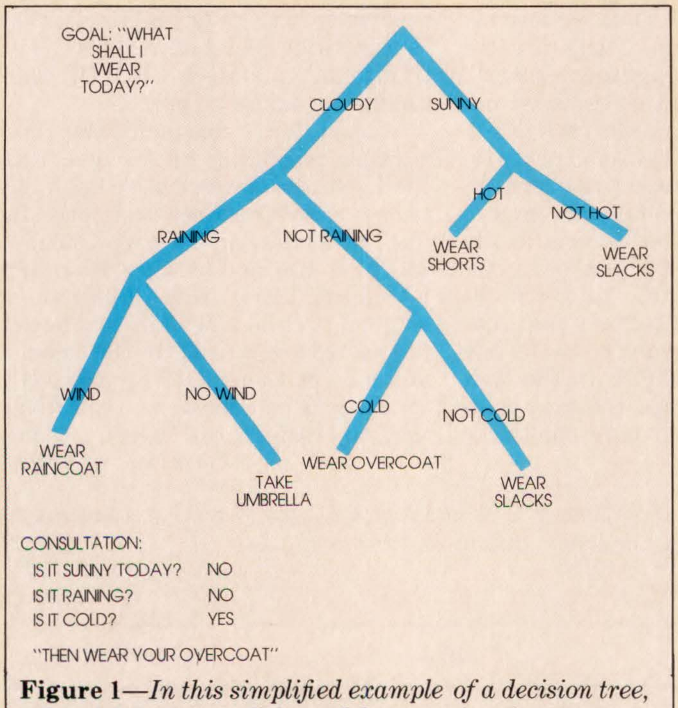


Figure 1—*In this simplified example of a decision tree, related data is sorted through by querying the user and a conclusion is reached.*

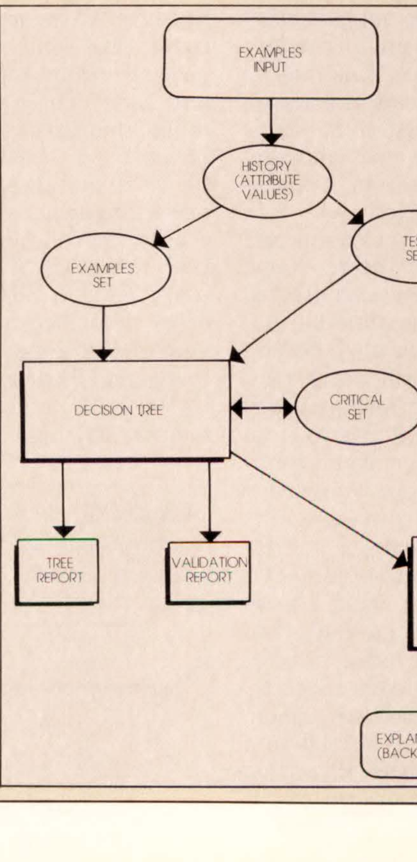


Figure 2—*An inductively learning expert system can learn from accumulated, existing data files by dividing the data examples and test sets.*

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6. I just can't find personal computing tools for minis.

7. It wouldn't integrate with my other OA systems.

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9. I need a spreadsheet that will talk to DATATRIEVE.™

10. I don't care if it works on VAX, if it won't work on my PCs.

11. It could never read my Lotus 1-2-3 models.

12. It wouldn't give me goal-seeking capability.

13. I need to move entire models between VAXes and PCs.

14. It wouldn't give me the rounding features my finance people need.

15. It wouldn't let me use worksheet macros like my PC spreadsheet does.

16. It wouldn't let me handle really big models.

17. The error messages are hard to understand.

18. I don't think the on-line HELP would be that helpful.

19. I wouldn't be able to see my worksheet and graphs simultaneously.

20. I don't think I could bring up four graphs at once.

21. It wouldn't do multiple key sorts.

22. I don't want it if it can't do database operations.

23. The last thing I need is another stand-alone software product.

24. What good is it if it can't import text from my WP?

25. It isn't useful if it can't produce good-looking reports.

26. I don't think it could support international currency, date and time formats.

27. I would have to remember too many file names.

28. It wouldn't let me point-to formulas like my PC spreadsheet does.

29. I don't want to have to buy any more hardware.

30. It wouldn't consolidate financial statements across my organization.

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" Today, [expert system development] tools exist that do not require extensive formal training in AI as a prerequisite to rapid construction of interesting expert systems."

continued from page 77
base." However, it should be noted that PROLOG does not offer database management capabilities in the normal sense of the term.

PROLOG's clausal representation isn't particularly well-suited for numeric processing. It has no built-in mechanisms for handling uncertainty or for supporting fuzzy variables. Within such limits, a developer uses a text editor to specify a collection of clauses that pertain to some problem area.

The PROLOG interpreter (or compiler) is able to accept a problem stated as a predicate. This predicate should appear as the conclusion for at least one Horn clause specified by a developer. To respond to such a problem, the PROLOG software applies the resolution technique of predicate logic. In effect, this means the software functions as an inference engine that uses backward chaining on the clausal rules. The clauses are selected for processing in the order in which they were specified with the text editor. A developer has little control over the inference process proper.

In addition to Horn clauses, a developer can specify modest procedures that a user can execute, composed of the problem predicate embedded in a series of input and/or output instructions for interacting with the user. These can be programmed to carry out the expert system's explanation activities, as well as its requests for further inputs from the user during the inference process.

Programming Language

OPS5 is often described as a "programming language" for production systems. The OPS5 interpreter is able to interactively accept various commands from a user. When it has executed a command, the interpreter is ready to read the user's next command. These commands can accomplish such tasks as allocating memory elements, opening and closing files, executing external programs written in LISP, and execut-

values are extracted from the mass of available historical data and placed into a history file. The individuals managing this process must, of course, have a strong sense of the "expertise" that they are trying to recreate. They must identify those data items that they believe to be essential components of the problem, and their judgement as to what is relevant matters a great deal. This data can be stored in any reasonable format, so long as the data items within it can be found and understood by the program that will be actually used to generate the decision tree.

The selected historical data is then usually divided into two randomly selected portions. The first, called the examples set, is used as input to the program that subsequently generates the tree. The second set, called the test set, is held for future use in testing the accuracy of the "expertise" gleaned from the first portion of the data.

After the decision tree is generated from the examples set, an iterative and interactive process occurs in which the expert system developer works towards satisfying himself that the tree built from the given examples is correct and complete. There are a number of techniques that can be used here, including extensive tree pruning methods used to rid the tree of misleading or incorrect historical data. Essentially, examples that do not fit well are referred back to the expert for ongoing resolution and modification.

This, then, is one of the salient characteristics of working with inductively developed expert systems. The system's expertise is tuned and adjusted by modifying not the rules and principles deduced from the data, but the actual data contained within the examples set instead.

Given large amounts of historical data, such modifications to the examples set eventually prove arduous, and perhaps even impractical. For this reason, the process supports the generation from the decision tree of a component known as the critical set. The examples set must have attained a certain level of correctness before the critical set can be generated.

The critical set is defined mathematically as the minimum set of values and conditions required to generate the same decision tree that would be created from all of the data in the examples set. Working with the critical set gives the person building an expert system maximum control over the evolution of the knowledge base, while minimizing the amount of data that actually has to be manipulated and changed. It can be generated as many times during the process as required, and greatly speeds the construction of accurate and complete decision trees.

The final steps come after the decision tree has finally attained the degree of accuracy and consistency desired. The tree then becomes available to the organization as a representation of the particular knowledge resource. It can be accessed via specialized consultation software (offering standalone consultative use) or by integration with normal business application programs—providing that the programmatic and user interfaces have been built correctly.

For the many kinds of circumstances where the availability and completeness of historical information permit use of the ID3/C4 methodologies, there are several advantages above and beyond the obvious ones relating to the ease of setting up the initial knowledge base. For one, inductively learning systems execute efficiently. Being inherently goal-oriented, they traverse relatively short paths to make decisions, in contrast to some rule based systems that have to scan the rules and knowledge base to decide the next rule to execute.

Other advantages include their almost uncanny ability to "discover" knowledge that was apparently not there. Human experts often do not really understand the processes they go through to solve problems. The objectivity of inductively learning systems often results in surprising and valuable findings that were either missed or filtered out by human rulemakers.

What appears to be an essential next step is the creation of more complete and accessible expert systems development and execution environments. Almost all of the pieces are in place to permit the closer integration of regular business application systems with induced expert system technology, resulting in an effective blend of fourth- and fifth-generation capabilities. When this merger of technologies is complete, application software systems may be given easy and direct access to the induced knowledge bases that surround them in abundance.

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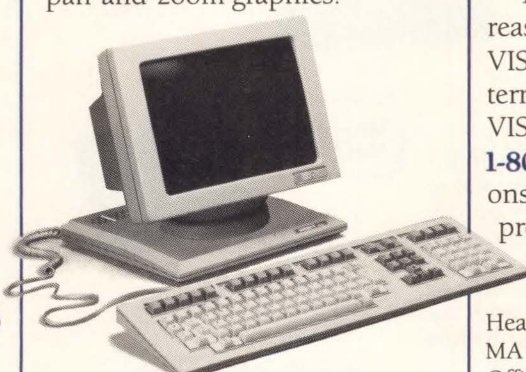

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ing a production system. It is this latter capability that allows OPS5 to be fairly regarded as an expert system shell.

A production system is an unordered collection of statements called productions. A production consists of a left hand side (LHS) and right hand side (RHS). In expert system terminology, an OPS5 production is a rule with a premise that is the LHS and conclusion, the RHS. The OPS5 interpreter employs forward chaining to process the reasoning knowledge embodied in a production system (i.e., in a rule set).

OPS5 allows multiple conditions in a premise and multiple actions in a conclusion. Both equality and inequality operators are allowed in the conditions, and the operands in these conditions can be constants and variables. OPS5 requires that each variable be defined as part of a memory element, which is a named collection of variables. Thus, the OPS5 interpreter tests the validity of a rule's premise by examining current working memory contents. The actions in a rule's conclusion can be any of a dozen different commands. Some of these involve creating, deleting, and modifying working memory (e.g., changing a variable's value), and others involve such tasks as calling external LISP programs, manipulating files, and line output. Modest numeric processing is supported by a "compute" function, and there are also functions to accept streams of user input.

OPS5 has no built-in support of certainty factors, fuzzy variables, or reasoning explanations. It does provide some minimal control of inference engine behavior by allowing either of two rule selection strategies to be used. To facilitate the expert system development process, OPS5 allows various kinds of inference tracing and the selective designation of inference breakpoints.

System Shell

KES is an expert system shell. It provides an inference engine that can process rules that have been parsed by the KES parser. A set of rules is specified and maintained with an external text editor. Each rule has the familiar:
IF premise THEN conclusion
appearance. Each condition in a premise can involve an equality or inequality with operands as expressions containing literals and/or variables (i.e., "attributes" in KES terminology). Two kinds of actions are allowed in a conclusion: assignment statements and line output statements.

In addition to rules, a KES rule set can contain an initialization sequence and variable descriptors. An initialization sequence is a series of commands executed at the outset of any consultation involving the rule set. These can be commands for rudimentary line input or output, consultation invocation, assigning of a value to a variable, and requesting of automatic tracing of the inference process that follows initialization. A variable description denotes the existence and various characteristics (its possible values) of a variable used during the inference process.

The KES inference engine processes a rule set's rules via backward chaining. As it does so, it's able to obtain values for unknown variables from the user by either line-oriented prompts or numbered menu options. In the case of a prompt, the user can, prior to typing in a response, enter commands to discover why the requested information is needed. This interrupt mechanism can also be used by a developer to alter and examine variable values in the midst of consultation testing.

As it processes rules, the KES inference engine is able to incorporate uncertainties about variable values into its reasoning process, so that generated solutions are qualified by varying de-

KES provides an inference engine that can process rules that have been parsed by the KES parser.

grees of certainty. However, only one built-in certainty algebra is supported and there are no fuzzy variable operators. In general, there are few built-in controls for tailoring the inference engine's processing behavior (alternative rule selection strategies are not allowed), and there is no built-in mechanism for preserving the full history of a consultation. Aside from the inference engine, KES provides two other standalone programs that are not used for expert system construction—a Bayesian calculator and a diagnostic system.

Skeletal Environments

The KEE, Knowledge Craft, ART, and S.1 tools can be viewed as skeletal environments. All four support a frame-oriented approach to knowledge representation, in addition to the rule representation allowed by shells. All recognize the need for more diverse and flexible knowledge representation facilities. They address this need not by supporting familiar knowledge representation techniques such as databases and spreadsheets, but by requiring developers to design frames.

Generally, a frame denotes an object or class of objects. Each frame is composed of slots with values that define the nature of a frame. For instance, slots of a customer frame characterize the class of customers (e.g., the number of customers and the average customer account balance). At a more concrete level, there may be frames for specific customers. For example, there may be a frame with slots that have the values John Doe and 2000.

In a situation where one frame represents a member of the class denoted by another frame, the two can be linked in a frame hierarchy in such a way that designated slots in the class frame are inherited by each member frame. For example, slots such as customer name and account balance may be declared for the customer frame. Every member frame is assumed to inherit these two slots and to have values for each.

When a frame is created, the developer can program various methods for that frame. A method is software that carries out certain actions on the frame's slot values. As with slots, methods can be inherited by members of a class. Messages can be sent from one frame to another. When a message is sent, the target frame and method are stated. The indicated method is executed and a reply may be sent back to the message sending frame. Frame implementations commonly allow procedures to be attached to individual slots. When such a slot is referenced, its procedure is automatically executed.

Frame Handling

Each of the four tools previously mentioned supports some variation of frame handling. The basic idea is that a developer can use such a tool to represent and process descriptive and procedural knowledge in terms of classes of objects, individual concrete objects, and their respective methods. Reason-

> " Like KES rule sets, a Guru rule set can have an initialization sequence in addition to rules. "

ing knowledge is still represented as rules. For instance, KEE provides a predefined rule set class, having preprogrammed forward chaining and backward chaining methods. These KEE methods are implemented as LISP programs. As a developer instantiates a rule set, "if-then" rules can be specified in terms of slots. The two built-in inference engines are not designed to handle uncertainty or fuzzy variables (i.e., "fuzzy slots"). Developers who want to alter an inference process or user interface can do so by revising or creating LISP programs (and perhaps frame structures) to exhibit the desired behavior. Due to the complexity of the frame approach, tools that focus on this representation technique fall short of the expert system environment ideal of allowing end users, as well as developers, to make direct use of the tool.

Guru is an environment that accommodates both developers and end users. This is accomplished by making the notion of frames "invisible." Rather than implementing raw frame facilities for designing object classes from scratch, a variety of prefabricated classes and associated methods are available in the Guru environment. These object classes include such techniques as variables, arrays, spreadsheets, relational database tables, forms, templates, procedures, and textual passages. Another prefabricated object class is provided for rule sets. Built-in methods are supported for each class of objects. As concrete members of these classes are specified for a particular problem domain, they inherit the ready-made slots and methods of their parent classes. In addition, new special-purpose methods can be specified.

Rule Specification And Rule Sets

Guru's rule specification possibilities are shown in Figure 2. Any rule can directly reference any of many different kinds of knowledge and can carry out many kinds of knowledge processing actions in its conclusion.

Beyond a premise and conclusion, a rule can optionally have other characteristics. It can have a sequence of preactions that the inference engine will carry out once it has selected the rule for consideration, but before an attempt is made to evaluate the premise. If a reason is specified, the inference engine will present the reason's text to a user when explaining the usage of the rule. Comment text can be included for internal documentation purposes. Various refined inference controls are available to indicate how the rule can be processed during a consultation (e.g., what strategy to use when testing its premise, and a cap on the maximum number of times the rule can be fired in a consultation). If these are omitted, standard defaults are assumed.

Like KES rule sets, a Guru rule set can have an initialization sequence in addition to rules. All of the kinds of actions that are allowed in the conclusions and preactions of rules are allowed in an initialization sequence. They are also permitted in a rule set's completion sequence. This is simply a sequence of actions that the inference engine carries out as soon as it has finished processing the rules.

A rule set can have various other aspects such as security codes and variable descriptions. Security codes govern who will be able to consult the rule set. A variable description can influence the way in which a variable will be treated during the inference. This includes issues such as how fuzzy a vari-

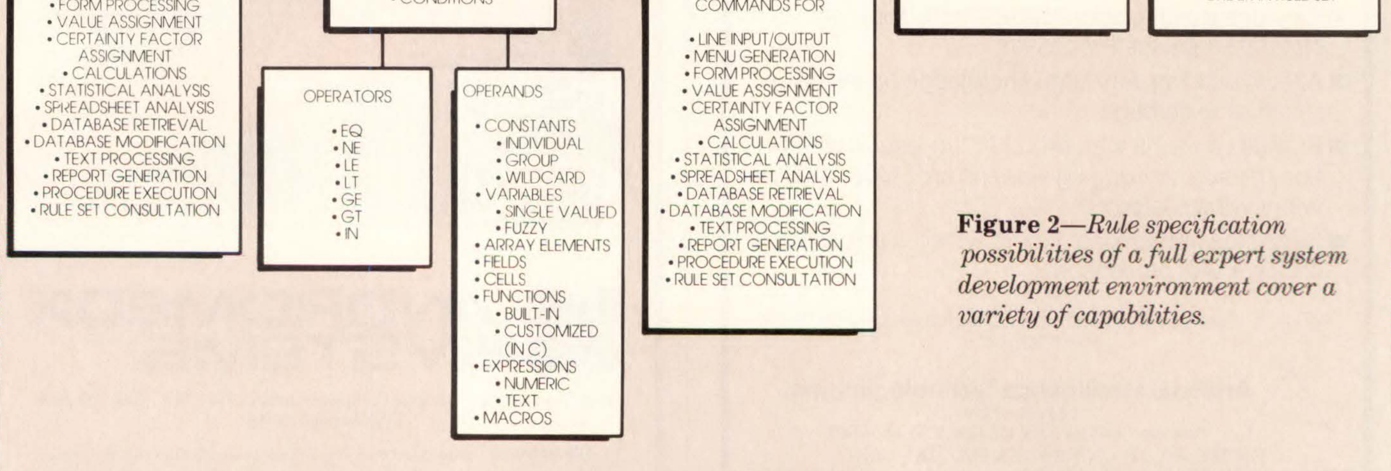


Figure 2—*Rule specification possibilities of a full expert system development environment cover a variety of capabilities.*

able can be, how its value is to be found, how rigorous the inference engine will be when deriving its value, and which of the 16 built-in certainty factor algebras should be used for determining the certainty of its value. Rule sets can be created and maintained with Guru's integral text processing or rule set management facilities.

The Guru inference engine supports many variants of both forward and backward chaining. No programming is needed to use the desired chaining variant. Instead, many environment switches are provided (e.g., for governing the rule selection strategy). These can easily be set to yield the desired inference behavior.

The Guru environment allows a rule set to be consulted in many different ways. A menu-guided interface is provided, allowing end users to do data management, spreadsheet analysis, rule set consultation, and many other activities by making menu selections. Alternatively, a consultation (as well as other kinds of knowledge processing) can be requested through Guru's natural language interface.

Tremendous advances in VAX-based expert system development tools have been made in the past 2 yrs. The possibilities that they present for more numerous, higher quality, more powerful, and less costly VAX expert systems are only just beginning to be exploited. Perhaps of even greater significance, some of these tools blend expert system and other computing capabilities to facilitate the creation of artificially intelligent application systems for information management and decision support. The full realization of such potentials for the VAX will depend on a broad and clear understanding of what expert systems are, what artificially intelligent application systems are, what kinds of tools are available, and what their distinctive characteristics are.

How would you rate the technical information in this article?
Too complex Enter No. 606
Just right Enter No. 610
Too simplistic Enter No. 614

Product: ART
Company: Inference Corp.
5300 W. Century Blvd.
Los Angeles, CA 90045
213-417-7997 Enter No. 600

Product: Guru
Company:MDBS Inc.
P.O. Box 248
Lafayette, IN 47902
800-344-5832 Enter No. 618

Product: KEE
Company: IntelliCorp
1975 El Camino
Mountain View, CA 94025
415-965-5533 Enter No. 620

Product: KES
Company: Software A&E
1500 Wilson Blvd., Ste. 800
Arlington, VA 22209
703-276-7910 Enter No. 624

Product: Knowledge Craft
Company: Carnegie Group
650 Commerce Ct.
Pittsburgh, PA 15219
412-642-6900 Enter No. 662

Product: OPS5
Company: Digital Equipment Corp.
77 Reed Rd.
Hudson, MA 01749
617-568-4000 Enter No. 672

Product: S.1
Company: Teknowledge Inc.
525 University Ave.
Palo Alto, CA 94301
415-327-6600 Enter No. 674

The Automatic Digitizer Performs A Critical Function In The Production Of Technical Documentation

Digitizing of engineering drawings for storage in CAD/CAM databases continues to play an important role in the design documentation process

by Ebbe Reker
SysScan Inc.

Millions of manhours are stored on engineering drawings. These drawings are stored in filing cabinets, desk drawers, archiving centers, and even on top of drafting tables. When CAD/CAM systems came into the engineering design scene, many thought that would be the end of the drawings.

However, the drawings are still there. Even though CAD/CAM has enhanced engineering design, valuable information still remains on drawings. As such, a major issue for CAD/CAM is what to do with the investment in manually drawn documentation.

The necessity to input drawings into CAD/CAM systems isn't only expensive, but time consuming as well. Redesign mandates that the existing drawing is entirely redrawn on the CAD system, and thus prone to errors being introduced into the CAD design. A skilled CAD operator is necessary for the operation.

Likewise, tracing the drawing with a stylus or puck via a manual digitizer isn't necessarily more accurate. Although a less skilled person is required, the procedure is still time consuming and error prone.

Automatic Digitizers

With more companies converting to CAD/CAM, the need for automatic digitizing is on the upswing. These systems optically acquire graphic information from a variety of engineering drawings and convert it to a compatible database format. Presently, more than a dozen companies are involved in this market. Current systems are fast, accurate, and affordable. An additional market area has developed for just the scanning of drawings—that is, the scanning of all technical documentation including tech manuals, mapping, and surveying documentation.

As CAD/CAM use increases during the next decade, manually drawn documentation will greatly decrease through attrition. Even so, the need for automatic digitizers is expected to be a billion dollar market until it peaks at the end of this decade and then gradually tapers off until the end of the century.

Because of the complex information presented in technical documentation (Figure 1), the automatic digitizing

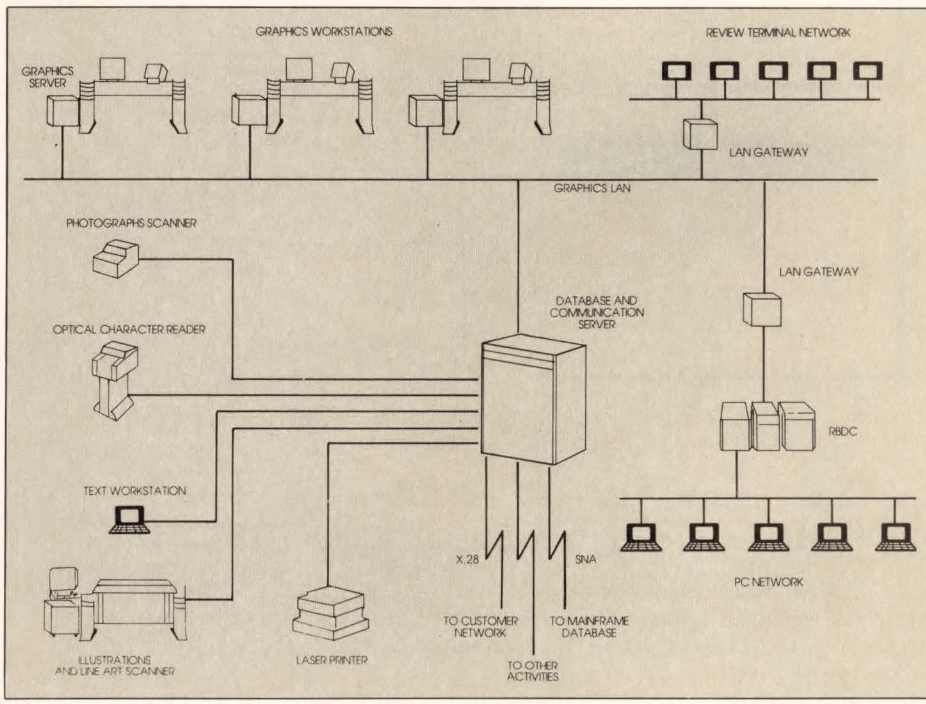


Figure 1—*A typical system configuration for the automation of technical documentation enables review, revision, and composition of both graphics and text data, as well as the storing and distribution of it.*

Ebbe Reker, president of SysScan Inc. (Jericho, N.Y.), holds an M.B.A. from NYU. He has been president of SysScan for the past 2 yrs. With 25 yrs. of high tech experience, Reker has been involved with telecommunications, navigation, and dynamic positioning products. Prior to SysScan, Reker was an executive with Kongsberg Vaapenfabrikk in Kongsberg, Norway.

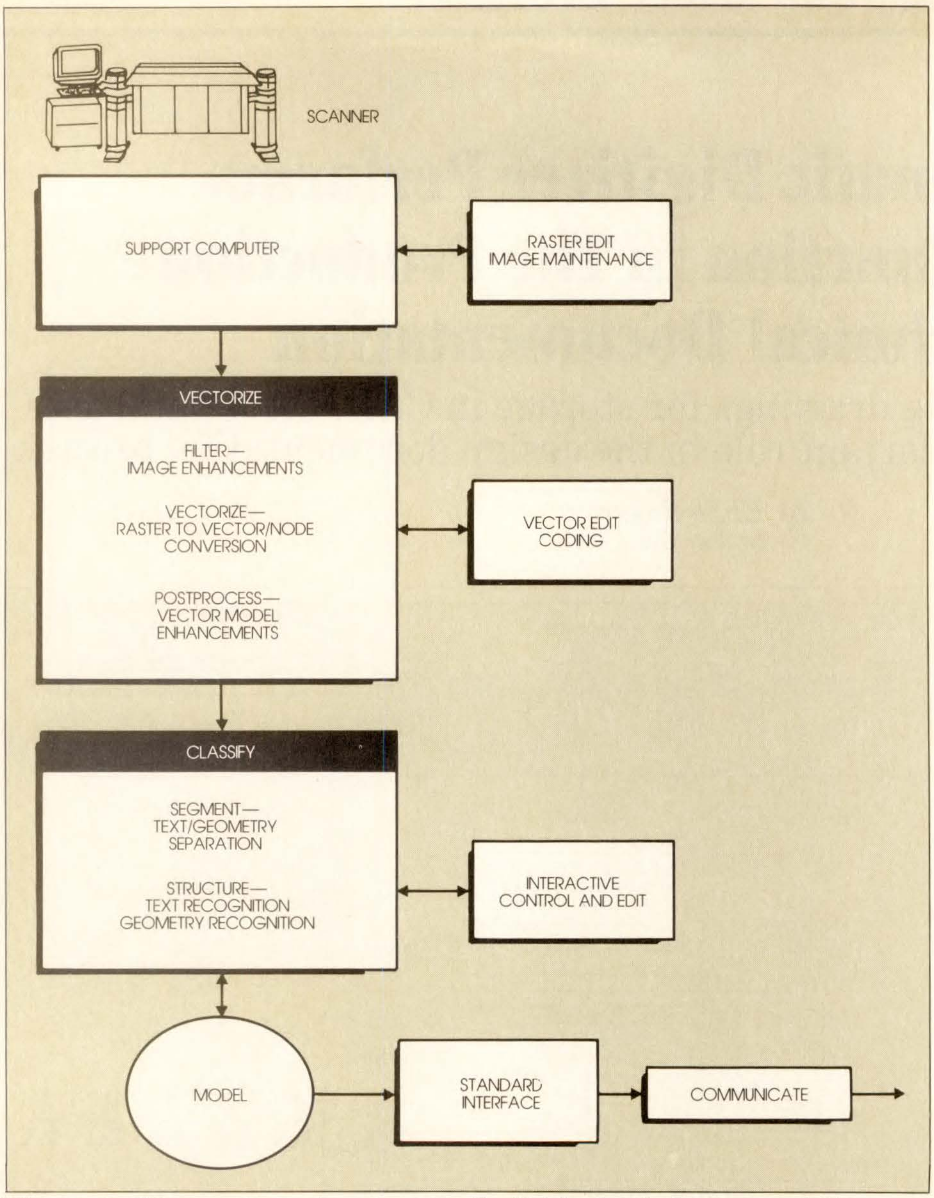


Figure 2—*When an image is automatically digitized, it is first scanned, then vectorized. Next it is reduced to its component parts and the intelligent output model is produced.*

process must be capable of combining narrative content (text) with illustrations (graphics). In addition to integrating paper-only graphics, systems must also integrate word processing, CAD, new line art, and generate hardcopy (including automated typesetting) output. Having the capability to integrate with CAD systems requires raster to vector conversion.

The system must be able to review, revise, and compose both graphics and text data, then store and distribute it efficiently. A database and directory management structure with secure data access are vital to the distribution of up-to-date information for engineering, manufacturing, product support, and marketing.

Providing for a modular, flexible, and expandable system requires combining computer graphics and distributed processing to automate the production of technical documents. By using a local graphics server with its own processing power, the high cost of telecommunicating with a central processor is minimized and the performance of each user workstation is maximized. In addition, an upgradable series of review stations is useful for redlining of text and graphics. Suitable main processors are the Digital VAX series, and IBM PC XTs or ATs are good review stations.

In general, there are four major steps involved in the automatic digitizing process (Figure 2): scanning, vectorizing, classifying, and the intelligent output model.

Scanning, which is the fastest of the four processes, can scan a day's work in an hour. The operator then sets a series of filters for preprocessing and image enhancement. This process runs in batch mode on all the scanned drawings and passes the results to the vectorization algorithms. Once data has been vectorized (Figure 3), it is passed to a software package.

The software performs two major functions: segment—where the text and geometry are separated, and structure—where the data is classified as text, text strings, or symbols, and geometry is reduced to its geometric primitive (i.e., circle = center point and radius). The result of this process yields greatly reduced file sizes and more intelligent data for CAD usage.

A hybrid database can provide quick access to technical data on the graphics local area network (LAN) within each activity. The communications server provides the capability to connect with remote graphic LANs, packet switching networks, satellite communications, and other computer networks.

Optical Scanning

Most automatic digitizing systems start by scanning the drawing or document to capture and digitize a raster image file. There are two kinds of scanners that are particularly useful.

One uses a pass-through method

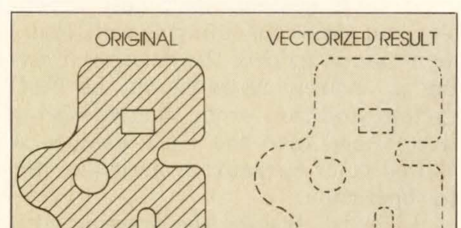


Figure 3—*Vectorization is performed on image data previous to its being classified.*

whereby the drawings are passed over a scanhead consisting of a linear array of charge-coupled devices (CCDs), covering the full width of the image area. Raw data from the CCD sensors is represented by a series of 8-bit digital greytone values, which are then adjusted according to information obtained from an initial calibration process. Corrected data is converted to a compressed binary format that defines each element of the image as either black or white. The whole process takes place in realtime. Drawings up to 54 in. wide with an image to 52 in. wide (26,000 pixels) can be accepted. Since a pass-through method is used, almost any length can be considered. Average scan speed is 0.2 in./sec.

Another scanner is a flatbed system whereby drawings are scanned by passing a scanhead over the drawing in a series of strips. This scanhead also consists of a linear array of CCDs and is mounted on a moving traverse. The flatbed is a high precision machined table with a vacuum system securing the drawing. This prevents bends in the drawing media that might cause distorted geometry. Typical scan speed for an E-size drawing with 50μ resolution is 260 sec.

The pass-through system is used for high quality, binary scanning of illustrations, engineering drawings, maps, or graphic and half-tone images with a low to medium density of detail. The flatbed is used where a high degree of geometric accuracy is required such as topographic applications and utility maps used for gas, electricity, water, and telephone systems. Scan data from both systems can be stored on hard disk, magnetic tape, high-density cartridge, or it can be transferred to an online host computer.

Different drawing media, such as paper, diazo, sepia, velum, and mylar may be scanned, and a continuously adjustable scanning threshold is used to help compensate for poor quality originals. Operators are guided through the scanning process by a user-friendly menu system. Scanned drawings are transferred to the database via a high capacity magnetic cartridge.

A special software package is supported on the scanner and database server that provides functions for image scanning, data files compressing, and entering these files into the user's database, using either the cartridge or via a direct communications link. Rerasterizing and scaling of scanned data is also supported to produce resolutions coarser than 500 dots/in.

Graphics Workstations

Many drawings require revisions or upgrading. Countless engineering change orders often leave many drawings with no relation between dimensions and actual measurements. Regardless of the reason, there is often human judgement required and a powerful graphics workstation facilitates the display, revision, merging, composing, and compression of graphic image data, whether the data is from the scanner, input from CAD systems, printed text, or by user creation at the console.

Image data is displayed on a high resolution 256-color monitor, which is controlled with a keyboard, data tablet, and puck. The software provides interactive raster image composition, editing, and illustration maintenance. It can include the following:

- prompting and help files;
- realtime image zooming, scaling, translation, and rotation;

- multilayering;
- geometric vector/raster-based design and updating lines, areas, ellipses, line types and thickness, textures, help lines (isometric) coordinate or image-based;
- realtime raster to vector conversion of selected parts within an image (vectorization);
- symbols, image macros, standard parts library, selectable in raster or vector/stroke representation, and
- composition of onscreen page layout, including merging of raster, text, and vector represented onscreen images.

Automatic Digitizing

Because many companies have rushed into CAD, there are often more problems created than there are solutions, mainly in management and personnel. While the economics of CAD/CAM can be disputed, the benefits of CAD/CAM cannot. With its accuracy and its forcing of various engineering disciplines toward unification and standardization, CAD/CAM is here to stay.

However, the problem of engineering drawings remains. Actually, justifying automatic digitizing is quite easy. If manual redesign is used to enter previous manually drawn documentation into a CAD system, automatic digitizing will easily cut that cost in half.

But there are more considerations than just the entering of drawings. The whole issue of engineering documentation is concerned. With digitizing equipment, text, old drawings, CAD generated material, and photographs can all be merged together through one system. The output can be archived, printed, or relayed via electronic communications.

Applications

Although the automated digitizing of drawings for integration into CAD/CAM systems is widely publicized as the most pressing need, data compression and archiving are equally important.

Illustrating the need for automatic digitizing is best exemplified through actual and planned installations. At Grumman Aerospace, an automatic digitizer system is used to scan and digitize 70,000 metal aircraft templates at the company's Long Island, New York headquarters. The system provides significant time, labor, and cost savings over a manual measuring and digitizing method initiated by Grumman about 6 yrs. ago, and is more accurate, achieving tolerances of 1/10,000 in. During the first two months the system was in operation, over 4000 templates were processed. Previously, it required a year to process just 1000 templates via the manual method.

Scan data is reduced to geometric primitives for use by Grumman's IBM CADAM "autonesting" program that feeds numerical control output generation of aircraft parts. Automated manufacturing is a key factor in reducing the price of government military contracts and cutting costs and improving turnaround time for spare parts production and retrofitting of aircraft.

"Because of the complex information presented in technical documentation, the automatic digitizing process must be capable of combining narrative content (text) with illustrations (graphics)."

Turnaround time has already been reduced from 30 to 90 days to just under 21 days.

The system used by Grumman consists of a 26½ x 39 in. scanning digitizer, two raster/vector color workstations, a VAX-11/785 computer, and a variety of related hardware, peripherals, and specially developed software. A second phase of the program calls for the system to be used to digitize background documentation for aircraft projects including text, graphics, engineering drawings, and publication materials. In the future, the system will be integrated with the development stages of engineering drawings and publications, plus it will be able to communicate information to remote sites.

Scandinavian Airlines Systems (SAS) plans to use an automated document scanning/data compression system to digitize, update, store, and transfer aircraft maintenance documents. It will be used to electronically convert aircraft maintenance documents, such as technical drawings, operations manuals, and work procedures from paper to digital form. Existing documents can then be updated directly on a computer graphics screen, thereby eliminating duplication and decreasing the time making record changes. Documents will be stored in digital form in a computer database, eliminating the manhours and space necessary to maintain them in paper form. The system will be able to electronically transmit documents to SAS facilities worldwide through network and satellite links in a matter of hours. Presently with manual systems, this can take days and even weeks.

Total Communications

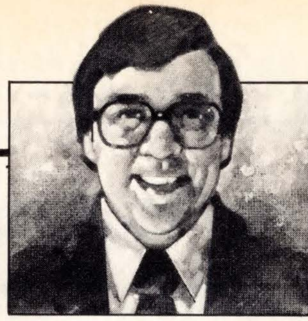
An automatic digitizing system should be looked at as the beginning link of an integrated engineering database communications system. Likewise, it can be viewed as the beginning link of an engineering electronic publishing system.

With a local area network (LAN) for graphics, the database of each activity can be connected with the graphics server supporting each user console. The graphics server provides the processing power to drive the applications software for each graphics console. Local equipment within each activity, such as the review terminal network or the regional business data collector, may also be connected to the LAN and a LAN gateway can be used to handle any necessary protocol changes.

Users have access to all system facilities via a menu-driven system. This user-friendly interface acts as a buffer between the user and computer operations and guides the user through available options and database queries.

And for communications with the outside world, the database of each activity has communication links to remote locations via X.25 packer switching, Systems Network Architecture (SNA), RS232, and V.35 serial data protocols. These functions are centralized at each activity by a communications server. This server may also handle high speed communications between activities, if the physical connections are available to support them.

Automatic digitizing systems should not be viewed as the panacea to all engineering communications. However, such systems can be the catalyst to developing totally integrated engineering data systems, as the automatic digitizer is the first step in actually converting paper drawings to an electronic format.



The VAXmate Report

by Theodore Needleman

The VAXmate is not intended to be a standalone PC

Digital Equipment Corp.'s recent announcement of the VAXmate has generated a lot of excitement. Many questions are being asked as to what the system can do, and the best ways to accomplish certain tasks. This column was established to provide *Hardcopy* readers with some of the answers. In upcoming columns, we'll examine both the hardware and the software (MS-DOS and VMS) that drive the system. We encourage you to write us with your questions.

Since the September 4 announcement, I've been frequently asked if the VAXmate will be a success and if I recommend purchasing one. There's no doubt in my mind that the VAXmate will be successful because of Digital's definition of success, and the VAXmate system itself.

It may be a bit of a mystery how a company can consider the Rainbow a failure with between one quarter and one-half million units sold, yet will consider the VAXmate a success if it sells the same one-half million. Part of this seeming paradox has to do with expectations. When the Rainbow was introduced, Digital felt that the buying public would flock to a superior engineered microcomputer. When they bought 9 million IBM and compatible PCs instead, Digital withdrew from the retail scene.

The VAXmate, on the other hand, is, contrary to popular belief, not an IBM compatible system. It may have a large degree of compatibility, but it was designed for a completely different purpose. The compatibility is a bonus, not the system's primary selling point. This may disappoint Rainbow owners who hoped the VAXmate would be their next step up—the system the Rainbow should have been, but never was. Because it wasn't designed as a "mass-market" system, Digital doesn't have any grandiose expectations for it. In the retail market, half a million machines represents a failure. To a niche market, especially the one Digital has designed the VAXmate to fit into, the same number of sales will mean Digital has been successful in meeting the particular need that they set out to fulfill.

That need, as Ken Olsen has pointed out frequently, is to do networking—to do it well, and deliver it now. And that leads to the second reason for success, the VAXmate's design. As its name suggests, the VAXmate was designed from the start to fit into a VAX-based network. It does so superbly. On the hardware side, the built-in Ethernet board allows easy connection to the network, and rapid transfers in both directions. The 80286 processor and 1 Mbyte of memory provide sufficient power to offload tasks of considerable size from the network. Tasks requiring more computing resources are handled by more powerful nodes.

". . . the first time you use VMS Services' ability to access the VAX's disk as a VAXmate virtual device, you'll wonder how you ever managed to get along with standalone PCs."

The hardware, while well designed (except for the pizza box overheating problem), is not the most impressive piece of engineering that Digital performed on the VAXmate system. This honor belongs to the software components—PC All-In-1 (on the VAXmate side), and VMS Services for MS-DOS (on the VAX side). These (along with MS-Windows when used with VMS Services) allow the VAXmate to treat the rest of the network simply as additional resources, accessible as easily as any peripheral included in the VAXmate's system box.

This sounds like a simple thing. In theory and concept it probably is. In the real world, however, it hasn't been particularly easy up to now. Networking is relatively new, and the development of "drop-in-and-use" network components represents a significant achievement.

And the very success in meeting this particular need answers the question of whether the VAXmate represents a good buy. If your need is for standalone microcomputing, go buy an IBM PC, a compatible, or an Apple Macintosh. The VAXmate is not for you, and chances are very good that you'll be sorry if you purchase it for this purpose. That's if you're even able to purchase just one. Digital has been very honest with potential buyers. They make no bones about it not being intended as a standalone DP system, and will not extensively support it as such. While I have no doubts that somewhere there will be Digital VARs selling turnkey systems built around the VAXmate, if you ask a Digital sales representative about the best micro-based general ledger package for the VAXmate, be prepared for a blank look.

On the other hand, if you are building, or if you have, a VAX-based network, it's a different story. The VAXmate will give you the ability to run whatever IBM-AT software you'd like, but it also offers three different user interfaces (MS-DOS, MS-Windows, and PC All-In-1) and almost effortless integration into the network. It's not inexpensive, but you wouldn't have bought Digital in the first place if you weren't impressed with the value of Digital's engineering. And the first time you use VMS Services' ability to access the VAX's disk as a VAXmate virtual device, you'll wonder how you ever managed to get along with standalone PCs.

Address correspondence to: Idea Technology, P.O. Box J, New City, NY 10956; MCI Mail to Theodore Needleman; or Source Mail to TCA920.

Unibus Electrical Characteristics Limit Optimum System Performance

Accumulated capacitive, resistive, and inductive effects on the Unibus reduce its reliability and throughput, but solutions to these problems exist

by John Jones
Setasi Research And Development

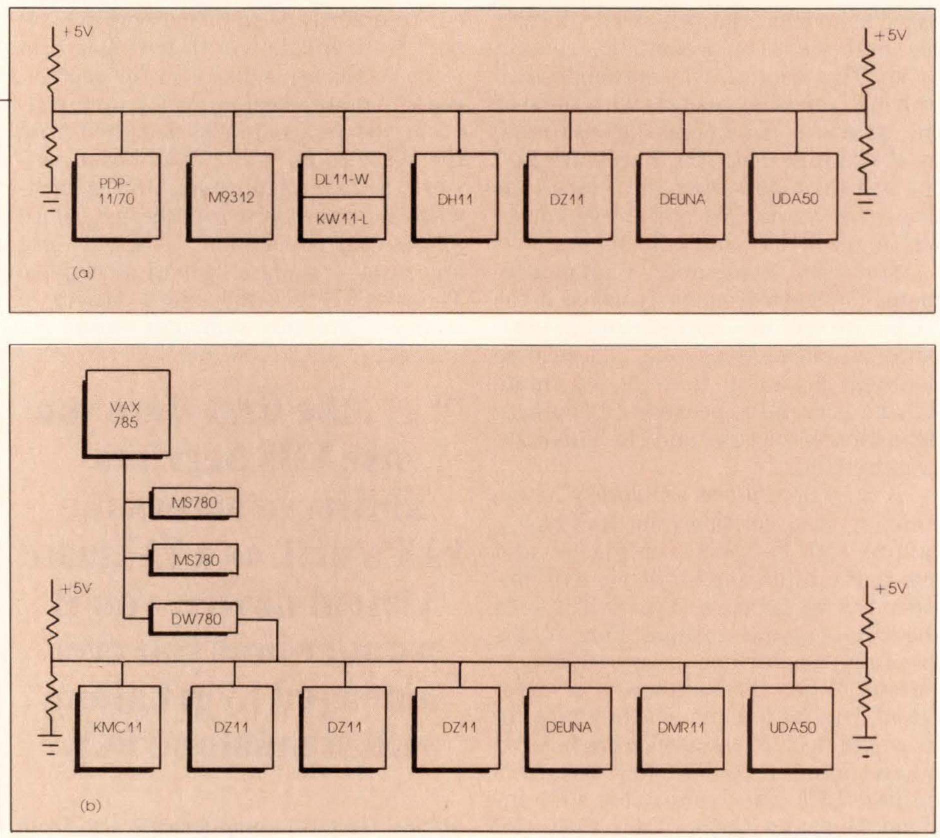


Figure 1—*The Unibus supports both standard PDP-11* (a) *and VAX* (b) *architectures.*

The Unibus is a parallel, bidirectional, asynchronous bus composed of 56 signal lines and provides the computer's major data highway, performing all transfers among the system peripherals, memory, and CPU.

Due to its asynchronous design, it handles devices of widely varying data transfer rates without increasing system overhead. Because each device runs at its fastest possible rate, replacing an older, slower device with a newer, faster one means the system runs faster with no other hardware or software changes.

Full direct memory access (DMA) is inherent in the structure with byte, word, or multiple word transfer capability, and is available to all DMA devices simultaneously.

Memory is the primary speed control device, and with MOS memories operating at 650–700 nsec, the Unibus can handle a 2-byte data transfer in approximately 900 nsec. This translates to more than a 2.2 Mbyte/sec. transfer rate that is available to any device on the system.

Its modular design allows maximum ease of configuration as virtually any device can be connected where there is physically enough room (Figure 1). This scheme also implements automatic priority selection and nonpolled high speed vectored interrupts. Power fail and auto restart are supported with either core memory or battery backed up MOS memory systems.

The Unibus architecture is also supported on many CPUs that aren't limited by the 256-Kbyte memory addressing scheme. These CPUs access their memory on a separate bus that the Unibus can also access; they can have main memory capacities up to 64 Mbytes.

Unibus Protocol

Unibus protocol consists of handling 56 signal lines grouped as address, data, control, arbitration, and failure reporting. These lines are asserted low ($<=.8$V) true, high ($>=2.5$V) false, with the five grant lines vice versa.

The signals of primary importance are the control signals, as these are effective immediately upon assertion or de-assertion, and are not de-skewed (as are the address and data). Another important item in an asynchronous bus is the fact that leading edges (asserting) and trailing edges (de-asserting) have

John Jones, president of Setasi Research and Development (Hollywood, Fla.), holds a Ph.D in computer science from the University of Massachusetts. He and his partner, Bud DeFore, worked at Digital Equipment Corp. for many years as a customer troubleshooting team.

equal importance in the successful completion of a transfer.

An example of a simple Unibus transfer best explains this. Consider that the CPU needs data from memory and is ready to use the bus. The following events occur (Figure 2).

- The CPU checks to see if any higher priority device is requesting use of the bus.
- If not, the CPU, now bus master, asserts bus busy (BBSY) to notify all other devices the bus is in use.
- The CPU then asserts the address of the location in memory on address lines A0-A17 and control lines C0 and C1 to indicate a read word operation.
- The CPU waits 150-180 nsec for the lines to settle (de-skew), then asserts master sync (MSYN) to notify all devices on the bus that a command is waiting for the slave identified by the address.
- The slave device—memory—decodes that it is to respond to this address, does an internal select, drives the selected data onto the data lines, then asserts slave sync (SSYN) to indicate to the master that its request has been fulfilled.
- The CPU, upon receipt of SSYN, latches the data on the data lines, then de-asserts the two lines commanding the bus, BBSY and MSYN.
- Memory, upon the de-assertion of MSYN, knows the transaction is complete, performs an internal de-select, and de-asserts drive on both the data lines and slave sync.
- The cycle is now complete and the bus is again ready for use.

While this transfer was occurring, the next bus cycle was being primed in the bus arbiter, and commences as soon as BBSY is de-asserted. The new bus master then asserts BBSY and the protocol implemented for its cycle—either interrupt request or DMA.

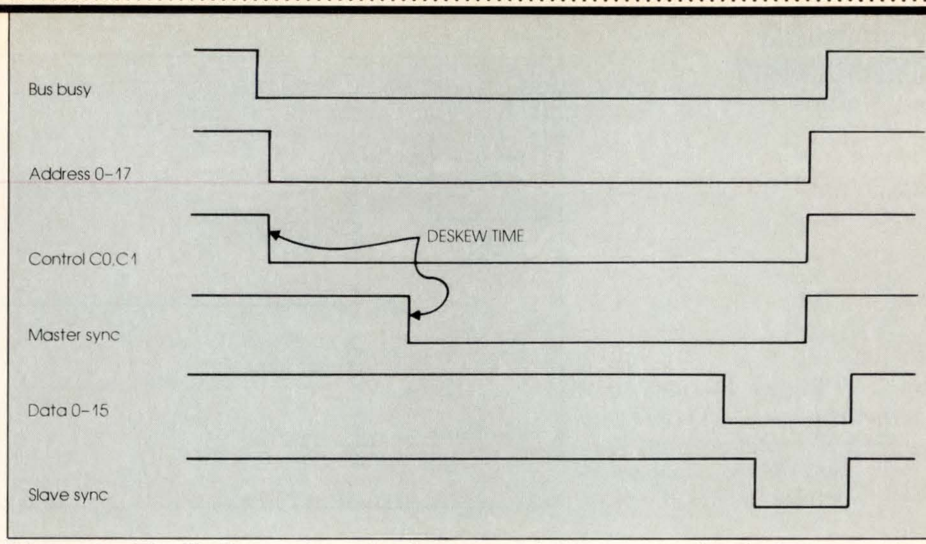


Figure 2—*The Unibus waits a de-skew time of 150-180 nsec for the bus to settle down before asserting the master sync signal to notify all devices on the bus that a command is waiting for the slave identified by the address.*

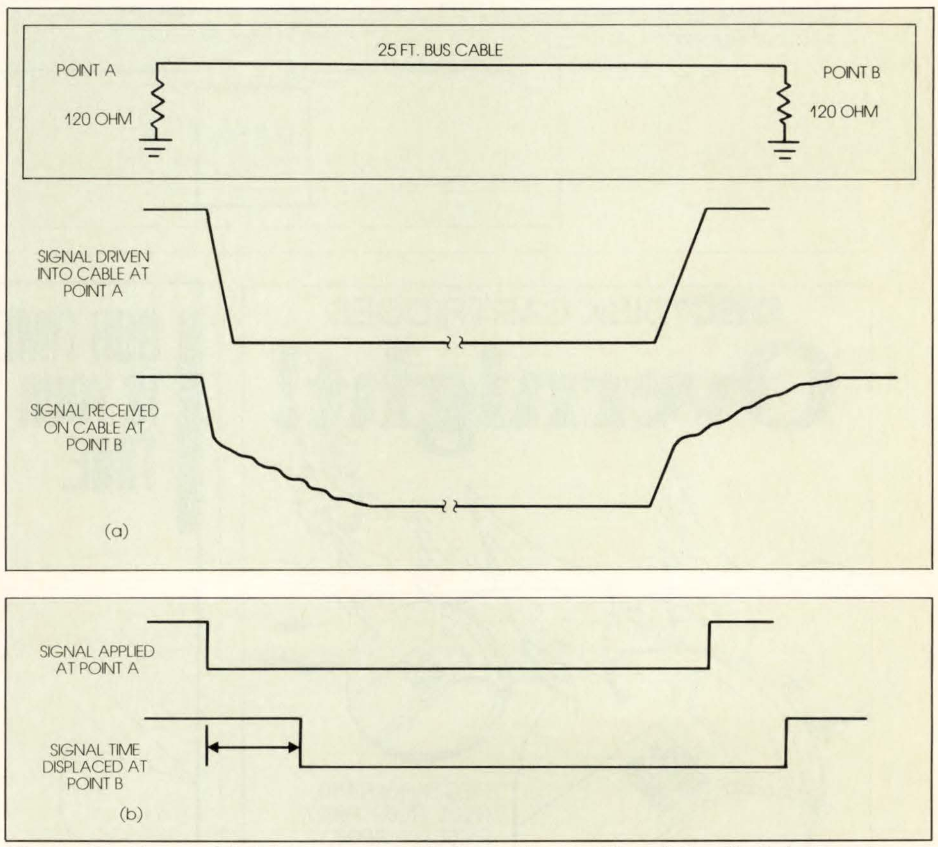


Figure 3—*Due to high frequency cable loss, the quality of the digital signals on the Unibus deteriorates as the signal moves through the cable* (a). *Propagation delay is another problem, and is defined as the difference in time between when a signal occurs and when it is received by the affected component* (b).

Transmission Line Effects

Transmission line effects can be grouped into several categories. Each imposes a different affect on the transmission.

High frequency cable loss—This is typically referred to as "skin effect," and occurs when a wire is driven with a fast-changing signal such as encountered in digital signals on the leading or trailing edge. It's desirable that the signal change from one state to the other as rapidly as possible. However, as this occurs, the wire stops carrying energy through its entire cross section and current flow is confined to the very outer perimeter of the conductor. Thus the resistance of the cable during the rapid transition appears to be much higher than the actual DC resistance of the conductor. This changes what was a sharp edge at the point of drive into the wire, into a type of stepped pulse at the other end (Figure 3a).

Propagation delay—This is the time required for a signal to travel from one point to another through a conductor. Contrary to popular belief, electricity does not flow through a conductor at the speed of light, but travels more typically somewhere between 50-90% of it, dependent on the materials used in the cable. The result is a very distinct dif-

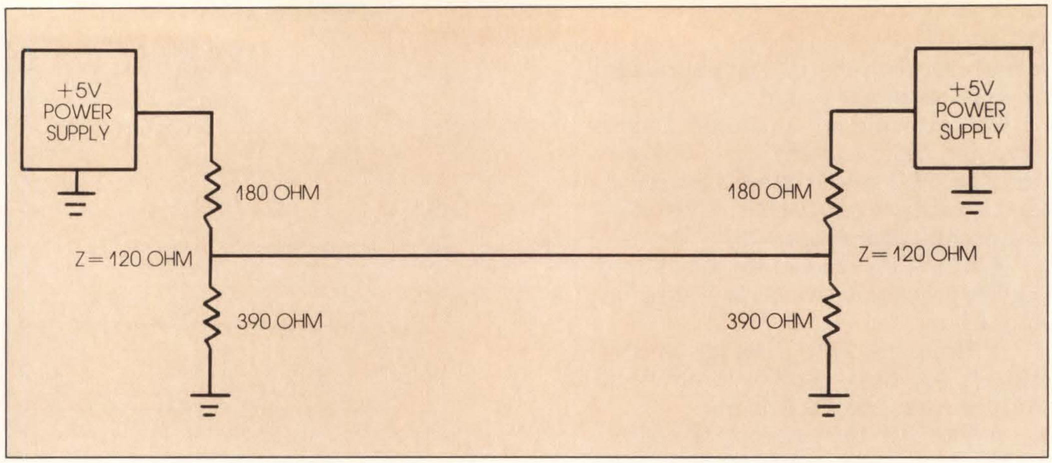


Figure 4—*Impedance matching is a technique used to ensure that the energy put into the transmission is received at the other end.*

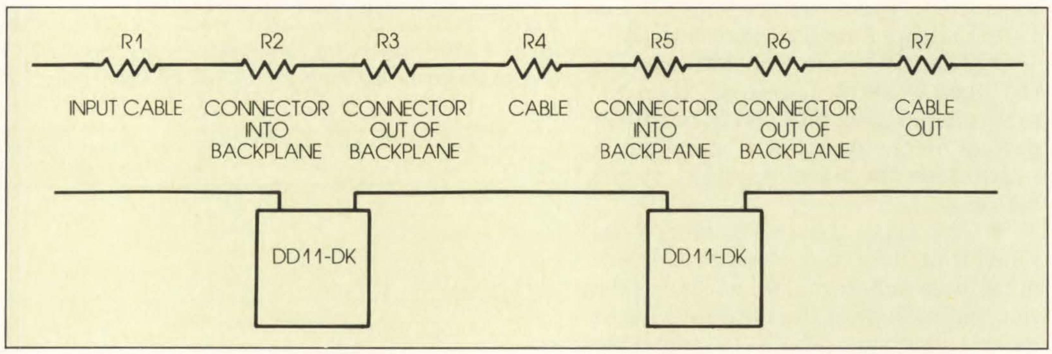


Figure 5—*Electrical resistance of the bus accumulates in the cable wire and connectors, as illustrated by the seven individual series resistances.*

ference in time between when the signal is received at the end of the cable and when it was transmitted. When using a cable with more than one conductor, or transitioning through a connector block, some of the conductors can become different lengths, resulting in a skew of times between transmission and reception (Figure 3b).

Impedance matching—This is a technique used to control the AC reactance of a line and thereby ensure that the energy put into the transmission is received at the other end. It's usually implemented by using a cable with a signal conductor and a ground conductor running parallel a particular distance from each other over the cable's length. This creates a characteristic impedance. Since this impedance is only true, considering no other losses, if the wire is of infinite length, it's further augmented by resistor termination (in the value of the impedance chosen) at both ends of the cable segment (Figure 4).

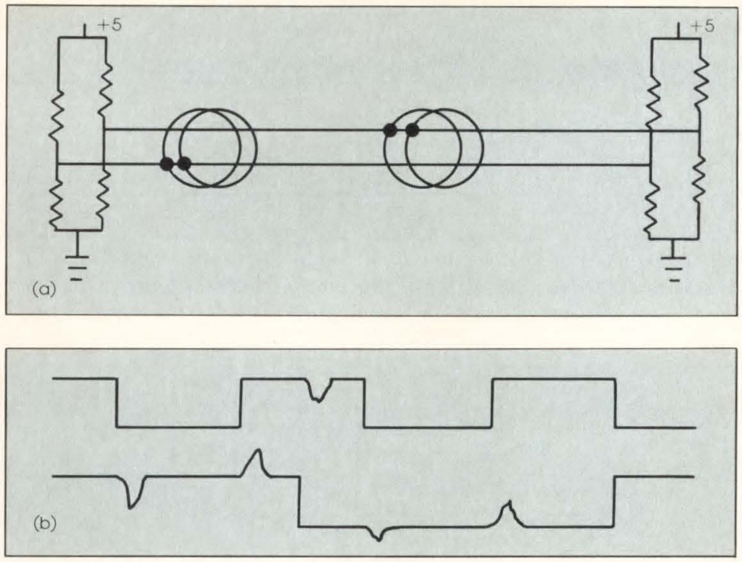


Figure 6—*Crosstalk occurs when lines of flux cut across conductors* (a). *The resulting waveform shapes in the conductors are distorted* (b).

Cabled resistance and connector losses—These are due to the material used to make a conductor. A piece of wire has a small amount of resistance per length, and as lengths become long enough to be useful, there's enough resistance to impact the amplitude of the signal received at the end due to the voltage drop on the cable. There's also resistance added at any point of mechanical connection, such as edgecard connectors or backplanes (Figure 5).

Cross talk—This occurs in a multiple conductor cable when many lines change simultaneously. The changes cause magnetic flux to develop around the changing conductors and can couple, with a transformer action, into another line in the cable that wasn't supposed to change (Figure 6).

Stubs and inductance—Stubs are connections to the transmission line to

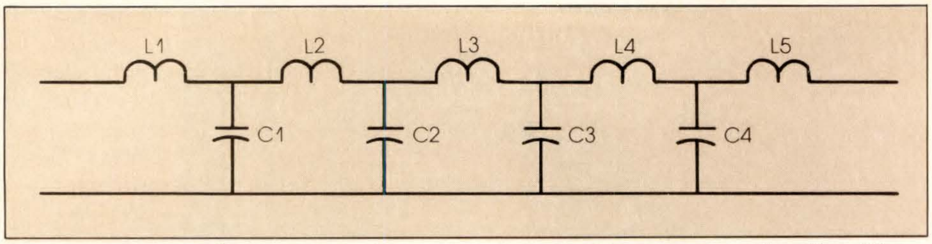


Figure 7—*Wire stubs act as capacitors when connected to a transmission line. The cable impedance caused by the segmenting of the bus is represented by the five inductors, and the stub equivalent capacitances are represented by the capacitors.*

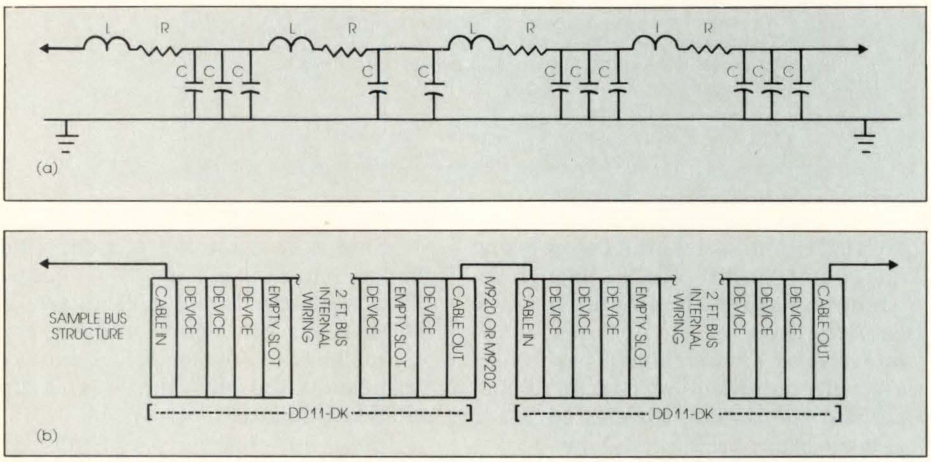


Figure 8—*The electrical representation* (a) *of a sample system bus structure* (b) *shows the complex RLC make-up of an actual system bus.*

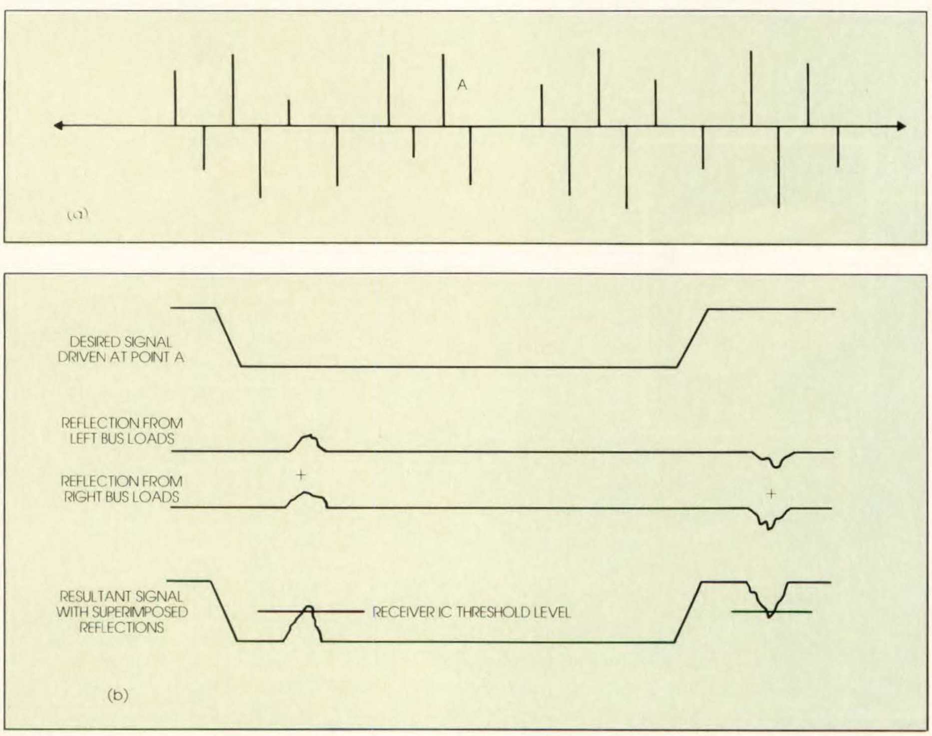


Figure 9—*A complex stub layout* (a) *is the reality behind an actual system bus. These stubs have a substantial effect on bus signals* (b).

link the information on the line to a device that needs to communicate over the line. They are formed of short pieces of wire that connect electrically from the main transmission path to some point on a module, and have the effect of connecting a capacitor to the line. The amount of capacitance is related to the length and mechanical position of the connecting wire. The inductance of cable runs between and within transition blocks, which can have variations, depending on the cable's proximity to metal chassis and racks, needs to be considered in an analysis of signal transitions (Figure 7).

Transmission Line Effects

Figure 8 shows a sample system bus structure and its electrical representation when transmission line effects are considered. The Unibus is a very complex RLC (resistor, inductor, capacitor) network. Fortunately, however, just one item is responsible for the majority of problems encountered.

The bus is no longer a clean piece of wire strung between two terminators with only one driver and receiver. Figure 9a is a representation of the stub layout for the sample bus structure of Figure 8. The stubs are the short pieces of wire connecting the IC's on the modules to the bus conductor.

"Systems using the Unibus range from the low end PDP-11/05 to the VAX 8000 series."

The major effect on the transmitted signal is produced by the stubs. They "de-tune" the transmission line. This occurs because they act as an energy storage point that dumps or absorbs energy during a transition, and as a varying resistance during a transition that causes impedance mismatches.

As shown in Figure 9b, when a signal is asserted (high to low) on the bus, it propagates down the conductor with a stepped wavefront. As this front encounters a stub (capacitive load) that was previously charged to the quiescent voltage of the bus, energy stored in the capacitor is discharged onto the bus. This discharge causes the signal level to rise above the lower level of the wavefront that was initially transmitted, and reflect back toward the transmitting device. If the capacitive load stored more energy than the transmitting device could instantaneously dissipate, its output level also rises. Since this reflection is directed back at the transmitting device from both directions on the bus, the waveform at the driver is composed of the two reflections superimposed. Thus added, it results in a level rise that may cross the

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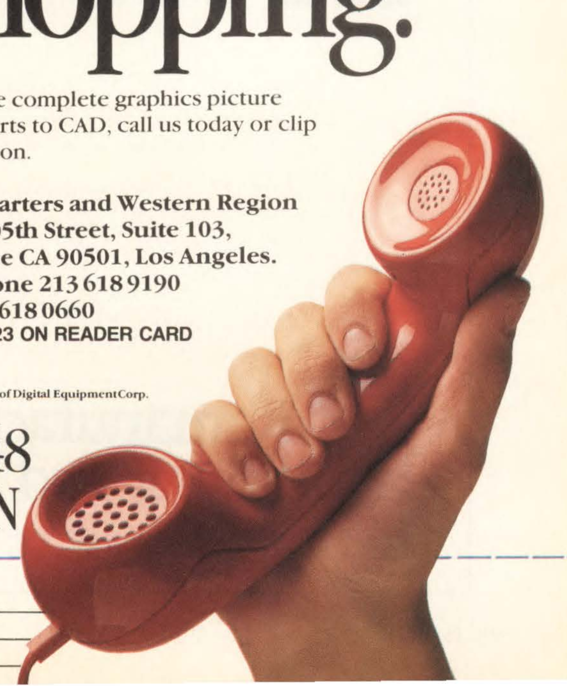

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CITY ______ STATE ______ ZIP ______ PHONE ______ threshold of other receivers on the bus. The same phenomena occurs at de-assertion of the signal (low to high), but with a low-going transition during the reflection.

To gain an understanding of the effect this has on a system, consider the previous example of a data transfer between CPU and memory, but occurring in the system environment.

In this example, there are more than two devices connected to the bus, and while only one device is to be active at any given time, a second device is arbitrated and ready immediately following the finish of the current transaction. This is commonly referred to as pipelining and is implemented to allow maximum throughput.

Assume the following conditions.

- The CPU is just finishing a transfer from a slave.
- The disk controller has been arbitrated for a nonprocessor request (NPR) cycle next.

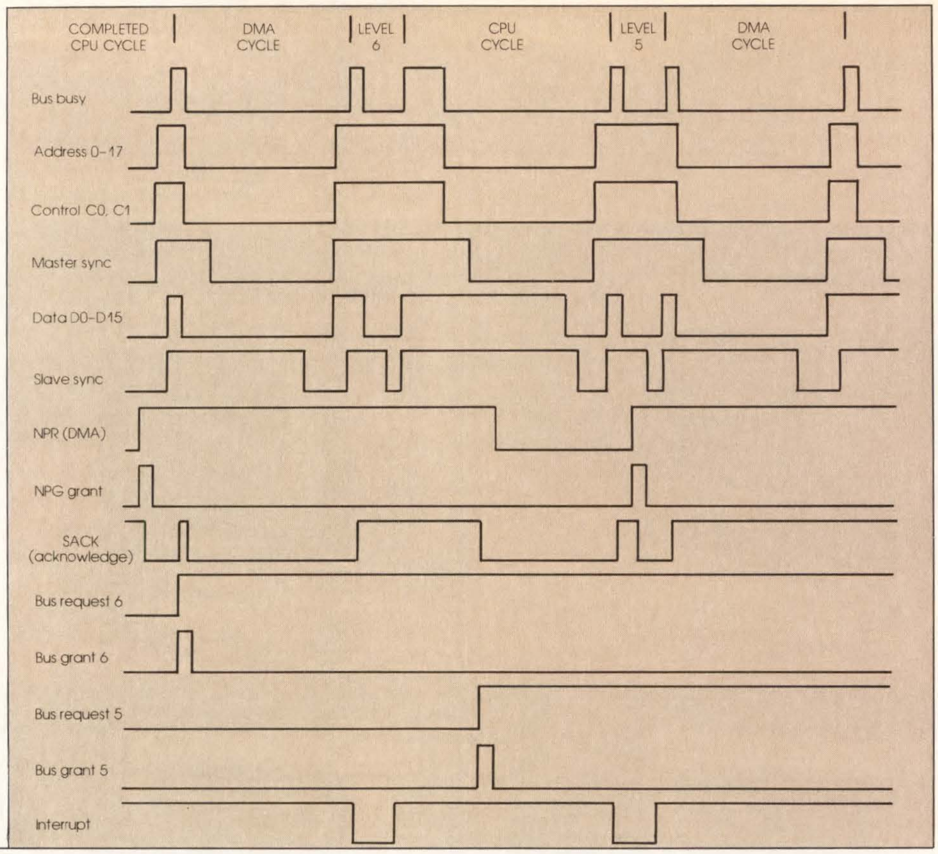

Figure 10—*A high level of activity on the Unibus allows for many possible errors due to the effect of stubs. See text for an explanation of this bus activity.*

• The DZ is requesting an interrupt on level 5.

• The line time clock is requesting an interrupt on level 6.

• Other DMA (NPR) activity may also occur at any time.

Figure 10 shows the timing sequence. The NPR cycle occurs first; it has the highest priority, but even if it hadn't, it has already been arbitrated. As soon as it starts, the interrupt request will be arbitrated with level 6 winning right to the next bus cycle, and when the arbitrator allows during the service level 6 routine, the level 5 request will be honored. This assumes that no other NPRs appear, as they can be interlaced within the level 6 service routine.

During this time, there have been several points at which control signals changed when another device was primed to use the bus. At these points, a glitch in one of the signals could have crossed the threshold of a receiver IC, allowing two devices to use the bus simultaneously. This results in the wrong data going to the wrong place, with possibly no failure indication, or an illegal interrupt. Or it may result in a data transfer being cut short with wrong data transferred or a cycle being hung, resulting in a bus timeout and a trap 4 crash.

Transfers that are garbled due to transmission line effects cause, at minimum, lost data or retransfers of data, requiring more system overhead. At the high end, total system corruption can occur.

Crash dump analysis tapes and error logs rarely indicate what caused the system to fail in these circumstances, as they only record events the system can logically sort out. This is the logical explanation for most illogical system crashes.

Bandwidth

Bandwidth is a term often misused in the computer industry. It refers to the operating frequency of a particular item, and is a count of complete cycles per a given unit of time, usually 1 sec. Properly used, it indicates a television receiver uses a 5-MHz bandwidth to display a standard video signal with sync and sound, or a high resolution graphics monitor may have a 35-MHz bandwidth required to plot all of the pixels required for sharp graphics. It's a measure of how many times something occurs, not how much information was transferred.

Throughput is the measurement of how much a specific commodity is moved within a given period of time. For computers, this is usually measured in megabytes per second (Mbytes/sec).

Another item that must be taken into account is the difference between theoretical and realistic throughput ratings. It's very typical of manufacturers to give a throughput specification based upon a particular operating mode of a given architecture. While what they say is true, in a real system application, achieving even a 50% mark may be unrealistic.

Consider the VAX-11/780 system. It has a bus rated at 13 Mbyte/sec. This is the theoretical upper limit, and with the proper data transfer sequence occurring and proper hardware installed, it could be realized. Realistically, however, this rarely happens in a system application.

When disk data transfer rates in the 2.2 Mbyte/sec. range became available some years ago, the 780 needed to be upgraded to two interleaved memory controllers to handle it. On the surface this seems contradictory, but in reality, while the bus could handle the transfer rate, the devices connected to it could not. With system overhead and the disk transferring simultaneously, this became a problem.

The synchronous architecture of the VAX-11/780 SBI can transfer from 1 to 8 bytes/cycle time. One full cycle typically requires seven or eight 200 nsec cell times, or about 1.4 μsec, which results in a .7 Mbyte/sec. to approximately 5 Mbyte/sec. average throughput, depending on the devices using the bus. The architecture uses the same amount of time to handle a fast device as it does a slow one. In typical applications, approximately a 3 Mbyte/sec. throughput is more realistic.

This in no way degrades the 780 architecture; it is simply mentioned to distinguish theoretical from realistic values.

The Unibus is an asynchronous bus, which means its cycle time varies dependent upon the device using it. The primary speed controlling device is memory. Most MOS memories used require approximately 650 nsec access time and 250 nsec bus overhead time to complete a cycle. This translates to a bandwidth of about 1.1 MHz and, whether doing a 1- or 2-byte transfer, either 1.1 Mbyte/sec. or 2.2 Mbyte/sec. throughput rate. This maximum rate is available to any DMA device on the bus, since DMA is the highest priority for bus use.

In both the Unibus and the SBIbus, interrupts were not considered in the throughput analysis. While they are a very necessary part of the overall operation, they make up only a small portion of total bus activity. An asynchronous bus also wins here, as it will usually handle an interrupt twice as fast as its synchronous counterpart.

Some other major differences between synchronous and asynchronous busses should also be considered.

A synchronous bus gets around transmission line effects by adding deskew to each of its clock cell times, resulting in the time for the operation plus about 100 nsec/clock cell as a minimum. This severely limits the length of the bus. Asynchronous busses must handle these effects only once per cycle, not seven or eight times.

On synchronous systems, degradation in speed of a device very rapidly results in system failures; thus fixes are required that help keep devices operating near peak performance. Conversely, asynchronous device slowdowns in response simply cause the system to slow down to accommodate them. These may take the form of slowed slave responses, illegal interrupts that waste CPU time, or passive bus releases.

Running at its standard DMA transfer rate, a Unibus can move enough data to fill a 700-Mbyte system disk in about 5 min. That is, if the system can accumulate that much data that fast, and if the disk can handle that transfer rate. Since that's more data than is usually handled in a day, it should be of little concern.

The Unibus will move enough data to support virtually any standard application, and most high speed applications. This assumes, however, that the bus is configured to attain its maximum throughput.

Solutions

There are several means of approaching an ailing Unibus problem. These are not in terms of solutions for root problems that affect a properly configured but heavily loaded bus, but in terms of making the bus as clean as possible. They are as follows:

- make cable lengths as short as practical;
- ascertain the BC11A cables have foam between the two runs;
- verify the cleanliness of the connectors on the ends of the cables;
- have a "bus tuner" tune the Unibus to the specific configuration.

While the first three are reasonably easy to accomplish, the last is close to impossible, and quite impractical. Assuming the first three items are implemented in a system, the most uncomplicated method of enhancing bus integrity is to install a segment isolator/high speed repeater on the system, such as the VSI/HSR available from MRI Computers (Ft. Lauderdale, Fla.).

Segment isolation causes the Unibus to be broken into two or more smaller segments instead of a single long bus, with proper termination at each end of a segment. This helps by distributing the capacitance to electrically isolated pieces of the bus, thereby reducing the amount of capacitive loading and impedance mismatch affecting the signal in that segment. This reduces the reflections that are the main source of the problem. As it changes timing, shortens duration, and lowers the amplitude of reflections that do occur, it in essence renders them harmless and of no consequence to proper operation. By shortening the length of the bus segment, it also lowers the voltage drop due to the length of bus cable, thereby providing a better signal level to the entire bus segment.

High speed repeating means that the propagation time through the repeater is fast enough that the system operates with virtually no degradation in speed due to increased bus cycle time, and adds an additional driver at each point where one is installed. This helps keep reflections in hand by having extra drive capability to sink the energy found in a reflection. It also means that an additional set of DC loads can be added to the bus.

Quite often, an overall system response time decrease (i.e., the system runs faster) is noted when the segment isolator/high speed repeater is installed. In most cases, this is due to reduced system overhead by eliminating most data transfer errors, which converts system time previously spent on retries to useful data processing time.

It also allows the system configurator greater flexibility in the bus structure as high speed devices will operate through several segment isolators/high speed repeaters without system degradation.

A segment isolator/high speed repeater is not just for large busses. On any size bus, it provides continuous integrity verification of the bus transactions, and often helps make an intermittent type problem very repeatable, and therefore easily repairable. ∎

How would you rate the technical information in this article?
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The Assembly Line

by Dr. Robert J. Schlesinger and Sylvia Tiersten

CIM, AI, and telecommunications fuel market for CIOs

Move over CEO and CFO, here comes CIO—no longer a typographical error on a business card, but a legitimate job title. The salary range for a chief information officer can run up into the $200,000 range or higher, according to Herb Halbrecht of Halbrecht Assoc., a Stamford, Conn. executive research firm. Computer integrated manufacturing, artificial intelligence, and telecommunications are fueling the market for CIOs or their equivalent; alternative titles include VP of information and strategic services, VP of information and logistic services, and VP of information resource management.

Halbrecht's hypothetical CIO is a kind of corporate visionary who works for a large corporation, probably reports to a CEO or some other high ranking official, is responsible for strategic aspects of management, and has a knack for spotting and tracking breakthrough technologies. He or she has "a passion for technology, some hands-on management experience with technical activities—but doesn't have to be a technologist," says Halbrecht. Finally, this individual "is not preoccupied with day-to-day DP functions."

If a company wants to install LANs on the factory floor or expert systems in the front office, then it's up to the CIO to assess the impact of the new technology on the company and its workers, and the availability of resources for making such a change.

Where does the qualified CIO come from? Only occasionally from the ranks of DP or MIS managers, says Halbrecht, although "some MIS people would like to be CIOs. Sometimes they are just looking for the title change," but once they have it, "their role doesn't change dramatically at all. And if it did," Halbrecht reflects, "they wouldn't be able to do the job."

Years ago, he recalls, there was considerable talk about the four stages of the MIS executive. At the bottom is the tinkerer who is interested in computers. A notch or two higher is the techie, who "knows technology—but doesn't understand its implications," Halbrecht says. The third category is the expert, a technically competent individual who understands the implications of the new technology, "but cannot market the thing internally." Stage four is the facilitator, who can "weave the technology into the corporation."

"If a company wants to install LANs on the factory floor or expert systems in the front office, then it's up to the CIO to assess the impact of the new technology on the company and its workers . . . ."

The CIO represents stage five in a corporate environment "where technology is actually a major factor in driving the company. Stage two and three individuals almost never get to that level." says Halbrecht. At present, he knows of no university that is specifically grooming its grads for the CIO role, which is probably as it should be. After all, ponders Halbrecht, "how do you train someone to be intuitive and creative?"

* *

The pros and cons of offshore manufacturing continue to consume megagallons of printers' ink. Recent articles in *Business Week* and *Forbes* suggested that the United States is squandering its intellectual capital and manufacturing skills by turning to overseas suppliers. "Our technology is leaking abroad almost as fast as we develop it," warned the editor of *Forbes*. At a seminar titled "How Offshore Opportunities Can Improve Your Competitive Edge" at the Wescon/86 electronics engineering show in Anaheim, Calif., speakers took a more bullish approach. But even invited lecturer Harry Bowers, whose contract manufacturing firm has maintained a presence in Asia since 1981, conceded that going offshore may be fraught with peril—particularly for the uninitiated.

Bowers, a vice president at Flextronics, a Newark, Calif.-based concern, began with a discussion of contract manufacturing. Many U.S. firms, he noted, including General Motors, no longer build their own products from the ground up. To circumvent complex technologies and procurement systems, they hire an outside subcontractor to manufacture either the entire product or some portion of it.

Although Flextronics maintains some domestic fabricating facilities, the company also has plants in Singapore and Hong Kong and plans to put one in Thailand as part of a joint venture with Japan. "These days," says Bowers, "you don't go to Asia for cheap labor. The issue is material." He claims that 90% of all materials that are routinely used in electronic products cost less in Asia than they do in the United States.

As to whether a company should build its products on or offshore, "there is no black and white answer," he says. "If your product has eight custom chips and the chips are no less expensive in Asia, then you might want to assemble your product at home."

Security—or the lack of it—remains a major issue. Countries such as Hong Kong and Singapore have acknowledged piracy as a threat to their own industrial success. Therefore, product rip-offs seem least likely in these Asian countries. On the other hand, politically unstable Korea "is still a great risk. I have witnessed a product coming back from a customer that is painted a different color with a different name," says Bowers.

Another Wescon speaker, Joseph T. DiBene, president of international operations at Maxtor Corp. (San Jose, Calif.), chided American companies for their egocentricity: "We must begin to look at foreign places as a shopping arcade. The world really is that small and accessible if you are going to be successful today." For more than 20 yrs., he noted, Japan has been shopping at its "secret supermarket—Southeast Asia—and the Japanese are masters at buying."

DiBene fears that many American firms are still "chasing cheap labor all over the world" and "still worrying about the wrong problem." Unlike the 50/50 ratio of material-to-labor costs of electronic products some 10 yrs. ago, material now accounts for 80-85% of the total cost.

Ticking off possible procurement strategies in Asia, he cited working through an Asian trading office, making twice-yearly trips to the continent, "putting one of your men in a small office in some key offshore area," building the product offshore, and subcontracting. "Above all," DiBene warned, "don't go offshore until you get your act together at home first."

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 who frequently reports on computer topics.

New High End Disk Alternatives For Digital Systems

Now it's possible to connect high capacity, high performance industry standard disk drives to VAXclusters and VAXBI systems through Digital's Standard Disk Interface

by Larry Tashbook
Emulex Corp.

In the past 3 yrs., the performance boundaries of the VAX architecture have been extended in several areas. Bus performance is one of the more dramatic examples: The VAXBI introduced 1 yr. ago touts a 13.3 Mbyte/sec. throughput that greatly surpasses the 1 Mbyte/sec. throughput of the Unibus. Much greater performance is also reflected in processor speed—the top-of-the-line VAX 8800 is capable of 12 million instructions per sec. (MIPS) compared to the 1 MIPS peak of the VAX-11/780, once the industry standard for minicomputer performance.

Along with the increase in processing power, the VAX now has greatly expanded access to data and computing resources due to the VAXcluster architecture. The loosely coupled VAXcluster makes it possible to build a computing complex with the equivalent of 60 MIPS processing power and several hundred Gbytes disk storage that supports thousands of users.

Yet, while recent VAX CPUs have been reaching new heights, the disk storage peripherals available from Digital Equipment Corp. for the VAX have been in a holding pattern that dulls the luster of system performance gains. Unless all the elements that determine overall system performance—including the processor, main memory, I/O, and disk storage—are in close proportion, a system will fail to achieve its full potential.

In the past, when a typical Digital installation had a 1 MIPS VAX-11/780 and Unibus peripherals, the top-of-the-line 456-Mbyte RA81 disk drive with its 2.2 Mbyte/sec. burst data rate was adequate. The Unibus was the bottleneck that limited overall performance. With the Unibus fading out of the picture as VAXclusters and VAXBI systems gain popularity, the RA81 has now become the bottleneck.

Digital is not yet delivering disk drives with the performance, capacity, and reliability necessary to make the most of increased VAX capabilities. As of this writing, the rumored RA82 has increased capacity, but offers no greater throughput.

On the other hand, companies that make a living solely from manufacturing disk drives would soon be out of business if they failed to keep up with the latest technology. A very competitive market has spurred manufacturers to develop drives that clearly eclipse the RA81 in virtually every respect, offering higher transfer rates, lower access times, greater capacity, longer meantime between failure (MTBF) ratings, and exceptional price/performance ratios.

As VAXclusters and VAXBI systems gain popularity, Digital's RA81 disk drive has become a performance bottleneck.

While these drives clearly go a long way toward easing and possibly eliminating the bottleneck caused by the RA81 on VAXBI-based systems and VAXclusters, Digital restricts its users' choice to its own proprietary RA series drives. Digital controllers support only Digital's Standard Disk Interface (SDI) used by the RA drives, so the far more competitive industry-standard drives such as those using the Storage Module Drive (SMD) interface are not supported by Digital.

Digital also discourages independent development of controllers that implement the SMD interface on VAXBI and VAXcluster systems. The VAXBI is closed to vendors not licensed by Digital and protected by Digital's desire to uphold its "intellectual property rights" in court. Companies providing competitive mass storage products will not be granted BI development licenses.

There is, however, a straightforward solution that doesn't infringe on Digital's patents. Make the high performance disk drives that are available on the market, particularly SMD/SMD-E drives, appear like RA drives through an emulating interface for the SDI port on Digital controllers. One such interface is the Storage Module Disk Interconnect (SMDI) from Emulex Corp. (Costa Mesa, Calif.). With SMDI installed, the user can connect an industry standard disk drive with the SMD or SMD-E interface to any Digital

Larry Tashbook, director of strategic marketing, storage products for Emulex Corp. (Costa Mesa, Calif.), holds a B.S. in geophysics and geology from City College of New York and an M.B.A. from Pepperdine University. He was previously vice president of marketing for U.S. Design Corp. (Lanham, Md.).

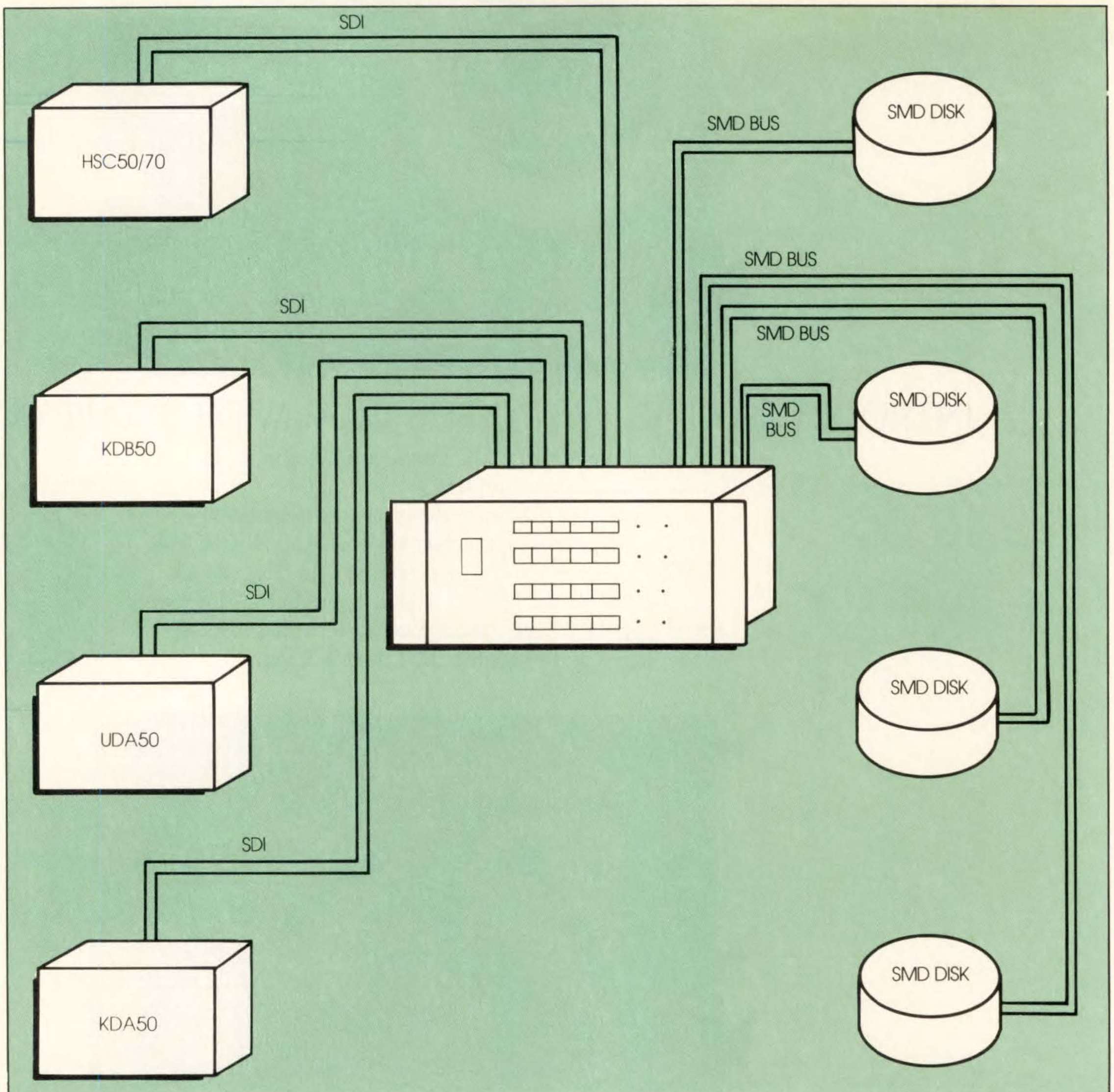

Figure 1—*Several Digital controllers use one common interface: SDI. By transparently converting SMD bus protocol signals to SDI signals, an SDI/SMD converter can work with a variety of Digital systems and VAXclusters.*

disk controller that supports SDI, including the HSC50/70 used on VAXclusters and the KDB50 used on VAXBI systems.

The "C" series of disk drives from System Industries (Milpitas, Calif.) also provides RA emulation, but unlike SMDI, the emulation circuitry is contained within the drive and is available only through SI. The SMDI consists of an independent converter that can connect to many different drives using the SMD/SMD-E interface.

100% DEC Compatible

Using a disk-emulating interface rather than building a new controller represents an approach that provides Digital users an alternative in selecting compatible disk storage peripherals for Digital systems. It offers both complete compatibility with the Digital Storage Architecture (DSA) used on all large VAX systems and VAXclusters and protects the user's investment in disk storage peripherals.

Because SDI bus protocol signals are transparently converted to those used by SMD disk drives and vice versa, resulting in a logical emulation of Digital's RA80/81 drives, no operating system modifications are required and all the features of DSA are maintained.

One of the key features of DSA is the ability to support different drives, and SDI/SMD converters take full advantage of this capability. Prior to the development of DSA, offering a new disk drive was a cumbersome task requiring the writing or modification of the disk device driver—a real headache for the vendor and user. DSA and the Mass Storage Control Protocol (MSCP) were developed to solve that problem by providing a generic disk "class driver." Now, all that's required to support new disk drives is providing the controller with the parameters of the new drive.

Thus, it's possible to connect almost any size disk drive to a VAX system whether it's a Digital drive or an SMD drive made to look like a Digital unit. When the Digital controller checks for the drive type and parameters, the SMD drive is identified as an RA81, but with different size and performance parameters. Since DSA is designed to accommodate drives of different sizes and performance, the controller simply adjusts to the new parameters and goes to work.

The approach of emulating the SDI interface provides an easy migration path across different Digital systems. SDI is the interface used by DSA-compatible controllers, including the HSC50/70, KDB50, KDA50, and the UDA50 (Figure 1).

Full RA81 Emulation

In addition to emulating SDI, an SDI/SMD converter is designed to make SMD drives appear functionally like an RA81 in many respects, providing support for full diagnostics and RA81-like front panel switches.

The SMDI is housed in a 19-in. rack-mountable enclosure that contains a power supply, room for up to four SM80 SDI/SMD converter boards, and a front panel assembly. The 5¼-in.-high unit is typically contained in a cabinet with room for up to four disk drives, similar in size to the RA81 cabinet used by Digital.

At the heart of the SMDI is the hex-size SM80 board that mounts in the SMDI chassis. Each SM80 can support one SMD disk drive, with transfer rates of up to 3.125 Mbyte/sec. An Intel 8085 microprocessor is used to drive the unit. To support dual porting, the SM80 is equipped with two SDI ports.

A single 512 x 8 PROM used for drive configuration can contain up to four different predefined configurations, with alternative configuration PROMs available. The maximum sectors per track is 256, and the maximum number of cylinders per drive is 65,535. Configurations are selected by option switches located on the SM80.

The front panel switches and LED indicators located on the SMDI system unit provide the same level of control as on the RA81. Switches and indicators are provided for run, port select, write protect, fault, and diagnostic modes.

As for diagnostic modes, the SMDI has three basic diagnostic sequences. The power-up sequence runs whenever the unit is turned on. A default sequence runs whenever a request is made from the SDI controller. And the user can initiate an internal diagnostic sequence of 18 tests from the front panel. The internal test thoroughly checks the subsystem, running through the entire chain of operations from disk interface to drive read/write heads, and back to the adapter.

Formatting of drives is a special consideration. For new installations, preformatted SMD disk drives are available. For users who want to migrate their present disk drives, disks can also be formatted in the field. An SMDI Field Format Unit is available that can format drives from the drive manufacturer's defect lists or from a user-entered defect list in about 30 min.

Performance And Capacity

To date, the SMDI is the only DSA compatible product available that can support a variety of different disks with a 3.0 Mbyte/sec. data transfer rate. Only the HSC50/70 with the 13.3-MHz clock rate can support a 3.0 Mbyte/sec. data transfer rate. The HSC50/70 with a 12-MHz clock rate, the UDA50, and KDA50 can only maintain a maximum data transfer rate of 2.8 Mbyte/sec.

Of course, the Digital controllers all offer higher transfer rates than the RA81 at 2.2 Mbyte/sec. More importantly, in multiuser inquiry response environments, the RA81 is hampered by its comparatively slow seek time of 28 msec. SMD disk drives can help ease the bottleneck caused by the RA81's slow seek times by providing seek times as low as 16 msec.

A representative sample of what's available in the industry today is the 9772 14-in. disk drive from Control Data Corp. (Minneapolis, Minn.) using the SMD-E interface. This drive features a 3.0 Mbyte/sec. data transfer rate, an average seek time of 16 msec, a formatted capacity of 661 Mbytes, and an MTBF rating of 30,000 hrs.—or 3½ yrs. of continuous service. At the same time, the CDC 9772 is one of the most cost-effective disk drives ever produced on the basis of price per formatted Mbyte. With a list price of $16,800, the 661-Mbyte drive (formatted) costs less than $25/Mbyte. The RA81 has a per Mbyte cost of $42, while the RA80 costs $116/Mbyte.

Unlike Digital, which is sitting on the laurels of its almost 5-yr.-old RA81, other disk drive manufacturers have been continuously introducing ever more powerful and more diverse products. At Fall Comdex, CDC introduced a new version of the 9772 drive, offering 1330 Mbytes (unformatted) storage capacity. The drive is scheduled to start shipping during the second quarter of 1987.

Also making their debut at Comdex were several high capacity 8-in. disk drives using the SMD-E interface. Drives using an 8-in. form factor make a lot of sense in many VAXBI installations. With systems such as the VAX 8200 and 8300, Digital has greatly reduced the size of the processor in comparison to the VAX-11/780 and 11/785. But the footprint of the disk storage

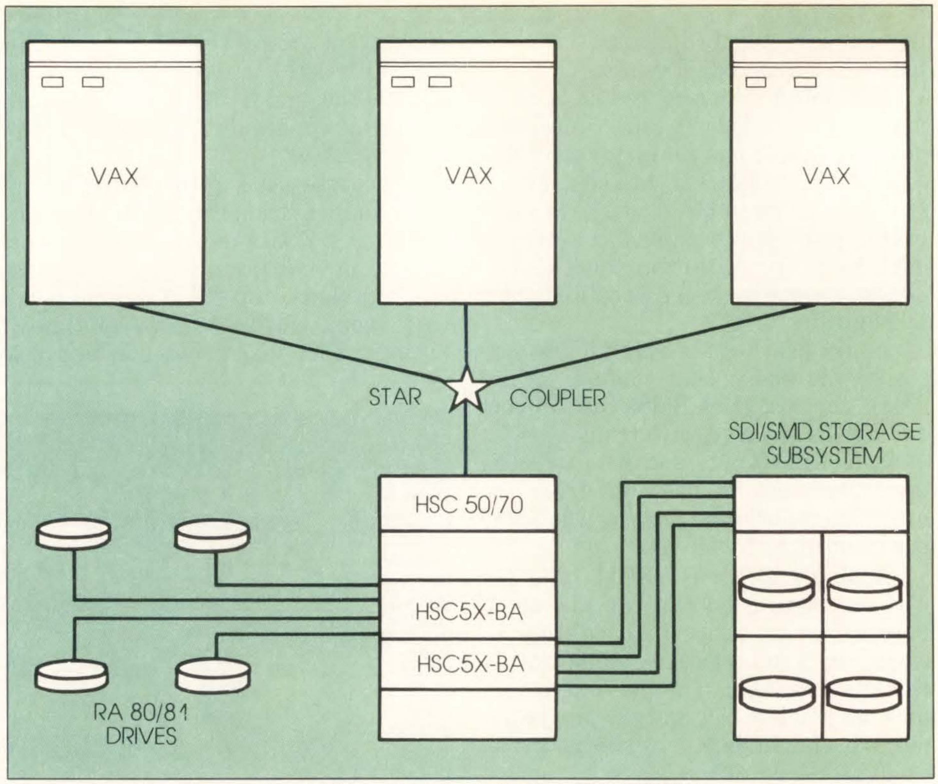

Figure 2—*In an existing VAXcluster installation, SDI/SMD storage subsystems can be added to, or mixed with, existing RA80/81 drives.*

subsystem has stayed constant. Eight-in. drives can be mounted two-abreast in a standard cabinet to boost the amount of storage that can be packed into a given footprint.

At Comdex, new 8-in. drives with capacities of more than 600 Mbytes were on display. Fujitsu America's (San Jose, Calif.) latest 690-Mbyte, 8-in. model offers an average access time of 18 msec and a 2.46 Mbyte/sec. transfer rate. Rodime PLC (Glenrothes, Scotland) announced an 8-in. unit using the SMD-E interface with 674 Mbytes (unformatted) storage capacity.

Universal Application

The need for high capacity, high performance, reliable, low cost disk drives is universal in the Digital environment. With virtual memory paging Mbyte after Mbyte of data in and out of memory, and the advent of increasingly sophisticated programs that require greater storage, disk performance is a critical element of system performance. Compared to solid state RAM, all systems are in a sense disk bound and can benefit from faster disk drives. Random access memory can retrieve data in 120 nsec, while the mechanical heads in disk drives take an average of 15 msec.

Although any Digital system can derive performance gains from the installation of improved disk storage peripherals, VAXclusters and VAXBI-based systems have the most critical need. In clusters especially, the sheer volume of disk drives that can be installed makes large capacity, cost-effective drives a must. The HSC50 can support up to 24 RA80/81 and/or SDI/SMD disks. The HSC70 expands this number to 32 storage units. Each disk channel connection on an HSC50/70 costs more than $7,000; disk drives that provide the maximum capacity possible are able to take full advantage of that investment.

Since an SDI/SMD adapter can be used in virtually any Digital environment, clustered or nonclustered, SMDI disk drives can be intermixed with RA series drives on the same controller, just as the same controller can support different Digital drives (Figure 2).

SMDI provides the user with several migration possibilities. An installation that begins with a single VAX, but plans to eventually move to clusters, could protect its investment in data storage by beginning with SMD disks and a third party SMD disk controller. When an HSC cluster controller is added, the drives could be migrated via SMDI.

Vendors Directory

Control Data Corp.
8100 34th Ave. S.
Minneapolis MN 55440
612-931-3131 **Enter No. 650**

Emulex
3545 Harbor Blvd.
P.O. Box 6725
Costa Mesa, CA 92626
714-662-5600 **Enter No. 652**

Fujitsu America Inc.
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3055 Orchard Dr.
San Jose, CA 95134
408-946-8777 **Enter No. 654**

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1855 Barber Ln.
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408-942-1212 **Enter No. 656**

Interface Update

by Vipul Mehta and Joe Jaworski

Third party manufacturers must remain flexible to flourish in the changing Digital marketplace

As we enter 1987, it may be an opportune time to reflect on the past year's events in the marketplace, and take a closer look at what is likely to happen in the new year. Of course, there have been a lot of changes in the past 12 mths., and the next 12 will be equally eventful.

As in the past, we'll see a flurry of new products and new faces. Third party suppliers will be busy pushing the limits of technology, and Digital Equipment Corp., in turn, will continue to push the independent suppliers. Users will continue to demand higher performance and better support at a lower cost. However, there's one thing that won't change—the evolution of Digital computing into new levels of power, performance, and price.

Overall, 1986 was a good year for the Digital world, including Digital itself. While most of its rivals succumbed to "weak demand" and "adverse market conditions," Digital soared to new heights. Products were introduced across the board—from low end PC compatibles to the most powerful machines in Digital's history. During the next few years, the competition (IBM included) will be scurrying around to find "VAX buster" products, as the minicomputer market once again follows the pace set by Digital.

Traditionally, the fortunes of independent DEC compatible suppliers have run parallel to Digital's own performance levels. Lately, though, third party suppliers have been wondering if this still holds true. For one thing, none of the independents have come close to duplicating Digital's financial success throughout 1986. Secondly, Digital has created barriers that are crippling the ability of third party suppliers to interface to new busses and mass storage architectures. What will this do to the future of independent suppliers of mass storage controllers and subsystems?

There is no doubt that many third party suppliers will be able to capitalize on Digital's success. Last year, a sudden flurry of new products and different architectures from Digital took the industry by surprise. Engineering groups at most of the third party suppliers were inundated with data and new specifications that took time to digest. But rest assured that 1987 will witness the introduction of many new products supporting the new architectures. There will be memory boards, controllers, and subsystems for new Q-bus computers, and the VAXBI.

"As we transition into 1987, there will be new issues and new complexities to contend with."

Digital's efforts to close its architectures have been less than successful. While the legal issues continue to drag on in the courts, the independent suppliers are free to develop and market new products. And they are doing just that. There is no shortage of mass storage control protocol (MSCP) controllers or subsystems in today's market. In fact, Peripheral Concepts' recently published *Controller Concepts 1986* lists more than 40 MSCP compatible controller products from 11 different manufacturers. The majority of these products support the MicroVAX on Q-bus and some work with the Unibus. Furthermore, some third party suppliers have already found ways to attach peripherals on the new VAXes by circumventing the VAXBI altogether.

Industry growth projections also remain upbeat. For example, *Controller Concepts 1986* predicts that revenues from third party DEC compatible peripheral controllers will jump from \$72.5 million in 1985 to \$128.2 million by 1989. Q-bus compatible controllers will benefit handsomely from the closed nature of the VAXBI. They will account for 64.9% of 1989's total market, up from only 58.9% in 1985. This doesn't mean that the VAXBI won't grow, but most of the growth will be captive to Digital. On the other hand, the Unibus and other VAX busses like the Synchronous Backplane Interconnect (SBI) will continue to decline through 1989.

As we transition into 1987, there will be new issues and new complexities to contend with. The key to survival will be following Digital's changing directions, strategies, and new products. But there will also be a strong growing market that brings a host of new opportunities. It all boils down to satisfying the needs of the end user, be it 1987 or 1977.

Joe Jaworski and Vipul Mehta are the principals of Peripheral Concepts, an Irvine, Calif.-based consulting and market research firm. The company also publishes several market reports on Digital and other interface technologies.

Tape Alternatives For The Digital Environment Keep Pace With Industry Trends

Advances in the rapidly changing tape market become available for Digital users from a variety of third party manufacturers

by Edward Judge

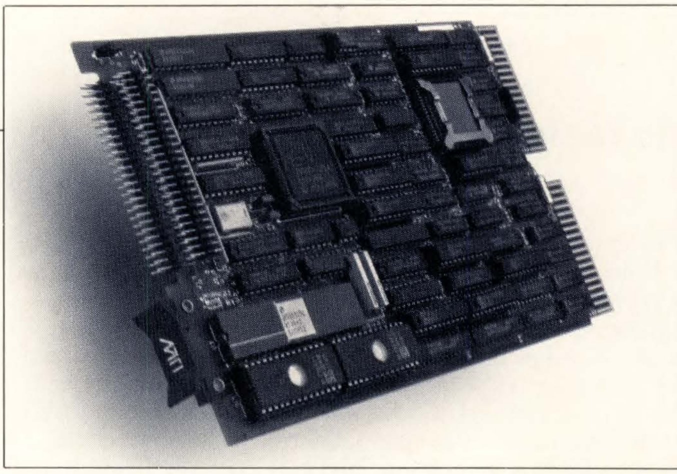

Figure 1—*MTI's MSV15 TSV05/TS11 compatible ½-in. tape coupler for the Q-bus is an example of the new dual-wide high performance tape control boards.*

Until recently, magnetic tape wasn't widely available for small systems because of cost, but that's changing. Third party vendors offer Digital Equipment Corp. computer users a wide variety of options at significant savings over similar Digital products.

Magnetic tape has many attributes that make it desirable as a means of backing up disk drives. It has a low cost/Mbyte and high capacity; it's highly standardized, rugged and compact in form, and highly reliable. Extensive data archiving is done almost exclusively on tape.

Tape systems are available in five basic formats: ½-in. reel-to-reel (RTR), ½-in. cartridge, ¼-in. cartridge, ¼-in. cassette, and ⅛-in. cassette. RTR is subdivided into start/stop (conventional tape drives), and streaming tape drives.

The ¼-in. cassette is of the audio type and is used almost exclusively for low end personal computers. The ⅛-in. cassette is used mostly in micro dictation (the micro-cassette recorder). No major system using these form factors is currently available for any Digital system.

History

Mag tape began as a media for inexpensively transporting programs and information between IBM systems (a role that the floppy disk was later deigned to handle for IBM's smaller systems).

The first modern tape system was the 9-track, 800 bits per inch (bpi) non-return-to-zero inverse (NRZI) drive. It had several 7-track predecessors at 200 and 556 bpi, but came together in the 800-bpi 9-track, a machine with adequate speed and error checking for the time. It stored about 20 Mbytes and ran at 45 in. per sec. (ips).

Today's drives range from inexpensive 12.5 ips, 800 bpi low end to super high performance 200 ips, 6250 bpi group-coded recording (GCR) machines available from $35,000 to $50,000. Current machines are typically 800/1600/6250 bpi (along with 3200 bpi phase-encoded [PE] machines made popular by Cipher Data Products Inc. [San Diego, Calif.] with their Microstreamer) and 45–125 ips.

There are two commonly used standard ½-in. tape drive interfaces: Pertec (from Pertec Peripherals Corp. in Chatsworth, Calif.) and STC (from Storage Technology Corp. in Louisville, Colo.). There are others, such as the Telex (from Telex Computer Products Inc. in Tulsa, Okla.) and Kennedy Co.'s (Monrovia, Calif.) Pico, but these are in limited use. The Pertec interface is most common among small Digital systems, with the faster (and more expensive, and bigger) STC interface more common for larger systems. The limit for the Pertec is about 125 ips, and most drives in the 200 ips range use the STC.

Today most controllers are actually couplers that assume the electronics exist in the drive system to format the incoming data as needed. Currently, there exist three common densities/modes for RTR—NRZI, PE, and GCR. In the changing cartridge world, standards aren't as common; density is constantly increasing, and some form of GCR is usually used.

Using well-known NRZI recording techniques with better error detecting techniques, GCR is considered the most reliable of the three methods. Many GCR designs are very expensive because of the required electronics, but VLSI is changing this dramatically.

Using RTR

Dan Sullivan, vice president of marketing sales for Micro Technology Inc.—MTI (Placentia, Calif.) has cited what the tape industry thinks are acceptable rates for the backup process—three media changes and less than ½ hr. to back up the Fujitsu 2351 Eagle.

Currently, ½-in. tape dominates most markets, with the exception of the price sensitive personal computer market. In 1986, three times more ¼-in. devices were sold, but the value was about 30% of RTR value.

Using Kennedy as an example, a typical moderately high technology drive is found in its tri-density 9400 drive. It's rated for 800/1600 bpi at 75 ips, and 6250 bpi at 45 ips. It's perfectly matched in transfer rate by a new coupler—the MSV15 (Figure 1) from MTI. The MSV15 coupler has about 10% more throughput than the maximum

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transfer rate of the 9400, and is a dual-wide card.

More than just data is written to tape. To bring down the cost of performance in tape drives, the drive motor is given some space (the inter-block/record gap—to accelerate the tape from where it halts between data blocks. This allows drive motors to bring the tape up to the speed that the read/write electronics are designed to work at most efficiently. The IBG can vary from .3-in. to .75-in.

With a less expensive drive motor, a streaming drive can be assembled with equivalent performance of the more expensive start/stop drive. Streaming technology has lowered the price of moderate performance RTR systems. The streamer offers high performance at lower cost than standard systems with some restrictions. They can handle the same format as the standard systems, but they do it "on the fly."

Using software and hardware (particularly caching techniques) to prevent interruptions in data transfer, streamers use less expensive drive mechanics and take advantage of the economics of LSI and VLSI technology to keep parts count down and reliability up. This makes a streamer the perfect backup device, offering reliability, portability, performance, and a low cost relative to start/stop drives. Streaming at 100 ips in GCR is a good performance rating. Some of the newer streamers are showing repositioning times near 30-40 msec. Most streamers have figures around 200-300 msec.

Kennedy's 9400 drive is now available as the 9600 streamer, and is also available in quad-density (800/1600/3200/6250)—the 9610 (Figure 2). The 9600 series will also operate in the start/stop mode at 50 ips. This is a basically more powerful drive than the 9400 in a much smaller package, and could be a price/performance breakthrough in a full-featured streaming tri-density RTR drive. The newest MTI controller, the MUV15, uses the GCR mode at full speed, along with Tape Mass Storage Control Protocol (TMSCP) emulation.

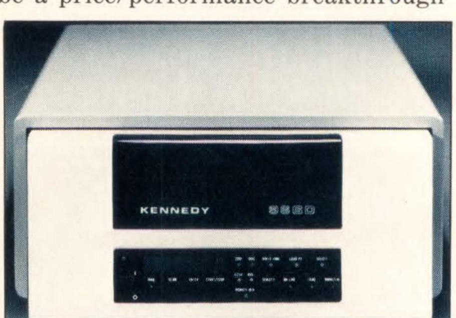

Figure 2—*The Kennedy 9610 is a quad-density streamer that will also operate in start/stop mode. The M9660, shown here, is the 9610 with a cover.*

With an RTR tape, you can change the block size. Each block has its own minimum overhead—headers, error checks, IRGs—so if you make the block larger, up to a point, you can substantially lower the overhead and increase storage.

There can be a problem with backing up many small files. If they are smaller than the block size, they will still need at least a block of storage, so there's the possibility of wasting storage. You can get around this by storing small files together in one logical disk file.

There's an ANSI standard that uses 512-byte blocks, the same size as used on most common DEC compatible disk storage devices. Using GCR and the Digital standard, which is very close to the ANSI standard, you can get approximately 75,000 blocks (38 Mbytes) on a 2400 ft. tape using PIP. This means that approximately only 22% of the tape is being used for data.

There is nonDEC software that can help with this problem. Typical of these, ARK from Network Dynamics Inc. (Cambridge, Mass.), writes to the tape using special system subroutines that allow more choice in tape block size. ARK automatically selects the largest blocking possible with available memory, using up to a 16-Kbyte block, and can store about 150 Mbytes, using about 80-85% of the tape for data. ARK can also be run from a command file, which allows a batch-like backup procedure to be handled by less skilled personnel, and maintains a directory on the beginning of the tape.

With the recent introduction of Digital's TMSCP protocol, a tape version of the disk-based MSCP protocol, many suppliers are introducing emulating versions of their controllers.

MTI plans to ship its MUV15, which supports TMSCP, two tape drives, and GCR to 200 ips on a dual-wide card, early this year. Scientific Micro Systems—SMS (Mountain View, Calif.), recently introduced its SMS0108 TMSCP board (Figure 3). It's usually sold with a complete subsystem rather than sold separately.

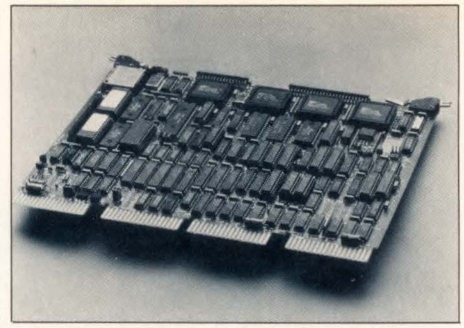

Figure 3—*SMS's SMS0108 is a triple-function (Winchester, floppy, QIC-02 ¼-in. tape) TMSCP controller that represents a trend in highly integrated multifunction controllers.*

Using Cartridge Tape

Although streaming has produced some very low cost RTR systems, they simply can't be as inexpensive as a device that has a 5¼-in. form factor and handles a small cartridge or cassette with small, inexpensive motors and lower parts counts. Thus, the main reason to go to cartridge format is that it results in a large, immediate decrease in cost and size, with more capacity than most PE RTR drive systems.

Cartridges are also easy to handle, store and manipulate, and are relatively immune to environmental hazards. Most accepted standard tape cartridge formats are multisourced, so media will usually be available at a reasonable cost, and this cost is steadily dropping.

IBM recently introduced its 3480 ½-in. cartridge tape. Its storage capacity is 200 Mbytes (and a 600-Mbyte model is expected), and supports a transfer rate of 3 Mbyte/sec. with a hard error rate of 1 in 10^{13} on 18 parallel tracks at 38 Kbpi. Most likely, some form of this drive will become the next OEM standard. Cipher is working with IBM to produce a lower cost drive using the 3480 cartridge.

Many vendors are trying to produce a lower cost 3480 version for the aftermarket, probably using the new (and as yet to be agreed upon) half-in./tape cartridge (HI/TC) standard. Most notable among this group is Megatape (Duarte, Calif.), which is already ahead in capacity with its ½-in. 500-Mbyte and 750-Mbyte (unformatted) cartridge products.

HI/TC for the 3480 cartridge is a breakthrough in the ½-in. realm. Drive specifications are 26 serpentine tracks at 18 Kbpi, for a 240-Mbyte formatted capacity. It will be implemented using the enhanced storage device interface (ESDI) with a small computer systems interface (SCSI) host adapter, and the transfer rate will be 250 Kbyte/sec.—2½ x faster than the TK50, with 2½ x the capacity.

Digital's TK50 has been slow in being accepted, as it has been plagued by reliability problems. It has been claimed that Digital wouldn't sell any if it weren't the standard MicroVAX II tape drive and a main software distribution media. The TK50 is one of the slowest and lowest capacity drives available.

The TK50's reliability problems have been attributed to "hot spots" in the new boxes that have compartments for 5¼-in. devices, and Digital supposedly already has a fix. They work well in a rack-mount system. Digital is the sole supplier of TK50 cartridges, and they are somewhat costly (about $30 each) and fragile.

The TK50 has a 16-Kbyte cache to maintain tape motion, but it handles data-late situations by essentially writing a blank block so it won't have to stop and reposition. In worst case situations, the TK50 can lose as much as half of its stated capacity. Also the TK50 has no end of tape (EOT) sensor. It counts revolutions. The TK50 will not become a standard in its present form.

Digital plans to remedy the TK50's problems with a TK52 and a rumored TK70. The TK52 will have a storage capacity of 190 Mbytes—twice that of the TK50—and the TK70 will store 380 Mbytes. If Digital steps up the transfer rate (currently at 62.5 Kbyte/sec. for the TK50), a new drive will probably do the job. The coming of the RD54 159-Mbyte disk (a Maxtor Corp.—San Jose, Calif.—XT-2000) for the MicroVAX II will probably hurry this along, as Digital likes to back up with one media.

Evaluating The Tape Market

Richard Hicksted, president of MTI and driving force behind the company's intention to garner a large part of the new half-wide, full-function controller market, says that MTI's priorities place highest emphasis on performance. A new level of user friendliness is second—typified by such features as on-board diagnostics and direct RS-232 access to the boards diagnostics and set-up features—followed by cost effectiveness.

Some companies, like Aviv Corp. (Woburn, Mass.), specialize in making just controllers, buying its drives from others to deliver complete systems. Haim Brill, president of Aviv, states that his company's goal is the delivering of the highest quality subsystems in all capacities. Aviv offers a full range of products, including the 200 ips Fujitsu GCR systems along with Megatape's cartridge system. All products are chosen because of their high reliability, but none are inexpensive.

Tape companies are trying to fill a specific systems niche. The third party manufacturer's charter is to have a reliable, high quality, technologically current alternative, available at prices lower than Digital's. Differing capacities and levels of performance are available for differing needs, and most offer complete systems, ready to "plug in and play." Many offer ¼-in. tape cartridge systems.

When considering a component-level purchase, ensure that the system you are choosing either exactly emulates a Digital tape system (TM11, TS11, TSV05) supported by your operating system, or is supplied with a handler. Most companies offer handlers, but some charge extra for them.

The ¼-in., 5¼-in. form factor drives, often using the SCSI and quarter-in. cartridge-02 (QIC-02) standards are developing rapidly. Many of these devices are slightly longer than a standard 5¼-in. device, though there's usually no problem with fit.

Because of emerging standards such as SCSI and ESDI, more of the intelligence of the ¼-in. tape controller resides in the drive, the traditional controller being reduced to a simplified version called a host adapter. A host adapter controls the host bus interface. Host commands are higher level than found with conventional controllers, resulting in reduced CPU overhead.

The major manufacturers of intelligent ¼-in. cartridge tape devices are Archive Corp. (Costa Mesa, Calif.), Kennedy, Cipher, and Wangtek Inc. (Simi Valley, Calif.). These companies' drives are standardized to read tapes written on each others' drives. Most of these drives are on IBM personal computers, and are now showing up on higher performance systems, as companies eliminate their ½-in. RTR drives and replace them with smaller, higher capacity devices.

In the QIC world, manufacturers have instituted a "round-robin" session of exchanging QIC tapes with each other to ensure tape and drive compatibility. This process began 3 yrs. ago and the manufacturers hope to continue to iron out any differences before making the standard final.

Digital makes the TK25, a 55 ips, 60-Mbyte backup tape system, using the 3M (St. Paul, Minn.) 300XL cartridge and a Control Data Corp.—CDC (Bloomington, Minn.) Sentinal drive in an 8-in. form factor. Dan Sullivan says his company is experiencing a brisk sale of controllers and subsystems with drives that are faster than Digital's TK25 unit. The new, backward compatible QIC-120 should be available soon, with more tracks and backward compatibility with QIC-02 tapes, and 125-Mbyte storage. Media breakthroughs will be required to stretch the capacity much further, and some manufacturers consider ¼-in. tape a dead-end technology.

The QIC-02 standard is essentially the QIC-02 bus standard. This standard defines electrical characteristics to communicate over the 50-pin cable that connects with the tape device's basic control electronics.

The drive interface electronics currently implement a QIC-36 standard that expects to see a QIC-24 format cartridge. A QIC-150 cartridge standard recently proposed would double the capacity while using essentially the same QIC-02 bus commands and modified QIC-36 commands, but using the new 3M DC600XTD cartridge. But since this new cartridge hasn't been widely available, the QIC 120 format was proposed—a cartridge that allows a capacity of 125 Mbytes with the important ability to read older QIC-24 cartridges.

The ¼-in. cartridge drives are inherently more error prone than RTR drives. This is because the motor is small and the instantaneous speed variation can be as much as $\pm 10\%$. This causes errors in the 1 in 10^{10} range rather than the 1 in 10^{12} range seen in ½-in. reels. Some may find this unacceptable.

Considerations In Using Tape

Especially for RTR systems, some tapes work better on some drives than others. Try several tape brands by reading and writing to them several times, and verifying the data. Cartridges seem to be somewhat more consistent, but problems can occur.

The amount paid for tapes doesn't seem to be related to whether the tapes work well with any given drive. For GCR, you can often use the cheapest GCR certified tape available without worry, due to the extensive error handling that is implemented.

In an effort to get even more storage, a 3600-ft. 10½-in. reel of tape is offered by some tape manufacturers. The standard 2400-ft. reel is made of 1½ mil tape that works well on all drives. The 3600-ft. reel is made of 1 mil tape—50% thinner.

The coating used to capture the information on a tape is a very fine, abrasive compound. As a tape runs over the head, it polishes away the guides and heads, sometimes cutting grooves in them if the tape track is out of alignment. This damages the tape that passes over them later. The tape path has to be kept clean, but glass cleaners can be sudden death for some of the sensors on an RTR drive, leaving films and possibly damaging materials. Isopropanol that is 91% pure is recommended, not rubbing alcohol.

Humidity as low as 45% can cause

Vendors Directory

Alpha Microsystems
3501 Sunflower
Santa Ana, CA 92704
714-957-8500 **Enter No. 527**

Archive Corp.
1650 Sunflower
Costa Mesa, CA 92626
714-641-0279 **Enter No. 528**

Aviv Corp.
24 Cummings Pk.
Woburn, MA 01801
617-933-1165 **Enter No. 529**

Cipher Data Products Inc.
10101 Old Grove Rd.
San Diego, CA 92131
619-578-9100 **Enter No. 530**

Control Data Corp.
8100 34th Ave. S.
Minneapolis, MN 55440
612-931-3131 **Enter No. 531**

Corvus Systems Inc.
2100 Corvus Dr.
San Jose, CA 95117
408-559-7000 **Enter No. 532**

Emulex Corp.
3545 Harbor Blvd.
Costa Mesa, CA 92626
714-662-5600 **Enter No. 533**

Kennedy Co.
1600 Shamrock Ave.
Monrovia, CA 91016
818-303-8241 **Enter No. 534**

Maxtor Corp.
150 River Oaks Pkwy.
San Jose, 95134
408-942-1700 **Enter No. 535**

Megatape Corp.
1041 Hamilton Rd.
P.O. Box 317
Duarte, CA 91010-0317
818-357-9921 **Enter No. 536**

Micro Technology Inc.
1620 Miraloma Ave.
Placentia, CA 92670
714-632-7580 **Enter No. 537**

Network Dynamics Inc.
1218 Massachusetts Ave.
Cambridge, MA 02138
617-547-2036 **Enter No. 538**

Pertec Peripherals Corp.
9610 DeSoto Ave.
Chatsworth, CA 91311
818-882-0030 **Enter No. 539**

Scientific Micro System
777 E. Middlefield Rd.
Mountain View, CA 94043
415-964-5700 **Enter No. 540**

Storage Technology Corp.
2270 S. 88th St.
Louisville, CO 80028
303-673-5151 **Enter No. 541**

Telex Computer Products Inc.
6422 E. 41st
Tulsa, OK 74135
918-627-1111 **Enter No. 542**

3M
Magnetic Media Div.
3M Center Bldg., 225-5N-04
St. Paul, MN 55144
612-733-1995 **Enter No. 543**

Wangtek Inc.
41 W. Moreland Rd.
Simi Valley, CA 93065
805-583-5255 **Enter No. 544**

greatly accelerated tape wear, on the order of at least four times. And "back-coated" tapes can further increase wear, according to some large users.

Some general environmental protection is needed for tape reels. Tape seals, which completely seal the reel, are quick to use, cheap, and effective. Contaminants include dust, smoke particles, and grease and oil. Handle tapes as though you will have to reenter the data by hand.

Write enable rings fit on the back side of the reel in a circular slot, allowing you to write on the tape. Write enable rings function in the same way as write protect notches do on floppies and cartridges. There is a switch near the tape drive hub that prevents writing on the tape unless it is pressed down, which is what the rings do. Check the write-enable light on the panel, as it is easy to load up the tape and have to unload it and load it again with the ring in position.

Use reel or cartridge labels. Information on the label is helpful, but it may be best to consider how much information you want to place on them if you think security will be a problem. There are complete self-sticking number labeling systems for log-book index methods.

Tape's Future

Certainly there's a trend toward smaller form factors, probably leveling out with the 5¼-in., but without new media, more storage capacity will be more difficult to achieve. Even with new media, some feel that the maximum capacity of the ¼-in. tape is going to be about 600 Mbytes. The ½-in. tape cartridge will probably reach a Gbyte.

Newer coating techniques will let tapes handle many more flux reversals per in., and new head technology will also help. And there's the optical disk, with talk of small "jukebox" devices with tens of Gbytes of storage. These now exist in the 30-Gbyte range. The possibilities for optical devices are enormous, particularly when erasable media is demonstrated.

Another trend is multifunction controllers. These combine hard disk, floppy, and backup tape interfaces on one board, for less than the cost of separate controllers. SMS's SMS0108 is of this type.

Intelligence is coming on strong in newer controllers. Software setup and diagnostics are becoming common, as is an RS-232 port directly on the controller for direct communications to these programs. EEPROM may make available revisable on-board controller program storage. When a new revision becomes available, you don't have to buy an expensive set of new PROMs.

Joe Traficante, product manager for Emulex Corp. (Costa Mesa, Calif.), thinks that the HI/TC and QIC systems are going to come along even further, and he has another thought—video tape backup using standard video cassettes. Corvus Systems Inc. (San Jose, Calif.) and Alpha Microsystems (Canoga Park, Calif.) tried this several years ago, but price, capacity, and reliability wasn't good enough for market penetration at that time. Traficante thinks that a low cost video cassette backup system storing around 400 Mbytes may be on the horizon, using standard recorders.

Edward Judge is a Northampton, Mass.-based freelance writer.

MicroVAX II Realtime Image Processing

Single-board hardware integration and the low cost/high performance of the MicroVAX II bring full-functioned image processing systems to users who previously couldn't afford them

by Ross Chapman and Thomas DiGennaro
Imaging Technology Inc.

Since its introduction, Digital Equipment Corp's MicroVAX II has enjoyed tremendous popularity because of its speed, size, and cost. It's only natural that the MicroVAX II find its way into the limelight of the expanding market for image processing applications.

The MicroVAX II supermicrocomputer is an ideal host for an image processing system. It's inexpensive, very powerful, and has an open architecture and small footprint. In addition, it's compatible with a vast array of applications software, communications protocols, and third party peripherals. Three operating systems are available for the MicroVAX II: MicroVMS, Ultrix-32, and VAXELN. The MicroVAX II provides a powerful programming environment that supports multiple users, and is familiar to a large audience of programmers. Digital's Digital Network Architecture (DNA) provides access to networks based upon DECnet, Ethernet LANs, Systems Network Architecture (SNA) gateways, and X.25 protocol, thus allowing a MicroVAX II-based image processing workstation access to large databases of images located offline from the workstation itself.

There's a large base of third party peripherals available for the Q-bus, the architecture upon which the MicroVAX II is built. With the introduction of the VAXstation II/GPX, users have the ability to merge graphics technology with their image processing application—a trend that is gaining momentum in the image processing world. The MicroVAX II is a powerful environment in which to build a high performance image processing application.

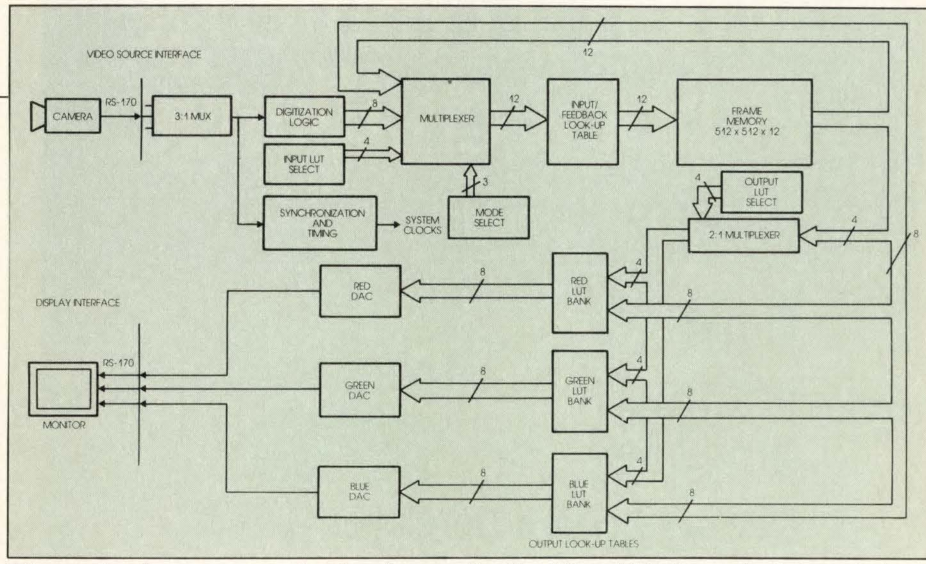

Figure 1—*Image processing hardware for the MicroVAX II can be integrated onto a single board.*

Image Processing Capabilities

Until a few years ago, image processing was available only to those institutions with large budgets, large computers, and a staff of full-time programmers. Typically, a pre-digitized image would be loaded, and the host CPU would proceed to perform operations on the image data that would monopolize the CPU for extended periods of time. Now, however, there's special-purpose image processing hardware that offloads the image processing task from the host, thus freeing it for overall system functions. Image processing modules are available to handle all of the digitization, processing, storage, and display functions required by most applications.

Typical image processing subsystems have previously required multiple boards. Separate boards were used for image acquisition and display, image storage, and special image processing functions. Now there are single board solutions that can perform all of the basic functions and implement realtime arithmetic and logical functions, such as those required for image averaging and subtraction algorithms.

A typical board accepts analog video from a camera and digitizes it to 8 bits resolution (Figure 1). Once digitized, the image is stored in an on-

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board frame buffer where it can be processed via a 4096 x 12-bit feedback/input look-up table (LUT). This mechanism is part of a digital feedback circuit that processes data in the frame memory so that realtime transformations and arithmetic operations can be performed on combinations of stored and newly acquired data. There's also display circuitry that converts the image back into an analog form for display on a high resolution monitor. All of these operations occur at realtime rates.

Realtime Image Processing

Realtime in the image processing realm refers to a frame rate of 30/sec. This means that every second, 30 frames of video images are acquired, stored, processed, and displayed. This corresponds roughly to 100 nsec to process each pixel in a 512 x 512 pixel image. Older image processing systems were very slow because the immense amount of data that comprised a single image had to be transferred to the host bus. In addition, the CPU speed of the host precluded image processing systems of the past from operating at realtime rates.

A key element in implementing the realtime processing capability lies in the frame memory and feedback LUT. The frame memory is 12 bit planes deep. This allows two 6-bit images to be imposed on each other at the same location. These two images are fed back into the feedback input LUT where they are treated as two 6-bit operands. The LUT is pre-programmed with the desired function of the 6-bit operands.

Integrating Image Processing Into The MicroVAX II

When integrating any peripheral, including image processing hardware and applications software, into an environment such as the MicroVAX II, users must consider both host environment and operating system factors.

To integrate the hardware, users must consider.

- *Bus compatibility*—What are the power requirements, physical form factor, and the signal requirements of the host/peripheral interface?
- *I/O and memory mapping*—What other peripherals are present and what portions of bus address space do they require?
- *Interrupt generation*—What is the system-wide convention used for interrupts? What levels of interrupts are the other peripherals in the system likely to generate?

To integrate with VMS, you must consider the following items.

- *File system use*—Image data files typically require large amounts of storage space.
- *Process context*—Are there other processes using the system that may conflict with the image processing application?
- *User interface drivers*—What sort of special considerations must be made with respect to the host environment and the way one must handle terminals, bit-mapped displays, and/or mice?
- *Interrupt handlers*—In a multiuser, time-sharing environment, smooth handling of interrupts keeps all users happy.

Bus compatibility is an important factor. One stumbling block, which in the past has hindered implementation of image processing on the Q-bus, is the absence of a -12 volt power supply (which most digitizers require for analog-to-digital conversion). An external power supply and/or some sort of customization of the MicroVAX II can be used, or the product can be designed not to require this voltage.

Assuming that the image processing hardware has been designed to meet Q-bus standards, it must be configured (usually with jumpers) to have a physical address that doesn't conflict with any other system component. Furthermore, the interrupt vector assigned to the board must be consistent with the system wide use of interrupts. Integration is greatly simplified if the interrupt vector assigned is used only by the image processing hardware and is jumper-selectable. This allows the image processing hardware to fit more easily into the host environment (as opposed to requiring the environment to accommodate the peripheral).

Using the VMS SYSGEN utility program ("SHOW /CONFIG"), users can determine the control and status register (CSR) addresses of existing boards in the system, as well as the interrupt vectors in use. The board to be installed must not conflict with existing hardware.

One must also determine whether the image processing hardware is to be a shared system resource. That is, will applications be allowed to use it in ways similar to those, for example, for a shared printer?

When any board is added to the host environment, a shared resource is created. To reduce early integration problems, users are advised to complete the configuration carefully. Usually, this is performed by the system manager, who has the necessary privileges to configure the system so that users will be able to accomplish their tasks (e.g., mapping of global sections to the image processing hardware).

When a Q-bus board is added to existing hardware, the SYSTEM user must create some system resources to enable unprivileged users to access the boards. When the system is configured, the PFNMAP privilege is required to create permanent global sections that provide access to the board. When these sections are created (via a call to $CRMPSC), public access permission will allow any user to access the board. A section will be created for the I/O-mapped portion of the board (i.e., the registers), and a separate section is created for the memory-mapped portion (i.e., the frame buffer). For simplicity and performance, it's desirable that this frame buffer section be large enough to allow one frame buffer (512 Kbytes) to be mapped at once. A utility can do the work of creating these globals and inform VMS of the board's presence, and allowing users access to the board as a system resource. These sections are referenced by name and the user process must map them into its virtual address space.

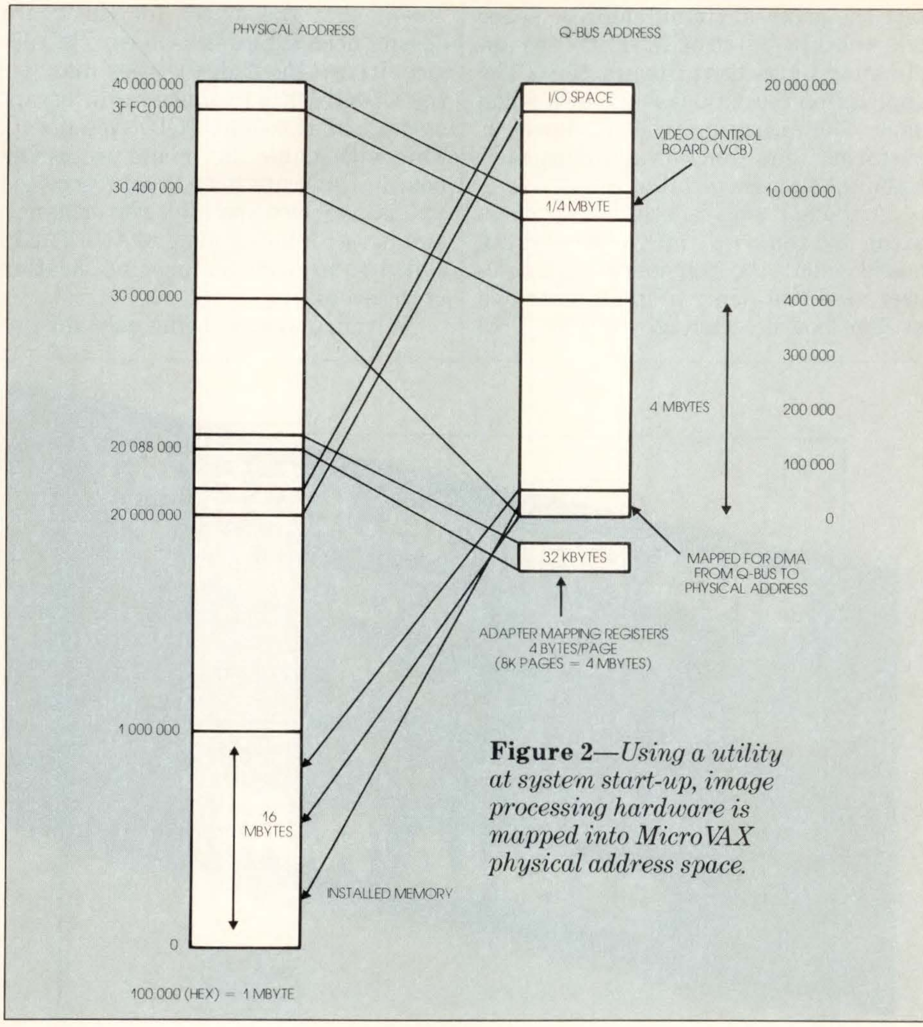

Figure 2—*Using a utility at system start-up, image processing hardware is mapped into MicroVAX physical address space.*

In addition to the creation of these sections, the utility sets up the Q-bus adapter mapping registers (Figure 2). Since an image processing board is often designed to power up without the frame buffer enabled as memory on the Q-bus, the configuration program must enable the frame buffer and clear the mapping registers that correspond to it. Each mapping register controls how the Q-bus adapter interprets Q-bus addresses for one page of Q-bus address space. The mapping registers allow Q-bus DMA devices to access MicroVAX physical memory directly, even though this memory doesn't reside on the Q-bus. When a mapping register (4 bytes) is set to zero, it marks the register as invalid, meaning that the area of memory addressed resides on the Q-bus directly. The utility clears these mapping registers and creates a separate, temporary global section to access them. The utility should be run automatically at boot time as part of the site-specific start-up procedure. In order to avoid conflict with system use of mapping registers, the memory-mapped frame buffer must not reside in the first (lowest) ¼ Mbyte of memory space.

Once configuration is complete, a system-wide lock is created. When an application program needs to use the image processing hardware, it calls an initialization function that attempts to allocate the exclusive lock. If this succeeds, then the image processing hardware's permanent global section is mapped into the process' virtual address space. If the lock fails, it means another application process is using the hardware. In a multiuser, time-shared system, this prevents conflicting use of the hardware by two simultaneous application processes.

After the board has been mapped

into the process' virtual address space (via another call to $CRMPSC), the application is free to use its functions. The application must release the lock when done. The operating system, however, performs that function automatically when the process terminates.

Although VMS is a multiuser operating system, an image processing board should be considered a single-user resource—only a single user can use the board at any given time. This means that the driver for the board doesn't need to be a full-blown VMS device driver. Instead, the user may use the CONINTER (connect to interrupt device) call through a $QIO system call. This will enable the image processing board's interrupt to be caught, serviced at high priority and high performance, and a user completion function (AST) called to provide the user notification of the event.

Within a system being used for image processing, there are several other processes that can be shared. These include:

- image files,
- LUT files,
- convolution kernels, and
- algorithm routines.

The typical method of handling these is to create a specific subdirectory, usually owned by the system manager. A logical symbol for this directory is then created and used by all image processing applications (e.g., "sys$imageprocess"). Naturally, individual users also have their own image processing storage areas, but early agreement on conventions is essential to reduce conflicts and to eliminate redundant storage.

Integration And Application Programs

After the hardware is configured and operating system considerations settled, programming an image processing application is not very different from any other type of application. There are subroutine packages available for use in the MicroVAX II environment that provide most of the basic image processing operations users require. These packages allow programmers to concentrate on the application, without unnecessary concern about exactly what part of the image processing hardware is performing any given function.

To provide maximum performance and flexibility in image processing application programs, it's important that the image processing functions are asynchronous. This allows an application to start an image processing task, then proceed to other tasks. This has obvious uses for time-consuming activities like moving images between frame memory and system storage. It also becomes important if successive frames are processed through several sequential steps. For example, if an application processed each frame with several sequential tasks, the completion function for each task (called as an AST when the task completes) would initiate the next task. The last task would then inform the application of completion via the standard VMS interprocess communication methods.

A few years ago, realtime, high performance image processing functionality cost hundreds of thousands of dollars. But now, with more capable image processing hardware and the MicroVAX II, powerful systems can be built very cost effectively.

Graphics Perspective

by Alan Bridges

SIGGRAPH '86 Brings Together State-Of-The-Art Graphics Hardware And Provides A Glimpse Of What's Ahead

State-of-the-art ideas and technologies were presented at SIGGRAPH '86 through presentations, exhibits, courses, panels, the film and video show, and the retrospective art show.

Many high resolution (1024 x 1024 pixels or higher) IBM PC/AT graphics coprocessors were introduced from manufacturers including Imagraph, Parallax, Microfield, Texnai, and Omnicomp. These include Vectrix Pepe, Number Nine PepperPro Series, and Verticom's H-16ACS International's GraphAX 2020.

The trend toward higher resolution graphic board sets for the PC actually began a couple of years ago with products such as the VXPC from Vectrix Corp. VLSI technology (e.g., high speed shifter RAMs and better graphics coprocessors) became available to meet the demand for higher resolution graphics.

The availability of high performance microprocessors, including the Intel iAPX286 and iAPX386, means high performance graphic processing power no longer has to be limited to 32-bit workstations. In fact, when the iAPX386 becomes available, there may be very little distinction between between the low end 32-bit micro or minicomputer workstations.

For example, Adage (Billerica, Mass.) introduced a 1280 x 1024 resolution VLSI-based graphics processor for the PC/AT. Ramtek's (Santa Clara, Calif.) OWL display system, based on application specific integrated circuit (ASIC) technology, provides 1280 x 1024 pixel display capability for the PC/AT or PC/RT.

Availability of high quality software on PC/AT graphics workstations, such as Rendition from Numerical Design Ltd. (Chapel Hill, N.C.), Modelmaker (Cubicomp Corp., Berkeley, Calif.), Personal Designer (ComputerVision, Bedford, Mass.), AutoCAD (Autodesk, Sausalito, Calif.), and VersaCAD (T&W Systems, Huntington Beach, Calif.), will add to this trend.

Digital Equipment Corp. showed its newly configured, color, 4-plane VAXstation II/GPX workstation and a new workstation graphics tablet. The VSII/GPX consists of a MicroVAX II platform with floating point unit, pedestal enclosure, 5 Mbytes of memory (expandable to 16 Mbytes), 71-Mbyte disk, 95-Mbyte streaming tape drive, Ethernet controller, operating system and workstation software (ULTRIX-32M or MicroVMS), 4-plane graphic coprocessor, and black and white or color monitor (1024 x 864 resolution).

Digital also showed the VAXstation II/RC and the VAXstation 500 Series. Sun and Apollo introduced 32-bit workstations. The significance of these introductions is that low-cost, expandable 32-bit workstations with up to 8-bit planes are available from $20,000 to $30,000. These include the VAXstation II/GPX, Apollo's DN3000, IBM PC/RT, Sun's 3/110C, and Hewlett-Packard's HP 9000 Model 320C. These workstations have CPU ratings of 1-2 millions of instructions per sec. (MIPS). Apollo and Sun offer some form of PC-DOS or AT compatibility, while HP and Digital offer VMEbus and Q-bus, respectively.

High-performance workstation manufacturer Silicon Graphics (Mountain View, Calif.) announced plans to incorporate the MIPS Computer RISC processor into its next generation superworkstation in order to offer 10 times the current graphic performance of the IRIS 3000 Series. Silicon Graphics also introduced the 10 MHz Geometry Engine that performs object manipulation at a rate of 110,000 3D floating point coordinates/sec.

General Electric's (GE) Graphicon 700 uses 10-MHz semicustom integrated circuits to implement 3D geometry and image-rendering algorithms. According to GE, the Graphicon 700 performs 30 million (IEEE) floating point operations per second (MFLOPS).

Pixar's (San Rafael, Calif.) Image Computer was demonstrated in a variety of image processing and computer graphics applications. Symbolics' SCOPE, an intelligent image processing and synthesis workstation, combines the Symbolics 3675 AI engine with the Pixar Image Computer.

Alias Research's (Toronto, Canada) Alias/1 used the Pixar Image Computer as a fast rendering engine in conjunction with a Silicon Graphics interface. Wavefront Technologies (Santa Barbara, Calif.) showed the Pixar Image Computer manipulating Wavefront-animated dynamic images in realtime.

The first pixel-plane machine ever built was on display at SIGGRAPH '86. This machine represents a radical solution to the problem of speeding up raster image development. The pixel-planes machine is based on logic-enhanced memory chips for storing images.

Meiko Inc. (Oakland, Calif.) demonstrated a 3,000 MIPS computer utilizing more than 300 processors. This new system uses a Computing Surface in a supercomputer architecture formed by configuring a mixture of VLSI computing elements in an application specific topology.

Trends in these superworkstations include pipelined processors, semicustom, or full-custom VLSI graphics engines for geometry and image rendering, multiple processor and multiple-bus architectures, high-resolution (1280 x 1024), and predominance of the VMEbus. The prime reason for these trends is to support high-end pseudo 3D realtime graphics (as opposed to true 3D stereographic displays).

Alan Bridges is a Hardcopy *columnist.*

Digital To IBM Networking Solutions Stress Standardization And Minimal Changes To Existing Systems

Networking nonhomogeneous environments has taken several different directions but is now standardizing on certain industry-wide interconnection schemes

by Donald R. Anselmo
Mitek Systems

Most of today's data communications networks are serving a nonhomogeneous computing environment. In most cases, this environment wasn't designed but instead evolved over time as both user needs and technology changed. Unrelated departmental islands of computing developed overlapping functions, causing noncompatibility issues and, in many cases, organizational conflict. The focal point for solutions to these problems is in data networking for a heterogeneous environment, building on large current investments in existing hardware and software systems.

A typical large company has a data processing department that's equipped with large business mainframes, such as an IBM or compatible. Within these companies, individual departments use their own processors and workstations to meet their needs. Digital Equipment Corp. and IBM are the dominant vendors in the departmental computing arena, and the personal computer has become the dominant intelligent workstation. Office automation systems, like those from Wang (Lowell, Mass.), meet specialized needs.

Wide-area networks (WANs) have been used for years by large corporations to move data between mainframes. Local area networks (LANs) have created departmental islands that now need to be interconnected. The current "hot button" is how to connect all of these networks in an effective way with corporate data processing centers. In many cases, Ethernet-based networks have become the LAN of choice, largely due to its stable existence in many markets.

Connectivity

System requirements are becoming clearer in many corporate accounts. Critical requirements are high performance file transfer, an effective application program interface (API) to deal with Systems Network Architecture (SNA) in mini and workstation software environments, 3270 terminal support, 3770 capability, and a path to Logical Unit 6.2 (LU6.2) and Document Interchange Architecture (DIA) capability. The installed base of Digital computers makes DECnet an important factor in any system's solution to the distribution of SNA to the departmental user. There are several current connectivity solutions bridging Transmission Control Protocol/Internet Protocol (TCP/IP) networks to DECnet. Two of these, D Bridge and stored DEUNA, were discussed in the August 1986 issue of *Hardcopy*. These solutions permit the DECnet user to share network resources, avoiding duplicate hardware. This also permits the sharing of wide-area facilities.

Standards

Systems integrators and architects must choose a data communication system to use for a heterogeneous computing and networking environment. This system must address both the local and the wide-area requirements. In the local environment, the devices must include terminals, keyboards, computers, and telecommunications equipment, while the network may include LANs and interfaces with a WAN. To bridge to both private and public WANs, the architect must select a network technology that will not strand or obsolete the capital investment already in place.

The solution to these problems is the use of a common communications environment across all the different vendors' systems. But getting the many vendors to follow one standard set of communications rules isn't easy.

One of the early efforts to solve this problem was attempted by the International Standards Organization (ISO) in the early '70s. As the efforts to develop the "one solution solves all" standard

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progressed, it became clear that common definitions and descriptions of the problems and rules would be required. This led to the definition of the Open Systems Interconnect/Reference Model (OSI/RM).

OSI/RM categorizes the common problems to be solved in a data communications environment into seven functional areas and arranged as a hierarchy. The seven functional areas are called layers and each is given a general layer name.

OSI/RM also describes the need for the functional layers to communicate among one another. Layers can communicate only with adjacent layers within a system, and with the same layer as itself in other systems. The communications between layers within a system are called interfaces. When a layer needs to communicate with a peer layer in another system, the information flow is called a protocol.

It's important to understand that OSI/RM describes only these functions, names them, and names their communications to other functions. It doesn't define the protocols or interfaces to be used. Unfortunately, this has led to confusion and a general lack of communication between vendor systems, which the vendors still claim are OSI compatible.

This communications systems multivendor standards anarchy has led to several user revolts. Two of the most well-known in the United States are the U.S. government's TCP/IP and the Manufacturing Automation Protocol (MAP) users group.

The U.S. government is a very large user of computers and communications equipment, and has procurement requirements that force multivendor environments. So, through the Defense Advanced Research Projects Agency (DARPA), the U.S. government established a communications system standard called TCP/IP.

TCP/IP has the advantage of being implemented in more than 60 different vendors' computers today, supporting LANs with Ethernet and WANs with X.25. TCP/IP provides for actual language interface specifications rather than just protocols. This makes possible the addition of compatible interface programs to support the use of other systems, such as SNA.

The MAP users group is a coalition of communications users and vendors who collaborated to achieve standardized communications out of the confusion of the OSI protocols. This group,

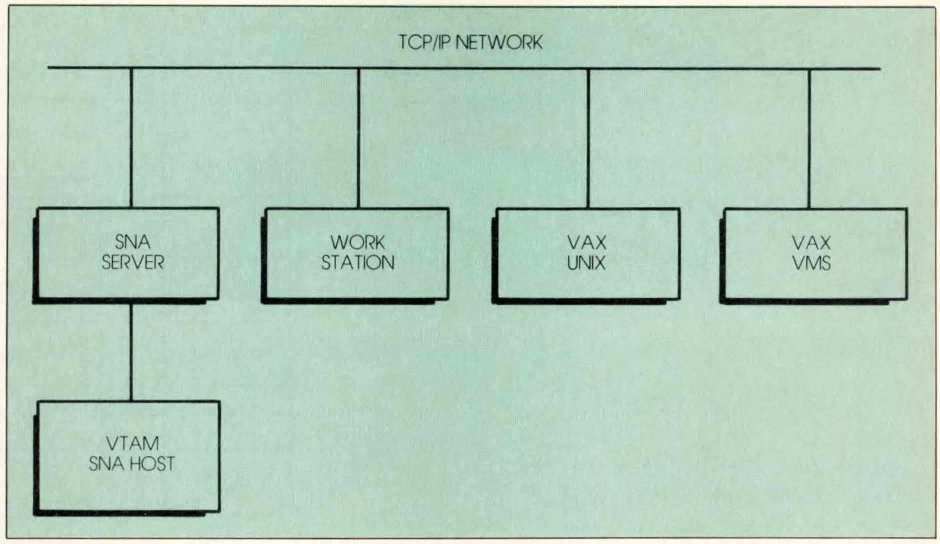


Figure 1—*An SNA server links a TCP/IP network to a host using SNA. Using an API, a software bridge is created that provides UNIX or VMS access to SNA host data.*

which started in General Motors, was initially interested in plant automation and the resulting communications requirements between the various automation components. This became a major protocol because of the buying power of the user group's members.

"TCP/IP has the advantage of being implemented in more than 60 different vendors' computers today, supporting LANs with Ethernet and WANs with X.25."

The MAP users group also developed the Technical/Office Protocol (TOP). The TOP environment is intended to address the need of technical and office communications requirements, and to implement as far as possible the same standard protocols used by MAP.

MAP and TOP have pointed out the user demand for general purpose nonvendor specific communications systems to be used as building blocks to solve business communication needs. Several users have made corporate policies that force vendors to show plans to support the MAP/TOP protocols in order to continue obtaining their business.

Basic networking standards that must be accommodated in any broad solution are SNA, OSI, and an evolution to Integrated Switched Digital Network (ISDN). IBM has stated that the choice of SNA will not be a problem for the customer as the communications world implements ISDN. However, what this means specifically is yet to be determined. Other protocol standards that must be accommodated to meet customer needs include Ethernet 802.3, MAP, TOP X.25, SNA X.25, Synchronous Data Link Control (SDLC), and High Level Data Link Control (HDLC).

Distributing SNA Services Via Ethernet

Customers requiring IBM mainframe connectivity to devices linked with Ethernet accomplish this either by using IBM applications and retaining a full IBM environment, or by moving departmental applications into the mainframe environment. The latter approach effectively uses the mainframe as a compute server, while the former approach distributes information to the departmental environment without perturbing the integrity of the mainframe system. Both approaches work.

Another approach is to preserve the IBM SNA environment on the mainframe and distribute SNA services to the nonIBM environment. The provision of an API for both 3270 and 3770 environments is a powerful applications tool to link both environments.

Use of a LAN SNA server, as shown in Figure 1, provides an extension of

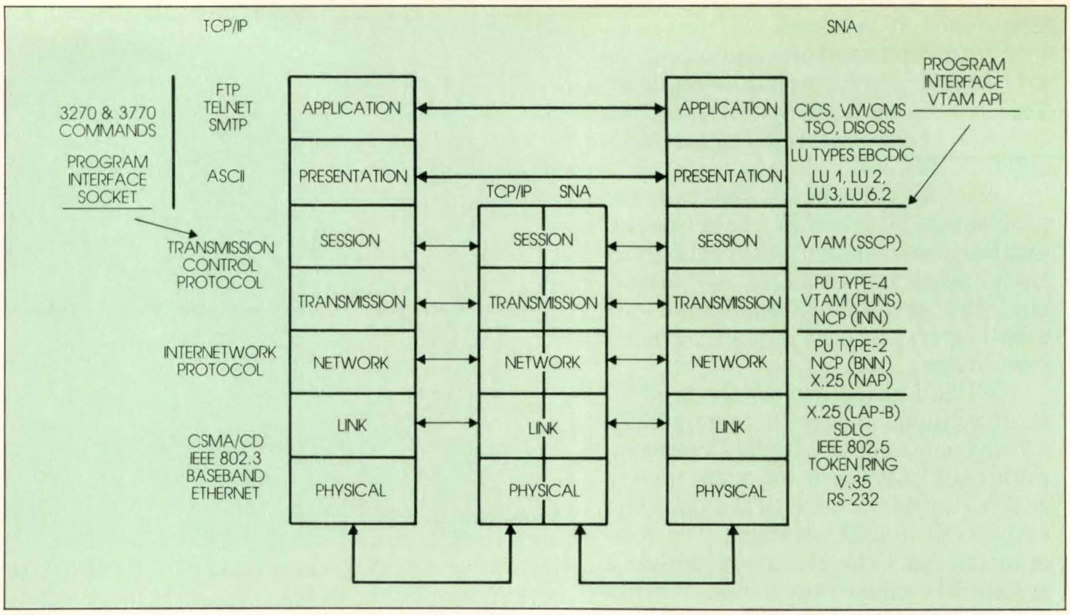


Figure 2—*Under an SNA LAN, SNA and TCP/IP are bridged with no modifications to either the IBM or TCP/IP computer.*

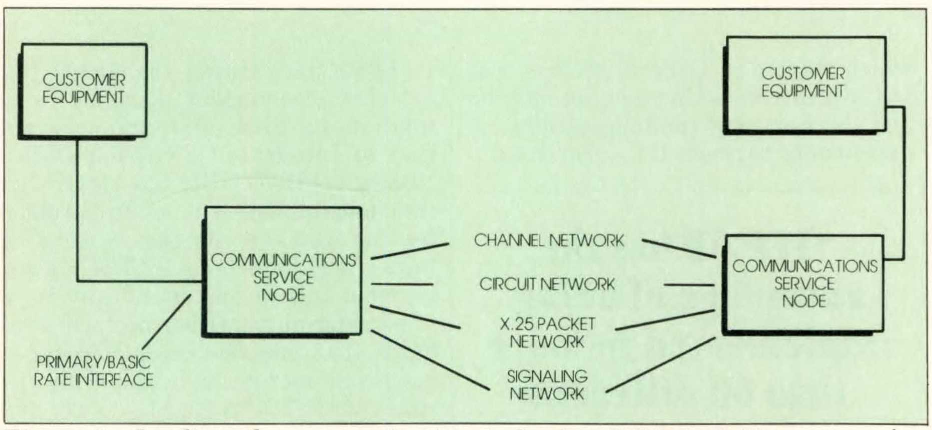
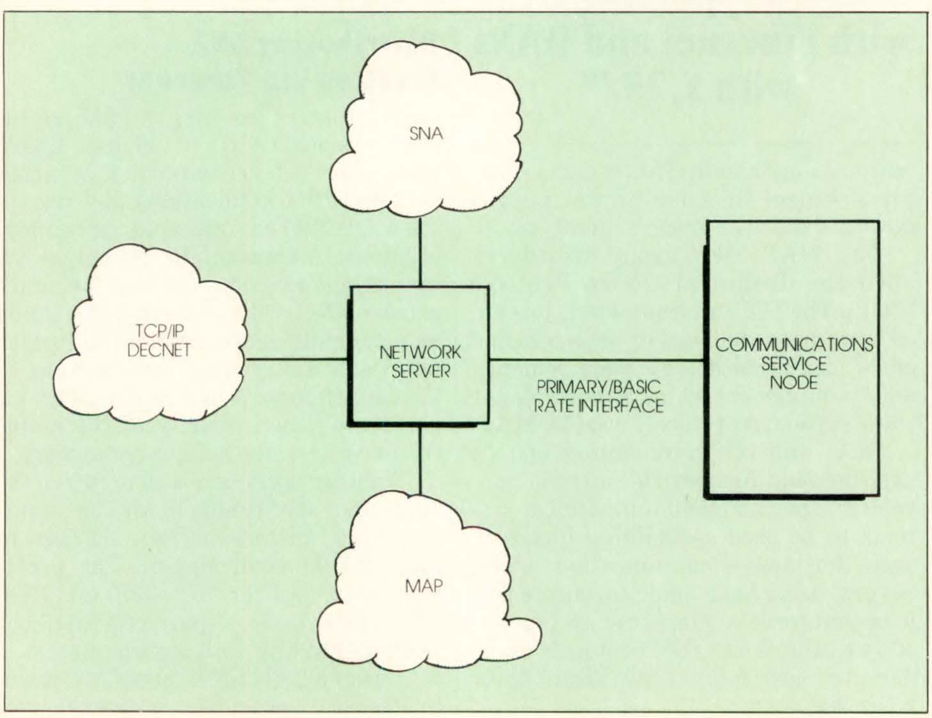


Figure 3—*Leading-edge communications technology is illustrated by communications service nodes linking computer installations over WANs.*



the standard TCP applications available to the user. Applications available to the user are augmented by SNA 3270 and SNA 3770 SNA access. In addition, a software bridge is provided via the API that, in essence, provides UNIX or VMS application software access to mainframe data.

The LAN Server Implementation

The SNA LAN server networking architecture is illustrated in Figure 2. The server effectively bridges SNA and TCP/IP environments by using the standard TCP/IP interface specification called a socket. No modifications are required to either the IBM or the TCP/IP computer. The user of the TCP/IP computer can access the IBM environment via standard IBM 3770 RJE for job submission and retrieval, standard 3270 terminal emulation, application access, and support. Concurrent 3270 and 3770 operations are permitted from the same host or multiple hosts. Application program interfaces for both 3270 and 3770 and application program-to-program communication are available to be used in conjunction with the application software resident in the departmental resources.

The server is provided with options for direct channel attach or remote link attach through RS-232 and V.35. Because of the layered implementation of SNA, this can be done without effect on the TCP/IP environment. All main-

Figure 4—*LAN servers can be extended to interface to a communications service node in addition to bridging dissimilar networks.*

frame SNA operating systems are supported, including OS/MVS, VM, and DOS; access is through VTAM, which supports CICS, IMS, TSO, VM/CMS, JES2, and JES3 applications.

What's Next?

Once SNA and LAN environments are linked, how these local environments can be linked to WANs, and how their links will migrate compatibly with ISDN facilities when they are widely available must be addressed. Figure 3 illustrates the function of a communications service node as the interface between the premises or local area environment and the WAN facilities provided by the common carrier. The service node functions can be integrated with electronic digital Private Automatic Branch Exchanges (PABXs) and electronic switches. The interface to the customer's premises will be an evolution of the current channelized interfaces to the new ISDN primary and basic rate interface. For the United States, the primary or PRI rate interface is composed of 24 slots (23B+D) and the basic rate (BRI) interface is 3 slots (2B+D). Each slot is a 64-Kbit clear channel. PRI is expected to be used for all major traffic sources, such as LAN host computers and PABXs. Full utilization of these capabilities cannot be exploited until fiber optic (or equivalent) access is in place with substantial coverage.

The LAN server can be extended to include a PRI/BRI or a broadband packet interface as illustrated in Figure 4. If the service node is a PABX, the issue of voice and data integration is raised. Who knows how many customers will implement integrated voice/data solutions? Currently, many take the position that first they must fully integrate a solution to their data networking problems, then they will address voice/data integration.

Challenging, new functions will have to be integrated into network servers as customers demand complete end-to-end voice and data service. Currently, only the basic connectivity issues such as protocol conversion have been addressed. In nonhomogeneous environments, it's more difficult to provide, except in very specific application environments, transaction routing and processing network security, and end-to-end network management in nonhomogeneous environments.

It appears that islands of incompatible computing resources are causing managers to be cautious in implementing leading-edge but unproven solutions. Many are looking to maximize current investments and, in addition, define solutions that offer open architectures that provide flexibility to expand around a government program. As managers distribute more computing resources to the end user, effective and controlled distribution of corporate information to those end users becomes an ever more important issue.

A universal device meeting this spectrum of customer needs seems unlikely, but the size of the market and the number and variety of products make it likely that users will find products that meet their needs.

How would you rate the technical information in this article?

Too complex	Enter No. 666
Just right	Enter No. 668
Too simplistic	Enter No. 670

Networking

by Larry Campbell

PCSA—Digital's Answer To The IBM PC Network

Last fall, Digital Equipment Corp. introduced the VAXmate, an innovatively packaged PC/AT compatible workstation with built-in Ethernet adapter. Along with the VAXmate, Digital also debuted the first round of products in what it calls PCSA—the Personal Computing Systems Architecture. This software architecture actually delivers complete and almost seamless integration of the MS-DOS workstation with departmental and mainframe computing.

PCSA is a blend of the industry-standard Microsoft Network's (MS-NET) networking protocols (Microsoft Corp., Redmond, Wash.), with Digital's own networking protocols, DECnet and LAT (Local Area Transport). The first set of PCSA products, dubbed "VAX/VMS Services for MS-DOS," allows personal computers to become full-fledged members of a DECnet.

Most personal computer networks today, including IBM's PC Network, are just that—personal computer networks. Period. The PCs can only talk to each other; they can't exchange data with minis or mainframes. Even worse, these networks are LANs only. Want to share your data with the West Coast division? Sorry.

Digital's PCSA, however, allows personal computer users to transparently share files with VAX users. And it functions equally as well over wide area networks (WANs) as it does over Digital's Ethernet LAN.

How does this work? The answer starts with Microsoft's MS-NET, a generic networking product that Microsoft sells to its OEMs, including Digital. It's generic in the sense that the OEM can provide his own network transport layer—that part of the software responsible for routing data from one node to another. To produce IBM's PC Network product, IBM glued together LAN hardware and transport software developed by Sytek Inc. (Mountain View, Calif.), MS-NET from Microsoft, and user interface software IBM developed. The result is a network that can support only IBM PCs and IBM Series/1 minis, and provides file sharing only among PCs.

Digital's PCSA is a result of the integration of MS-NET and DECnet, with some creative programming added by engineers at Digital's Littleton, Mass. facility. Digital used its existing DECnet-DOS product as a transport layer underneath MS-NET, so MS-NET applications running under PCSA can go anywhere DECnet goes. They're not limited to the confines of a single LAN.

Like IBM, Digital supplies a PC-based server software product that allows a VAXmate or PC to act as a file server for other PCs in the network. Digital one-upped the industry, however, by also supplying a file server software product—the PC File Server (PCFS)—that runs on VAXes, allowing PC users to store their files on a VAX and to share files with VAX users.

It's important to note that PC files stored on a VAX are ordinary VAX files that can be read and written by ordinary VAX applications—and this happens completely transparently.

The PC user sees the VAX as just another MS-DOS drive letter, J:, for example. To establish a connection between an MS-DOS drive letter and a directory on the VAX, the PC user issues a NET USE command with the drive letter, the VAX's node name, a directory name, and (optionally) a password. This is usually done automatically at boot time, through the MS-DOS startup command file, AUTOEXEC.BAT. Once this connection is established, drive J acts like any MS-DOS drive—but the files actually live on the VAX.

A VAX user can look in the directory corresponding to drive J and see all the files created by the PC user. In fact, some VAX users like to connect an MS-DOS drive to their login directory, so they can edit their ordinary VMS text files (LOGIN.COM, for instance) using MS-DOS editors like Microsoft Word.

There are a few obvious limitations. MS-DOS filenames are limited to eight characters in length, so an MS-DOS user can't see VMS files named A_VERY_LONG_FILENAME. TXT. But the advantages of this approach to file sharing are enormous.

- PC users can keep all their files on a VAX, and let the VAX operators do backups for them.
- VAX disk storage expandability is virtually unlimited, compared to the limitations on PC-based file servers.
- The PC File Server need not be on the same Ethernet—it can be anywhere in an extended, wide-area DECnet.
- The PC File Server also provides access to VAX printers, allowing a large number of PC users to share high speed printers like the LN01 laser printer.
- By connecting (via the NET USE command) to the same directory on the same VAX, other PC users can also share these files.
- Any number of connections can be made to any number of VAXes, limited only by the 26 drive letters available to MS-DOS.

File sharing is only part of the story. Digital also provides two very different and highly capable terminal emulators. The VT220 emulator runs within MS-Windows and also provides VT100 and VT220 emulation. The VT240 emulator runs outside of MS-Windows, and provides VT240 (ReGIS) emulation. Both emulators can access host systems on an Ethernet using Digital's highly efficient (but proprietary) LAT protocol.

At last Fall's VAXmate announcement, Digital announced its intent also to release versions of the PCSA software for Rainbows and IBM PCs. At press time, though, no release dates have been announced.

Larry Campbell is a Hardcopy *columnist.*

Digital Document Interchange Format Facilitates Desktop Publishing

DDIF will place Digital in a better position than before to participate in the burgeoning electronic publishing market

by Jim Meade

Digital Equipment Corp. is preparing to announce Digital's Document Interchange Format (DDIF)—a standard for the interchange of documents between one computer or peripheral and another—according to a number of sources close to Digital. DDIF is now being readied for the announcement by Digital's Robert Sanfacon within the Document Processing Marketing group in Merrimack, N.H., headed by Jackie Kahle.

Standards like DDIF facilitate electronic publishing and offer a number of advantages to users, say experts in technical publishing. For Digital itself, the biggest benefit is likely to be increased sales of computer equipment, suggest analysts like Associate Editor Peter Dyson of *The Seybold Report on Publishing Systems* in Media, Pa. By offering a formatting standard, Digital will be in a better position than before to participate in the burgeoning electronic publishing market.

Electronic publishing was a $3.4 billion market in 1985 and by 1989 will grow to a $7 billion market, says Woodrow Vandever, executive vice president of Interconsult Inc. of Cambridge, Mass.—a consulting company that cosponsors the well-known Corporate Electronic Publishing Systems (CEPS) conferences. Desktop publishing was a $221 million segment of the overall electronic publishing market in 1985, representing a small, but growing, piece of a whole that also includes commercial publishing (newspapers, magazines, and books) and all forms of corporate publishing from technical manuals to annual reports.

One indication of the size of the CEPS market is the number of various corporations becoming active in it. Companies that were in the typesetting business, like Interleaf of Cambridge, Mass. and Texet of Arlington, Mass., offer products for electronic publishing. Office automation companies like Wang and NBI are moving into electronic publishing. Film companies like Dupont, Agfa, Kodak, and 3M are entering electronic publishing, because publishing takes place on film as well as on paper. And computer companies like IBM and Digital are entering the marketplace as well.

Major benefit—*Interleaf Inc. markets an electronic publishing system for MicroVAX II and VAXstation II hardware. The company views DDIF as a major benefit to itself and its customers.*

Digital has not been among the early leaders in the best known electronic publishing fields—desktop publishing and newspaper publishing. Within the desktop marketplace, for instance, the leading companies, at present, are Apple with its Macintosh Plus system and Apple LaserWriter printer, Hewlett-Packard with its HP LaserJet printer, and IBM. A number of smaller companies dominate high end publishing, like Scitex of Israel.

Digital dropped out of the marketplace for commercial newspaper publication, notes Stephen Edwards of *The Seybold Report*, and has been concerned about its slippage in both the low and high ends of the electronic publishing marketplace.

DDIF can provide Digital with a basis for competing more effectively in electronic publishing. A standard like DDIF does for a formatted document what the well-known ASCII standard does for character transmissions. It specifies that transmitted characters be a certain size—a certain number of dots or magnetic bits. Standards like DDIF establish specifications for the formats in a document, as opposed to the alphanumeric characters in a text stream.

The Navy has such a standard, says Dyson, which is known as the Document Interchange Format (DIF). IBM also has a standard widely known to IBM users—Document Content Architecture (DCA). And a national committee has prepared a standard known as Standard Generalized Markup Language (SGML) that according to some experts is gaining acceptance more slowly than its proponents had hoped.

A document interchange format allows a document to pass from one system to another without losing its document format. Without a formatting interface, a markup expert has to recreate the formats each time the document passes from one system to another. And documents often pass from one system to another several times. A chart from a technical manual, for instance, may appear later in a slide presentation and, again, in a company annual report.

Without document formatting conventions, such elements as paragraph structure, emphasis (bolding and underlining), headlines, and footnotes all tend to be lost when a document is sent from one computer to another or from one system to another (i.e., a Wang word processor to an Interleaf desktop publishing system).

According to Dyson, a good markup language controls more than 250 structures including major headlines, minor headlines, subheads, lead-ins, first emphasis, second emphasis, footnote style 1, footnote style 2, and bulleted lists.

Numerous markup languages now exist. What has been missing—and missing for users of Digital computers—has been a standard for all markup languages that allows direct interchange between a computer system using one markup language and another system or peripheral using another. DDIF is expected to provide such a standard for the Digital marketplace.

For users, the first benefit is what Vandever describes as "a well-integrated system for exchanging documents within a corporation."

A more direct benefit to users, though, is likely to be the ability to conform to requirements for government work. In many cases, those who participate in the multibillion dollar government contracting business, notes Dyson, must submit documents that conform to the government's exacting MIL. standards, including the standards of the Navy's DIF.

Asked if computer manufacturers are under pressure to help their customers comply with such government standards, Dyson responds, "Yes, of course." In fact, he concludes, the biggest reason for a computer manufacturer to provide a formatting specification is to enable end users to comply with U.S. formatting standards.

Vendors Directory

Caddex Corp.
18532 142nd Ave. N.E.
Woodinville, WA 98072
206-481-7751 **Enter No. 518**

Datalogics
325 W. Huron
Chicago, IL 60610
312-266-4444 **Enter No. 519**

Interleaf Inc.
Ten Canal Park
Cambridge, MA 02141
617-577-9800 **Enter No. 520**

NBI Inc.
3450 Mitchell Ln.
P.O. Box 9001
Boulder, CO 80301
303-444-5710 **Enter No. 521**

Texet Corp.
37 Broadway
Arlington, MA 02174
617-641-2900 **Enter No. 522**

Wang Laboratories Inc.
One Industrial Ave.
Lowell, MA 01851
617-459-5000 **Enter No. 523**

The biggest potential users of formatting standards, though, are publishers, according to Dyson. If standards for electronic publishing become accepted, then publishers will be able to distribute and archive a library of titles electronically, in machine searchable form.

Reportedly, the Library of Congress is evaluating standards for document formatting, with an eye toward distributing documents electronically. While no one believes that a "paperless Library of Congress" is imminent, the possibility does begin to emerge as formatting standards become accepted. Should the Library of Congress require publishers to submit documents in a standard electronic format, researchers could as easily request a tape or disk from the library as they do the old-fashioned hardbound book.

Among the first to benefit from the expected announcement will be Digital's OEMs in electronic publishing, according to one such Digital marketing partner. Interleaf Inc. markets an electronic publishing system for Digital's MicroVAX II and VAXstation II hardware. The company sees the DDIF standard as a "major benefit to itself and its customers," in the words of company spokesmen.

Interleaf already has an internal policy that it will support DDIF when announced. The biggest benefit to Interleaf, say the spokesmen, is that such a standard frees the company's engineers to work on the company's specialties—document formatting, image editing, and creation—instead of on the interface between Interleaf and the Digital system.

Digital also had marketing agreements with two of the other leading companies in electronic publishing—Datalogics Inc. (Chicago, Ill.) and Caddex Corp. (Woodinville, Wash.)—which will both similarly benefit from the standard.

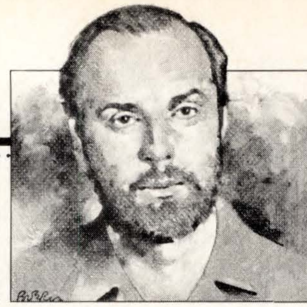
Though there are presently no software products from Digital known to adhere to the DDIF standard, word processing products are most likely to follow the standard as it emerges. Third party vendors in the competitive Digital word processing market will likewise find it "reasonable to be upward compatible with DDIF," according to several analysts.

"If companies are going to make these standards work, they're going to have to write filters or translation programs to go from a word processing file to a markup coded file [that meets the standard]," explains Dyson. Word processing companies with such filters in place will be best able to participate in the burgeoning market for electronic publishing.

At the moment, of course, no one outside of Digital knows precisely what form the standard will take. According to one source close to the company, even those inside Digital may not yet be certain of the standard. A vote within the company will ultimately decide the standard. The announcement will then follow.

Digital declined to describe the standard until after announcing the product—an announcement that one source close to Digital says is "about to take place" and another estimates may be as much as 6 mths. away or more. ■

Jim Meade is a Hardcopy *contributing author.*



The UNIX Connection

by Walter Zintz

The power of metacharacters

Metacharacters ... even the name sounds ominous. They're the characters in a UNIX system command line or text line that aren't themselves. On many systems the @ sign is the line-kill character. If you want to insert an @ in a line, you have to type something else, because typing a plain @ only erases everything you've already typed on the current line.

The power of metacharacters has a hefty price tag: user confusion. This is one place where you can't just learn the metacharacters you want to use. You must know them all, if only to avoid the catastrophes that arise from accidentally typing a metacharacter where you wanted the plain ASCII character.

UNIX systems aggravate this problem by using differing sets of metacharacters at different points within even a single line, and by having usage variants for the same mode or function within various utilities. All in all, metacharacters are about as nasty a hazard as the intermediate user faces.

Most of the confusion can be cleared away by organizing metacharacters, first in your mind and then on paper. The structure I've found effective uses two common and simple computing concepts: look-up tables and push-down stacks.

When you type at your terminal, the first software that interprets what you type is the TTY driver. Try thinking of it as taking each character as you type and looking it up in a table. The left-hand column of the table has one character on each line, and if the character just typed doesn't match one from this column (it usually won't), the TTY driver puts it back in its place in the line you're typing. If it matches, the driver checks the same line in the right-hand column to see what to do next.

Sometimes the instruction will replace the character with another character, a string of characters, or with nothing at all, as in ASCII NUL. Other lines may have commands in the right-hand column, and the driver executes the command instead of inserting anything in the line you're typing. An example of this is Control-S, which prevents the system from sending any characters to your terminal until you type a Control-Q.

The driver then passes the line to the program you're running, which has at least one look-up table of its own. If you're in *vi* and typing in a search pattern, the left-hand column for this mode has characters like * and ~ with appropriate listings in the right-hand column, and it also has other characters, like ^ and *$*, that use a center column in the table. The center column lists conditions that determine whether the referenced character is found. For instance, ~ is a metacharacter only if it's the first character in the search pattern. As with the table for the TTY driver, when a character is found, and fulfills any condition in the center column, the instruction in the right-hand column is executed; otherwise the character takes its place in the search pattern.

Sometimes the instruction in the right-hand column invokes a pushdown stack. If our *vi* search pattern contains a *[* character, the system discontinues searching for characters in the search pattern table and checks another table for character classes. One of the left-hand column entries in the character class table is *]*, and the right-hand column instruction for this ends the character class. In which case, the stack pops up the table you were using before you entered the character class—in this case, the search pattern table—and checks each character here until a character whose right-hand column instruction ends the search pattern.

Most of these look-up tables also have characters that temporarily suspend the look-up table to let you put in a metacharacter as itself. In either shell, different quote marks switch to a table with the same metacharacters but fewer of them, or with no metacharacters at all, but in either case, the table contains the same quote mark that invoked it as a command to return to the next level of the stack. The \ character doesn't even have the pop-the-stack command; the stack is always popped after the next character following the \ is read.

Finally, some of the right-hand column instructions alter the tables themselves, either the table currently in use or another one. In an *ex* editor substitution command such as *s/dog/cat/c*, the slashes that separate the string to come out and the string to replace it from each other and from the rest of the command are optional. Almost any punctuation mark could have been used if the same one was used in all three places. This is equivalent to a substitution command table that, when it finds any punctuation mark at the end of an *s* command, switches to the out-pattern look-up table, but also adds that punctuation mark to both the out-pattern and replacement-pattern tables as one that means end this pattern.

With these basic parameters, you can construct a table, or a sequence of tables, which analyzes and clarifies any UNIX utility's use of metacharacters. It's a shame that none of the ambitious publishers of quick reference cards for UNIX system users has thought to publish something like this, but it's so easy to make the tables yourself that perhaps it hardly matters.

Please send correspondence to: The UNIX Connection, Walter Zintz, c/o Uni-Ops Books, 2138 36th Ave., San Francisco, CA 94116-1645.

PRODUCT NEWS

Turnkey Systems

Desk-Top Computer

First-Mate Portable; Micro 11/23, Micro 11/73, or MicroVAX II; utilizes a VT100/200 compatible amber electroluminescent screen, a VT220-style keyboard, a 4-slot, Q-bus backplane, and a 200 W switching power supply; is portable and expandable with Q-bus compatibility; uses ¼ Mbytes—16 Mbytes of CPU memory, 10—100 Mbytes disk storage; can accommodate up to 32 users with remote terminals, depending upon the CPU installed; basic unit, $4,995; Micro 11/23, $9,995; Micro 11/73, $11,995; MicroVAX II, $19,995; shipping now.

Industrial Computer Products, 43 Mitchell Rd., Ipswich, MA 01938-1218, 617-356-7500. Enter No. 747

Mapping Database System

Distributed VAX Center (DVC); VAX; operates as a standalone workstation and as a self-contained work center that serves as the host for up to eight users, including three additional graphic workstations; designed to operate as a node on a distributed information processing network; $93,700; software only, $35,000; shipping now.

Synercom, 10405 Corporate Dr., Sugar Land, TX 77478, 713-240-5000. Enter No. 749

Superminicomputers

9810 and 9820; features Pyramid Technology's second-generation reduced-instruction set computing (RISC)-based CPUs, high-speed input/output processors, and the XTEND system bus in tightly coupled parallel processing configurations; 9810, $199,950; 9820, $299,950.

Pyramid Technology Corp., 1295 Charleston Rd., P.O. Box 7295, Mountain View, CA 94039-7295, 415-965-7200. Enter No. 751

Performance Enhancements

ESDI Controller

DQ696; MicroVAX, MicroPDP-11, and LSI-11; RT-11, RSX-11M+, RSTS/E, MicroVMS, Ultrix, UNIX, and DSM; fully compatible with the ESDI standard, including support of the ESDI parameter passing commands and disk drive manufacturers' flaw maps used in drive formatting; handles ESDI data transfer rates to 1.9 Mbytes/sec.; $1,450; shipping now.

DILOG, 1555 S. Sinclair St., P.O. Box 6270, Anaheim, CA 92806, 714-937-5700. Enter No. 753

Disk Controller

SDC-RQD11-EC; Q-bus to ESDI interface disk controller; RT-11, RSX-11, TSX, RSTS/E, MicroVMS, and UNIX; on-board WOMBAT utilities provide comprehensive off-line, menu-driven formatting and diagnostics; includes 1 Mbyte of cache memory; simultaneous disk

CALENDAR

Feb. 9,10
Software Project Management, Atlanta; Georgia Institute of Technology, Dept. of Continuing Education, Atlanta, GA 30332. 404-894-2547

Feb. 9–12
Supercomputers And AI Machines, Chicago; Technology Transfer Institute, 741 Tenth St., Santa Monica, CA 90402-2899. 213-394-8305

Feb. 9–12
VAX/VMS Real-Time Applications Design, San Francisco; Digital Educational Services, Seminar Programs, BUO/E58-15, 12 Crosby Dr., Bedford, MA 01730. 617-276-4949

Feb. 10–12
Computer Aided Publishing CAP '87 Conference And Exposition, Washington, D.C.; CAP '87, 90 W. Montgomery Ave., Ste. 200, Rockville, MD 20805. 301-294-8710

Feb. 10–12
Optical Memory Technology And Applications, London; Technology Opportunity Conference, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496. 415-681-3700

Feb. 10–13
High Performance Computer Architectures, Boston; Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213-417-8888

Feb. 10–13
Introduction To Multicomputer System Design, Toronto; Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213-417-8888

Feb. 10–13
Machine Vision And Image Recognition, San Diego; Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213-417-8888

Feb. 11,12
Software Production, Atlanta; Georgia Institute of Technology, Dept. of Continuing Education, Atlanta, GA 30332. 404-894-2547

Feb. 11–13
VMS System Security Features, Boston; Digital Educational Services, Seminar Programs, BUO/E58-15, 12 Crosby Dr., Bedford, MA 01730. 617-276-4949

Feb. 16–20
20th Annual DECUS Canada Symposium, Montreal; DECUS, 505 University Ave., 15th Fl., Toronto, Ontario M5G 2H2. 416-597-3437

Feb. 19
Understanding Computers, Bakersfield, CA; Padgett-Thompson, Padgett-Thompson Bldg., P.O. Box 8297, Overland Park, KS 66208. 913-451-2900.

Feb. 19,20
Local Area Networks, Los Angeles; Data-Tech Institute, Lakeview Plaza, P.O. Box 2429, Clifton, NJ 07015. 201-478-5400; Other Dates/Locations: **Feb. 26,27**—Baltimore, MD

Feb. 23–25
VAX FORTRAN V4 Advanced Programming Concepts, Orlando, FL; Digital Educational Services, Seminar Programs, BUO/E58-15, 12 Crosby Dr., Bedford, MA 01730. 617-276-4949

Feb. 24–27
Computer Network Design & Protocols, Washington, D.C.; Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614. 213-417-8888

Feb. 25–27
Managing Your MicroVAX, Orlando, FL; Digital Educational Services, Seminar Programs, BUO/E58-15, 12 Crosby Dr., Bedford, MA 01730. 617-276-4949

Feb. 26–28
Commtex International, Atlanta; ICIA, 3150 Spring St., Fairfax, VA 22031-2399. 703-273-7200

and Q-bus transfers for blocks in cache; can be programmed to perform "look-ahead" reads in anticipation of data requests; whole tracks or more can be read into cache; $1,325; shipping now.

Sigma Sales, 3401 E. La Palma Ave., Anaheim, CA 92806, 714-630-6553. **Enter No. 755**

Parallel Processor

Butterfly—Enhanced User Interface; VAX; acts as a user-transparent server on an Ethernet network; includes X Windows, a windowing and graphics capability, and the remote Butterfly shell that allows users to execute Butterfly programs from a UNIX environment; $37,000-$375,000; shipping now.

BBN Advanced Computers Inc., 10 Fawcett St., Cambridge, MA 02238, 617-497-3700. **Enter No. 757**

Memory Conversion Subsystem

STRETCH-16; VAX 11/750; VMS; allows user to replace 2-3 standard 1-Mbyte memory boards with 4-Mbyte memory arrays, for total of 14-16 Mbytes; basic subsystem (memory controller and two 4-Mbyte memory arrays), $7,900; shipping now.

EMC Corp., 12 Mercer Rd., Natick, MA 01760, 800-222-EMC2. **Enter No. 759**

Communications Controller

VMExICC; VME-based systems; features six serial channels (asynchronous or synchronous), downloadable software protocols, multioperating system support and device drivers, 2-Kbyte FIFO RAM and counters, Z80 microprocessor, 64-Kbyte RAM, 2-Kbyte BOOT-RAM; has selftest and debug capabilities, and optional Token Ring LAN controller or X.25 port; $1,495; shipping now.

ISKRA VME Technologies, 222 Sherwood Ave., Farmingdale, NY 11735, 516-753-0400. **Enter No. 761**

SMD/SMD-E Controller

UD33; Unibus-based systems; allows Unibus users to upgrade to 24 MHz SMD-E interface; up to 3.0-Mbyte/sec. throughput and more than 700 Mbytes/spindle; includes MSCP implementation; $3,500; shipping now.

Emulex Corp., 3545 Harbor Blvd., P.O. Box 6725, Costa Mesa, CA 92626, 714-662-5600 **Enter No. 763**

Storage Subsystems

Mass Storage Device

Gigastore; stores data on standard VHS cassette; employs an error correction technique with automatic write-retry when an error is detected; this results in a typically corrected error rate of 1 in 10^{23}; electrical interface is the industry standard (PERTEC), which looks like a 9-track streamer; Has 256-Kbyte cache buffer that allows transfer rates up to 7 Mbytes/min.; features a high speed search mode with an average acquisition time of 2.5 min.; $4,780; shipping now.

Digi-Data Corp., 8580 Dorsey Run Rd., Jessup, MD 20794, 301-498-0200. **Enter No. 765**

SMD To DSA Interconnect

Storage Module Disk Interconnect (SMDI); VAX host and SMD/SMD-E drives; connects variety of Storage Module Disk (SMD) products to Digital's Digital Storage Architecture (DSA); allows transfer rates of up to 3.0 Mbyte/sec. and capacities of up to 2.5 Gbytes formatted per subsystem; system with cabinet and one 850-Mbyte (unformatted) SMD-E disk drive, $20,500; shipping April 1987.

Emulex Corp., 3545 Harbor Blvd., P.O. Box 6725, Costa Mesa, CA 92626, 714-662-5600. **Enter No. 767**

Disk Drive Expansion

SA-H157; 8-in. Priam disk drive expansion chassis; supports two 8-in. Winchester disk drives (Priam Models 806, 807, and 808); includes mounting space, power and data cables, and rear I/O cable connections for the drives; $1,250; shipping now.

Sigma Sales, 3401 E. La Palma Ave., Anaheim, CA 92806, 714-630-6553. **Enter No. 769**

SCSI Disk Drive Subsystem

Power Tower; requires SCSI interface; uses one or two hard disk drives for up to 640 Mbytes of storage with 512 Kbytes-16 Mbytes of onboard cache RAM; transfer rate of 1.5 Mbytes/sec.; $3,995-$15,000; shipping now.

CMS, 3080-A Airway Ave, Costa Mesa, CA 92626, 714-549-9111. **Enter No. 771**

Terminals And Monitors

ASCII Terminal

WY-60; VT 52/100 lookalike; includes a 14-in., flatscreen CRT in green, amber, or white phosphor, a 7 x 12 character matrix in a 10 x 16 character cell with 3-dot descenders, 44 or 26 lines of text in an 80-column or 132-column format, respectively, and up to seven pages of local display memory; $599.

Wyse Technology, 3571 N. First St., San Jose, CA 95134, 408-433-1000. **Enter No. 773**

Terminal

Freedom ONE Plus and Freedom ONE Turbo; emulates VT220, VT100, VT52; Freedom ONE Plus takes full ASCII set of the Freedom ONE and adds a PC terminal operating mode; Turbo incorporates three major operating modes—ASCII, ANSI and PC Terminal; adds true emulations of ANSI standard terminals; Freedom ONE Plus, $549; Freedom ONE Turbo, $599; shipping now.

Liberty Electronics USA Inc., 625 Third St., San Francisco, CA 94107, 415-543-7000. **Enter No. 775**

Printers And Plotters

Dot-Matrix Printer

MP-1300; Lets user switch

from black and white to color printing; optional snap-in color printing kit adds complete color character and graphics printing capability to the printer; MP-1300, $699; color printing kit, $155; shipping now.

Seikosha Co. Ltd., 10080 N. Wolfe Rd., Ste. SW3/249, Cupertino, CA 95014, 408-446-5820. Enter No. 777

Printers

Linewriters 855T and 1200T; provides tamper-proof security by preventing the escape of radio frequency and electromagnetic emanations from information processing equipment; performs at speeds of 800 lines-per-minute (lpm) and 1200 lpm respectively; 855T, $14,500; 1200T, $16,900; shipping now.

Centronics Data Computer Corp., One Wall St., Hudson, NH 03051, 603-883-0111. Enter No. 779

VAX-11/750 Upgrade

NX750-SPU; VAX-11/750; increases the overall CPU and memory performance of the VAX-11/750 system; consists of an enhanced CPU board, a memory controller, and three 4-Mbyte memory arrays; increases overall CPU performance 18%; uses 256K RAM technology; recognizes both 64K and 256K technology; $13,100; shipping now.

Nemonix Inc., 106 South St., Hopkinton, MA 01748, 800-435-8650 or 617-435-9087. Enter No. 781

Pen Plotter

Autoplot; most CAD programs; D-size open frame flatbed pen plotter; 256-Kbyte buffer (expandable to 1-Mbyte) for downloading complete drawings from host; processor to examine contents of buffer and reorder drawing instructions to increase speed; makes drawings up to 22 x 34-in. with up to 8 pens at 0.001-in. resolution; one pen and 256K input buffer, $4,995; shipping now.

GTCO Corp., 7125 Riverwood Dr., Columbia, MD 21046, 301-381-6688. Enter No. 783

Laser Printer

LaserPower III; targeted for business applications; 10 pages/min.; 300 dpi resolution; up to four font cartridges (multiple fonts per cartridge); emulation modules for Diablo 630, IBM Graphics, Hewlett-Packard LaserJet Plus, others scheduled; monthly duty cycle of 6000 pages; handles letter and legal size paper, envelopes, and transparencies; $3,495; shipping now.

CMS, 3080-A Airway Ave., Costa Mesa, CA 92626, 714-549-9111. Enter No. 785

Graphics

Digitizer

DIGI-PAD 1724L; has active area of 17 x 24 inches (up to C-size), while maintaining 0.001-in. resolution; aspect ratio is suited to screen pointing; gives enough room for extensive menus; $2,000; shipping now.

GTCO Corp., 7125 Riverwood Dr., Columbia, MD 21046, 301-381-6688. Enter No. 787

Graphics System

928 Graphics Engine; Ethernet, VME, RS-232; interactive 3D graphics display systems designed for single operator trainers, target projectors, avionics displays, and simulators; optimized for developing sophisticated real-time graphics; uses finite state logic to allow the development and display of complex shaded models in real-time; user can create and display realistic combat scenarios with 16.7 million simultaneous colors; $34,900; shipping now.

Megatek Corp., 9645

Scranton Rd., San Diego, CA 92121, 619-455-5590.
Enter No. 789

3D Design Package

Assembly Modeller; lets the architect and engineer manipulate 3D building components within a 2D environment; features all the flexibility, speed, and familiarity of 2D drawing techniques with the benefits of a 3D model; $3,000; shipping now.

McDonnell Douglas, Information Systems Group, 325 McDonnell Blvd., St. Louis, MO 63042, 314-232-3965.
Enter No. 791

Graphics Controller

QG-1280A; MicroVAX I or II; 1280 x 1024 graphics controller board set for the Q-bus; operates at 60Hz non-interlaced and has 8 bit planes with a 256 of 16 million color palette; VT-100 operation and local graphics input support for mice and trackballs; $4,995; shipping now.

Matrox Electronics Ltd., 1055 St. Regis Blvd., Dorval, Quebec, H9P 2T4, Canada, 514-685-2630.
Enter No. 793

Asynchronous Digitizing Module

MAX-SCAN; VMEbus-compatible; digitizes non-standard video and analog input signals from asynchronous sources with different resolutions and frame rates; can set pixel conversion rate from as slow as needed, up to a maximum speed of 10 MHz; conversion rate can be locked into and governed by an attached sensor's sampling pulse rate, or internal clocks can control the camera's sampling pulse; lines of scanned information can be programmed to be up to 4,096 pixels long; can be adjusted to accept resolutions from 1 x 1 to 4,096 x 4,096 pixels; frame rates from several sec/frame to 1,000 frames/sec.; $3,250; shipping now.

Datacube Inc., 4 Dearborn Rd., Peabody, MA 01960, 617-535-6644. Enter No. 795

Color Printing System

CPS-201; RS-232; consists of a Lasergraphics rasterizing computer and a high-resolution high-speed color thermal transfer printer from Calcomp; accepts Lasergraphics Language (LL); the thermal transfer printer produces paper and overhead transparencies at 200 dots per inch, in color or black and white, with over a million possible halftoned colors or 100 shades of gray; $9,950; shipping now.

Lasergraphics Inc., 17671 Cowan Ave., Irvine, CA 92714, 714-660-9497. Enter No. 797

Communications

Terminal Emulation/ Communications Software

Reflection Series 2.0; emulates VT220 and VT102; standardizes the features available from the company's previous programs designed for IBM PCs; expands the background multitasking feature to the entire Reflection Series line; "pop-up" feature allows users to move between emulation and PC modes with a single keystroke; users can continue to work in PC programs while communications tasks, such as file transfer, continue in the background; $199–$499; shipping now.

Walker Richer & Quinn, 2825 Eastlake Ave. E., Seattle, WA 98102, 206-324-0350. Enter No. 799

Statistical Multiplexers

SPL; on-line manual is accessed through a separate asyncronous port that autobauds at 300, 1200, 2400, and 9600 bps; this port displays all set-up options and statistics about composite channel and terminal port activity and status; multiplexers concentrate up to 14 asyncronous terminal ports over one composite communications channel; full duplex composite may be either asynchronous or synchronous; $795–$2,995; shipping now.

DCB, 807 Pioneer, Champaign, IL 61820, 800-637-1127. **Enter No. 801**

Modem

9650PA; 9600 bps synchronous modem; provides four integral automatic dialers, full front-panel control and V.29 and V.27 *ter* compatibility; targeted at 2-wire dial-up applications, such as micro-to-mainframe SNA and bisync data transmission, point-of-sale, R.J.E. batch processing, and database uploads common among automotive dealers, retail chains, and others; operates at 9600, 7200, and 4800 bps; $1,695; shipping now.

Racal-Vadic; 1525 McCarthy Blvd., Milpitas, CA 95035, 408-946-2227. **Enter No. 803**

Fiber Optic Multiplexer Card

Versitron MP959; features a single channel, RS-232, synchronous interface port card for the company's fiber optic multiplexers; operates at up to 38.4 Kbps in a high speed configuration or up to 19.2 Kbps in a low speed configuration; shipping now.

Versitron, 6310 Chillum Pl., Washington, DC 20011, 202-722-8600. **Enter No. 805**

Statistical Multiplexers

Commander 16 and 32; designed to accommodate 16 and 32 channels; use checking routines to protect data from errors; an automatic retransmitting queue (ARQ) algorithm and a cyclic redundancy check (CRC) ensure that when line errors occur, data is automatically checked and retransmitted; any channel may be configured for synchronous or asynchronous operation; Automatic Baud Recognition (ABR) permits the multiplexers to recognize the speed of dialup inputs, eliminating the need for separate speed-dedicated lines, computer ports, or telephone rotaries; Commander 16, from $1,900; 32, from $2,800; shipping now.

ITRON, Cherry Hill Industrial Ctr.-9; P.O. Box 5730, Cherry Hill, NJ 08003-1688, 800-257-8352 or 609-424-9400. **Enter No. 807**

Data Protection System

Transaction Tracking System (TTS); requires System Fault Tolerant (SFT) NetWare Level II; protects database integrity in the event that workstations or file servers on a local area network (LAN) fail during network operation; TTS, $995; SFT NetWare Level II, $3,995; shipping now.

Novell Inc., 748 N. 1340 W., Orem, UT 84057, 801-226-8238 or 800-453-1267. **Enter No. 809**

High-End I/O Computer System

I/O Computer System 200 (IOC 200); running rates of 200 Mbytes/sec.; routes I/O traffic to and from attached devices such as high-speed disk and tape, array processors, general-purpose computers, telemetry systems, data acquisition equipment and custom devices; dedicates a high-performance I/O processor (IOP) to any mix of attached devices; handles data streams at rates as high as 12 Mbytes/sec., while performing data manipulations concurrently; $35,000-$100,000; shipping in March 1987.

Aptec Computer Systems, 9605 S.W. Nimbus Ave., Beaverton, OR 97005, 503-626-9000. Enter No. 811

Synchronous Communications

Network Interface Unit 140 (NIU-140); requires two Ungermann-Bass High Speed Remote bridges and a T-1 line; connects two synchronous devices over T1 lines at up to 1.544 Mbps transmission speed; supports common synchronous protocols from Digital, IBM, Sperry, and Honeywell; baseband models, $2,595; broadband models, $2,995; shipping now.

Ungermann-Bass Inc., 3900 Freedom Circle, Santa Clara, CA 95052-8030, 408-496-0111. Enter No. 813

Modems

Datalink 4800, 9600, and 9600 Fast Train; receives "signal quality" graph; features auto-dial backup; remote monitor screens; multidrop message broadcast, diagnostic feature update, additional quick setup functions, and a setup summary; Datalink 4800, $1,295; 9600, $1,795; 9600 FT, $1,995; shipping now.

Penril DataComm, 207 Perry Parkway, Gaithersburg, MD 20877-2197, 301-921-8600. Enter No. 815

Communications Software

3780Plus; VAX; Ultrix; enables Ultrix to talk directly to mainframe computers via 2780 or 3780 BSC protocols; $1,595; shipping now.

Cleo Software, 1639 N. Alpine Rd., Rockford, IL 61107, 815-397-8110. Enter No. 817

Token Ring LAN

p1380; PC/AT interface to a token ring LAN; Digital Equipment Corp., Sun Microsystems, Masscomp, Intel, and Motorola; plugs into two AT slots to allow access to Proteon's ProNET[R]-80, and 80 Mbit/sec. token ring LAN; $4,900; shipping now.

Proteon Inc., Two Technology Dr., Westborough, MA 01581-5008, 617-898-2800. Enter No. 827

Patch Panels

Data Communication Patch Panels; available in 24, 48, 64, and 96 I/O ports configured for 2, 4, 6, or 8 wire; functions as a fully connectorized (manual) port selector, switch demarcation point or multi-drops; $150-$595; shipping now.

Cable Management Systems Inc., 17955 Skypark Circle, Ste. F, Irvine, CA 92714, 714-261-2622. Enter No. 823

Monolithic VME Backplanes

J1/J2; VME; 21-, 10-, and 7-slots; features 8-layer construction with stripline design for uniform impedances and signal delay, with no forward crosstalk; reduces RFI because all signal traces are on the inside layers and the two outside layers are power and ground planes; optional ground to chassis connection further reduces RFI; $1,195; shipping now.

Vector Electronic Co., 12460 Gladstone Ave., P.O. Box 4336, Sylmar, CA 91342-0336, 818-365-9661.

Enter No. 819

Ethernet Software

Bridge compatibility option for FUSION Network Software (FNS); VAX; VMS, UNIX, MS-DOS, 8086 and 68000; provides compatibility with the network products from Bridge Communications Inc.; processors can connect over Ethernet with non-processing devices currently supported by the RS-232-based Bridge CS/1, CS/100, CS/200, and LS/1 terminal servers; supports both the TCP/IP and XNS protocols; FNS supports the upper levels of the ISO model for open systems interconnection to provide the transport and session level protocols to communicate with Bridge devices; from $100; shipping now.

Network Research Corp., 2380 N. Rose Ave., Oxnard, CA 93030, 805-485-2700.

Enter No. 825

Packet Assembler Disassembler

Model 1000; for X.25 networks; provides convenient network management facilities such as downline loading, local and remote loopback, and remote control terminal capabilities; performs self-diagnostics on power up; retains all configuration parameters if power fails; integrated easily into any data network; functions as a practical alternative in multiplexer applications; $1,725; shipping now.

Develcon Inc., 6701 Sierra Ct., Ste. E, Dublin, CA 94568, 415-829-6200.

Enter No. 821

Systems Software

SPACE Forecasting Software

SPACE; VAX; VMS; allows the facility manager or space planner to store and retrieve information about the space requirements of large groups; generates standard reports on topics such as detailed space needs for individual groups, adjacency requirements and workplace assignments; generates graphic reports such as organizational charts, adjacency matrices, bubble diagrams and bar charts showing relative group size in terms of area and number of personnel; supports up to six planning dates for forecasting facility requirements; $7,500–$20,000; shipping now.

HOK/CSC, 802 N. First St., St. Louis, MO 63102-2529, 314-621-4700.

Enter No. 829

PRODUCT NEWS

CASE Software

ProMod/RT; VAX, IBM/PC/XT/AT and compatible systems; a systems software CASE environment for the analysis and design of realtime programs; combines structural analysis and software design concepts into a common structure to improve quality, reliability and productivity in realtime software development; provides text editing and graphics tools to create the control flow diagrams, specification matrices and tables necessary in realtime analysis; syntex and structure checking (leveling and balancing) cross-checks all elements for consistency and completeness; VAX from $25,000; PC from $9,950; shipping now.

Promod Inc., 22981 Alcalde Dr., Laguna Hills, CA 92653, 714-855-3046.
Enter No. 831

System Management Software

V-X Master; VAX or MicroVAX; VMS; V-X Master I provides menu-driven system management for installations without a full-time data processing person; provides error-checked screens, queries, and on-line help for novice managers; V-X Master II provides tools for full-time system managers running multiple VAX systems in data center and remote sites; V-X Master I starts at $3,000 for MicroVAX II; V-X Master II starts at $3,500.

American Management Co. Inc., 420 Bedford St., Lexington, MA 02173, 617-861-6262. **Enter No. 833**

Electronic Mail Utility

MASS-11, V. 6-C; VAX, MicroVAX, IBM PC, Rainbow; features support for up to 500 mechanical and laser printers on a single VAX network; communications utility permits the transfer of MASS-11 MANAGER database files between PCs and

VAXes; features the ability to create and edit related columns on-screen by using multiple left and right margins in a ruler; index generator allows users to create a words/phrases index document against which documents are checked for indexed words and phrases; file integration command lets users integrate graphics files from popular graphics software packages into MASS-11 documents on the VAX; hyphenation program permits a hyphenation and formatting pass for proportional documents; features optional line numbering for documents; PC, $195-$395; MicroVAX II, $5,750; VAX Systems 8500, $17,250; shipping now.

Microsystems Engineering Corp., 2400 W. Hassell Rd., Ste. 400, Hoffman Estates, IL 60195, 312-882-0111.

Enter No. 835

Textual Data Management

BASIS-UNIX capability; VAX, MicroVAX II, Ultrix 32, Ultrix 32M; allows business, industrial and office environments to take advantage of BASIS's textual data management features united with UNIX's capabilities; features a full-text, modular system that also runs on IBM, Control Data Corp., Wang and PRIME minis and mainframes; VAX, from $15,200; MicroVAX II, from $17,250.

Information Dimensions Inc., 655 Metro Pl. S., Dublin, OH 43017-1396, 614-761-7300.

Enter No. 837

Resource Manager

Resource Manager 3 with Windows; features predefined inquiry windows; is an installation and system utilities package for the 14-module Open Systems Accounting Software (OSAS) product line; Upgrade prices $55-195 per module; shipping now.

Open Systems Inc., 6477 City West Pkwy., Eden Prairie, MN 55344, 612-829-0011.

Enter No. 839

Disk Restructurer

DISKIT/VMS, V. 4.4; VAX, MicroVAX II; VMS; restructures disks to create contiguous files and grouped free space, allowing specific file placement, disk restructuring in batch mode, and the ability to restructure multiple disks simultaneously; VAX, $2,950; MicroVAX II, $1,950; shipping now.

Software Techniques Inc., 6600 Katella Ave., Cypress, CA 90630, 714-895-1957.

Enter No. 841

Operating System Interface

Mimesis; VMS and MS-DOS; emulates the input of a variety of operating systems; comes with either a sample VMS- or MS-DOS-style shell already created, and the MIMESIS compiler, the tool used to create and modify user interfaces; can be used to limit the command set for a designated number of users; $2,000-$10,000 per CPU; shipping now.

J & L Software Inc., 1337

Heidi Dr., Plano, TX 75023, 214-423-1960. Enter No. 843

COBOL Compiler

ACUCOBOL; VAX; VMS, Ultrix; features 3,500 lines-per-minute compiles; supports 16 open files in the Ultrix environment; incorporates a built-in "windowing" option that speeds and simplifies windowing program development; from $3,000; shipping now.

Computer Cognition, 6696 Mesa Ridge Rd., San Diego, CA 92121-2906, 619-453-6660. Enter No. 845

Fourth Generation Language

ZIM v 2.53; MicroVAX II, VAX 11/7xx, VAX 8xxx; VMS; 4GL includes compatibility across several operating systems, full access to any VMS program, terminal description utility, compact databases, page locking and concurrency, optional logs for audit, screen formats; $3,500–$20,000; shipping now.

Zanthe Information Inc., 1200-38 Antares Dr., Nepean, Ontario, Canada K2E 7V2, 613-727-1397. Enter No. 847

Developer Support Software

ZIM Development Assistant; MicroVAX II, VAX 11/7xx, and VAX 8xxx; VMS and ZIM; provides developer facilities for ZIM, including automatic application generation, menu generation, on-line help, and full-screen data dictionary manipulation; $700--$5,000; shipping now.

Zanthe Information Inc., 1200-38 Antares Dr., Nepean, Ontario, Canada K2E 7V2, 613-727-1397. Enter No. 849

Device Driver

Talaris 800/1200/2400 device drivers; permits users of the device independent Precision Visuals' graphics software packages to take full advantage of the Talaris line of laser printers; supports the Talaris Models 800, 1200, and 2400; can produce from 8 to 24 pages of output per minute at a resolution of 300 dpi; provide text generation, with a hardware generated exact size font, as well as nine standard fonts; additional fonts are available from Talaris; $1,000; shipping now.

Precision Visuals, 6260 Lookout Rd., Boulder, CO 80301, 303-530-9000. Enter No. 851

Graphics Conversion Utility

Universal Raster Compaction Utility; converts raster data to Versatec Data Standard (VDS) compacted data for output to Versatec electrostatic color and monochrome plotters, resulting in less data for faster output in remote and online plotting applications; designed to work with most computer operating systems; output is either in one-dimensional or two-dimensional optimized raster format; One-dimensional compresses each scan line in the x-direction and requires less CPU time; $1,000; shipping now.

Versatec, 2710 Walsh Ave., Santa Clara, CA 95051, 800-538-6477. Enter No. 658

System Management Package

SystemMaster, V. 3.0; VAX; VMS; features on-line help, user interface, and system management tasks, including user authorization, internal authorization, queue management, device management, process management, software update and installation, cluster management, and DCL functions; $7,500; shipping now.

Ziff-Davis Technical Information Co., 80 Blanchard Rd., Burlington, MA 01803, 800-227-1209. Enter No. 853

Runtime Query/ Report Software

ZIM Query Runtime; MicroVAX II, VAX 11/7xx, and VAX 8xxx; VMS and ZIM; Adds ad-hoc query and report abilities for end users; $1,580–$8,000; shipping now.

Zanthe Information Inc., 1200-38 Antares Dr., Nepean, Ontario, Canada K2E 7V2, 613-727-1397. **Enter No. 855**

C Cross Compiler

Lattice MS-DOS C V. 3.1; VAX 7xx, VAX 8xxx, IBM 370; VMS, UNIX, Berkeley UNIX; allows a team of programmers to work on the same source code; uses Phoenix Overlay Linker; object module library, disassembler, more than 300 built-in functions, debugging; from $5,000.

Lattice, P.O. Box 3072, Glen Ellyn, IL 60138, 312-858-7950. **Enter No. 857**

ASN.1 Compiler

ASN.1; encodes and decodes data packets directly from C-language structures; ISO users can side-step manually encoding the protocol data units in a complex language syntax, Abstract Syntax Notation One (ASN.1); $19,750; shipping now.

Communication Machinery Corp., 1421 State St., Santa Barbara, CA 93101, 805-963-9471. **Enter No. 859**

Pascal Compiler

Pascal-2; VAX; PDP-11, VAX, VAXmate, MicroVAX, 68000/20, and 32000; features a large-memory model and 32-bit integer support, sophisticated debugger, error walkback, the Intel CEL87 mathematics library, an assembler interface, an execution profiler, and other utilities, including an interface to programmable BRIEF text editor; $350; shipping now.

Oregon Software, 6915 S.W. Macadam Ave., Portland, OR 97219, 503-245-2202. **Enter No. 861**

Applications Software

Mapping Database System

INFORMAP III; VAX, MicroVAX II, and VAXstation; VMS; combines interactive graphics, geo-relational database management, rule-based data capture, and specialized cartographic functions into a single, integrated software system; is a key component of the company's recently announced distributed architecture and is fully compatible with other Synercom software; from $35,000.

Synercom, 10405 Corporate Dr., Sugar Land, TX 77478, 713-240-5000. **Enter No. 863**

Statistical Software

S Software; VAX; VMS, UNIX; features an interactive high level language, fully interactive graphics capability, statistical analysis tools including EDA, robust methods, and univariate and mul-

tivariate techniques; includes integrated data management and structuring capabilities; $800-$3,000; shipping now.

Qualtech Systems Inc., P.O. Box 1123, Provo, UT 84603-1123, 801-379-3736.

Enter No. 865

Document Editor

Edit*PRO*; Sun 2 or Sun 3 workstation; Sun 2.x, Sun 3.x, Sun Windows; permits an operator to correct errors and potential errors detected by the CDP (Compound Document Processor) as part of its omnifont character recognition process; unrecognized and potentially misrecognized characters are flagged for correction; misspelled words are indicated; $1,500.

The Palantir Corp., 2500 Augustine Dr., Santa Clara, CA 95054, 408-986-8006.

Enter No. 867

Spreadsheet

20/20; VAX, MicroVAX II, VAXmate, Wang, IBM, Data General, Prime, AT&T; features integrated spreadsheet with graphics, database management, and project modeling; includes interface to Digital's All-In-1; MicroVAX II, $3,300; VAX 8800, $14,700; shipping now.

Access Technology, 6 Pleasant St., S. Natick, MA 01760, 617-655-9191.

Enter No. 869

CIM MRP Software

MANMAN/ENGINEER; VAX; links engineering design information with a manufacturing system (MANMAN/MFG); provides engineers with a database for new parts and product structures and transfers the product structures to the production database when design finished; turnkey system, $12,000-$17,000; software only, $16,000-$23,000; shipping now.

ASK Computer Systems Inc., 730 Distel Dr., Los Altos, CA 94022, 415-969-4442.

Enter No. 871

Developer's Tool Kit

FlexTools; VAX; VMS, UNIX; includes an online programmer's reference guide; trade secret utility; data and file relocation; documentation and maintenance; $195.

DataAccess Corp., 8525 S.W. 129th Terrace, Miami, FL 33156, 305-238-0012.

Enter No. 873

SQL-based RDBMS

Easy*SQL; VAX, MicroVAX, IBM PC; provides a visual interface for ORACLE users; interface is provided by the use of point-and-select techniques aided by pop-up windows, function keys, flexible menus, and automatic hints and context-sensitive help; mouse support is available on the IBM PC; provides facilities for report writing, color graphics, database table creation and maintenance; capabilities also include data entry and updates using fill-in-the-blanks techniques; With ORACLE IBM PC, VAX, $1,000-$48,000; shipping now.

Oracle Corp;, 20 Davis Dr.,

Belmont, CA 94002, 800-345-DBMS. Enter No. 875

Dental System

DENT-11, V. 4.0; Micro PDP-11; accounting and patient management system; designed specifically for the medium to large dental practice or clinic; allows each user to control four processes concurrently from a single terminal; provides screen editing with merge capability for correspondence and patient treatment; general practices or specialists; can be custom-tailored; $26,000–$100,000; shipping now.

J.L. Computer Systems, 3401 Lancaster Ave., Wilmington, DE 19805, 302-998-8030. Enter No. 877

Financial Planning Software

BOS Planner, V. 1.1; VAX; PDP-11; has facilities for budgeting, cash flow forecasting, "what-if" investigations, NPV, IRR, calculation of depreciation, etc.; single-user, $450; multi-user, $900; shipping now.

BOS National, 2607 Walnut Hill Lane, Dallas, TX 75229, 214-956-7722. Enter No. 879

Document Production Software

Scribe; VAX;VMS; UNIX; supports PrintServer 40; is electronic publishing software that produces documents in a variety of fonts; creates documents such as reports, manuals, journal articles, technical specifications and proposals for printing on laser printers and photocomposers; includes footnotes, bibliographies, table of contents, indices, mathematical equations, and cross-references; $4,000–$25,000; shipping now.

Unilogic Ltd., Ste. 240, Commerce Ct., 4 Station Sq., Pittsburgh, PA 15219-1119, 412-281-5959. Enter No. 881

Calendar Management Software

TARGET-> CALENDAR, V. 5.0; VAX; VMS; provides complete personal and group calendar management; users can maintain all daily appointments and meetings; can be accessed by other users in "read" or "write" mode once appropriate authorization has been granted; on-line help is available; entries may be "searched" for specific text; allows the user to print a hardcopy listing of their calendar; users are notified of current appointments when they log on to their system; MicroVAX, $395; 11/7XX VAX, $595; 8XXX VAX, $795; shipping now.

Target Systems Corp., 33 Boston Post Rd. W., Marlboro, MA 01752, 617-460-9206.

Enter No. 883

Typographic System

Mini-Set; PDP-11/73; minicomputer-based typographic system; comprised of four RP-500 editing terminals, a PDP-11/73 minicomputer with 2 Mbytes of memory, an 80-Mbyte Winchester disk for program and job storage, a 70-Mbyte tape cartridge for job archiving and Winchester backup, and a serial photo unit interface; contains an asynchronous communications multiplexer with eight serial port hookups for word processors, personal computers and modems; includes four expansion slots for added options such as additional terminals, the RayPort make-up station, and magnetic tape; $45,000.

RayPort Systems Inc., 10 Union Pl., New Windsor, NY 12550, 914-562-1982.

Enter No. 887

Decision Support Software

DecisionMaker; VAX; requires MANMAN; links ASK's MANMAN Information System directly to managers who need summary information in order to make decisions; includes exception reporting; $8,100-$15,000; shipping now.

ASK Computer Systems Inc., 730 Distel Dr., Los Altos, CA 94022, 415-969-4442.

Enter No. 885

Systems Security And Power Conditioners

Uninterruptible Power System

7000 series-rack mount version; assures on-line, regulated, continuous AC power for computers and other critical equipment in the 3 KVA power range; operates at 60 Hz with 120 VAC input and provides 120 VAC output to the critical load; $5,195; shipping now.

RTE Deltec, 2727 Kurtz St., San Diego, CA 92110, 800-854-2658. **Enter No. 889**

Backup Power Unit

Model 500; prevents system "mis-matching" and features a "self-test" function to assure that the unit is operational at all times; if overloaded by a computer system, either in the ac or inverter mode, an internal circuit is tripped, setting off an audible alarm and a red indicator lamp; features a fast 1–2 msec transfer time; fully synchronized transfer of power to inverter and back to the ac line allows the proper operation of all phase-sensitive equipment; $795; shipping now.

Safe Power Systems Inc., 528 W. 21st St., Tempe, AZ 85282, 602-894-6864.

Enter No. 891

Computer Security Utility

KBLock; VAX; VMS; temporarily blanks and locks screens; secures users' terminals by intercepting and

For additional product information, please write the appropriate reader service number on the Reader Inquiry Card.

throwing away unauthorized input; lock is initiated by pressing a user definable control character; no input is accepted until the correct password is entered; MicroVAX, $700; VAX 8600, $1,200; shipping now.

Clyde Digital Systems, P.O. Box 4500, Provo, UT 84603, 801-224-5306.

Enter No. 893

Uninterruptible Power Systems

5, 7.5, 10, and 15 kVA series; features electronic pulse-width-modulation inverters in both single- and 3-phase designs; operates continuously from the inverter during normal line-power conditions to provide voltage regulation plus isolation from line noise and transients; $12,200-$24,800; shipping now.

Sola, 1717 Busse Rd., Elk Grove Village, IL 60007-5666, 312-439-2800. **Enter No. 895**

Test Devices

Communications Analyzer

Datamon; RS-232 networks; communications analyzer, monitor, and patch panel; allows the user to view a realtime data transfer in several different formats as well as the recording of data to its standard 32K buffer memory; provides complete "Break-out Box" capability, status LED monitoring, baud rate conversion, and data pattern triggering—all through on-screen menu driven firmware; $795; shipping now.

Standard Logic, 132 Business Center Dr., P.O. Box 2319, Corona, CA 91720, 714-735-8610. **Enter No. 897**

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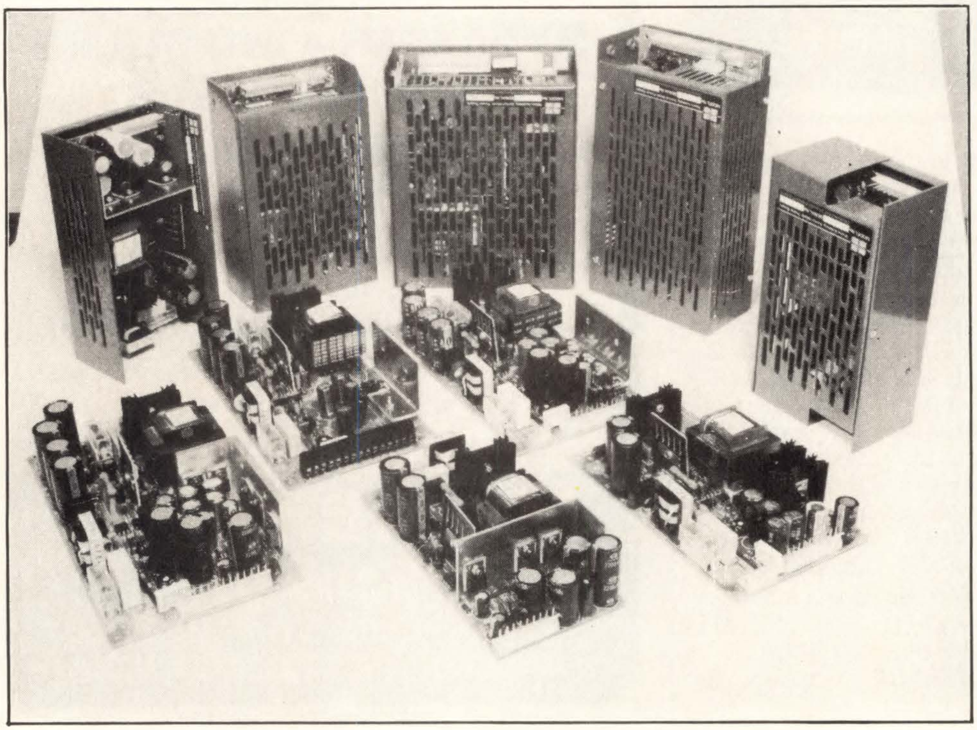

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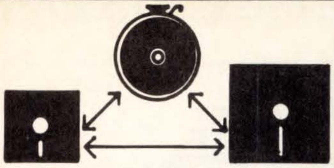

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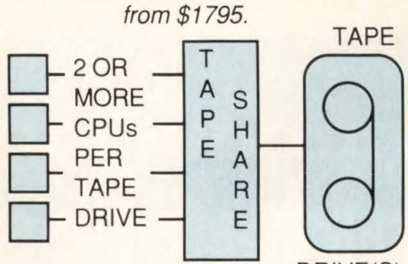

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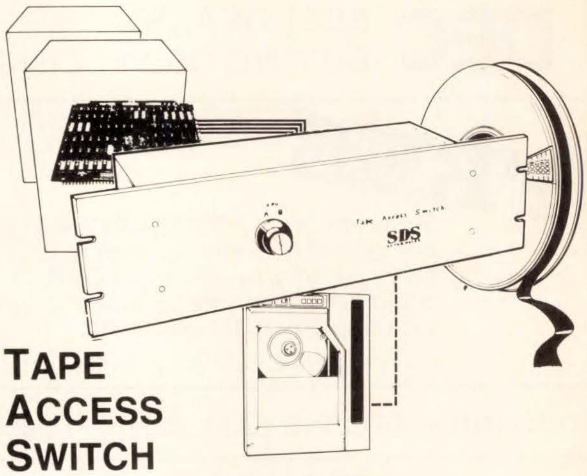

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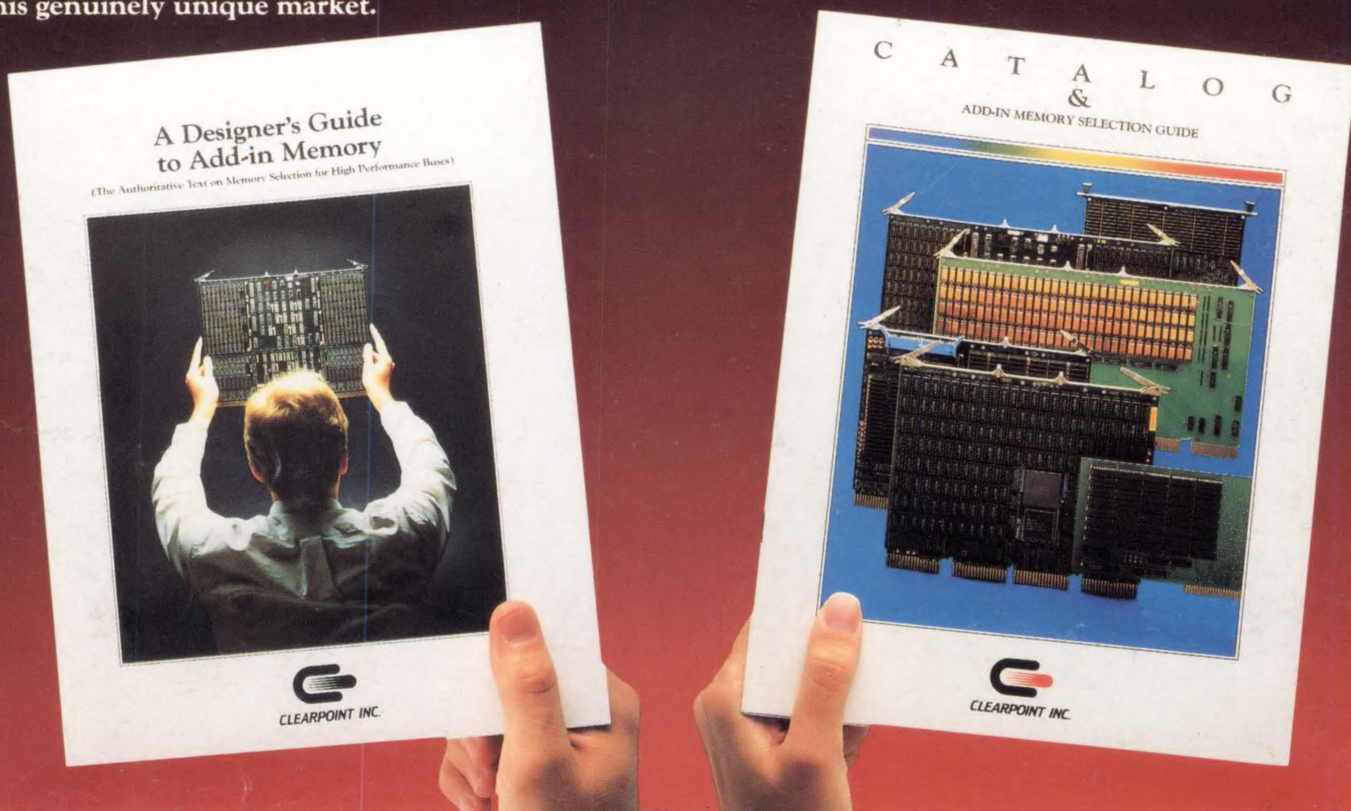

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