DEC VAX Systems

MANAGEMENT SUMMARY

UPDATE: *In recent months, DEC has introduced a standalone configuration of the VAX 8600 and added new VAXcluster packages for that top-of-the-line system. The company has also brought out its first packaged VAXcluster configurations, for the VAX-11/750 and VAX-11/785. New features have also been added to DEC's VT200 terminal. On the software side, the company has enhanced the Ultrix-32 operating system and made it available for the VAX 8600, added DECnet software for Ultrix, provided PCs with access to DECnet networks, introduced VAX-to-SNA communications products, and debuted office software that provides access to documents in IBM DISOSS libraries.*

DEC has recently moved to cut the cost of an initial VAX 8600 system purchase and lower the minimum main memory available on that top-of-the-line model by introducing new VAX 8600 configurations.

First, DEC has made the VAX 8600 available in a standalone processor configuraton. Heretofore, the VAX 8600 had been available only in a VAXcluster System Building Block (SBB), that is, a kernel system that could be used to connect a combination of up to 16 VAX processors and HSC50 hierarchical storage controllers linked by a high-speed Computer Interconnect. The initial system offering was a two-node VAXcluster SBB centered around a VAX 8600 CPU and an HSC50 controller and featuring 12MB of main memory.

The standalone VAX 8600 configuration features 4MB of main memory and replaces the HSC50 with a new storage control device, the RB86 Integrated Disk and Tape Controller, which allows users to configure up to four disk drives (to a maximum capacity of 1.8GB) and a 140MB streaming tape drive. According to DEC, the entry-level configuration is intended for users who have limited floor space and whose primary requirement is enhanced process- ➢

Digital Equipment Corporation continues to enhance the VAX family of 32-bit superminicomputers, offering new configurations for midrange and high-end systems, adding new features to its Unix-based Ultrix-32 operating system, and debuting DECnet and SNA communications software.

MODELS: VAX-11/725, VAX-11/730, VAX-11/750, VAX-11/780, VAX-11/782, VAX-11/785, and VAX 8600.
MAIN MEMORY: 1MB to 64MB.
DISK CAPACITY: 20MB to 164GB.
WORKSTATIONS: Up to 512.
PRICE: $21,500 to $509,000 (base configuration prices).

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation (DEC), 146 Main Street, Maynard, MA 01754-2571. Telephone 1-800-DIGITAL, Extension 990 or (617) 897-5111 (corporate headquarters number).

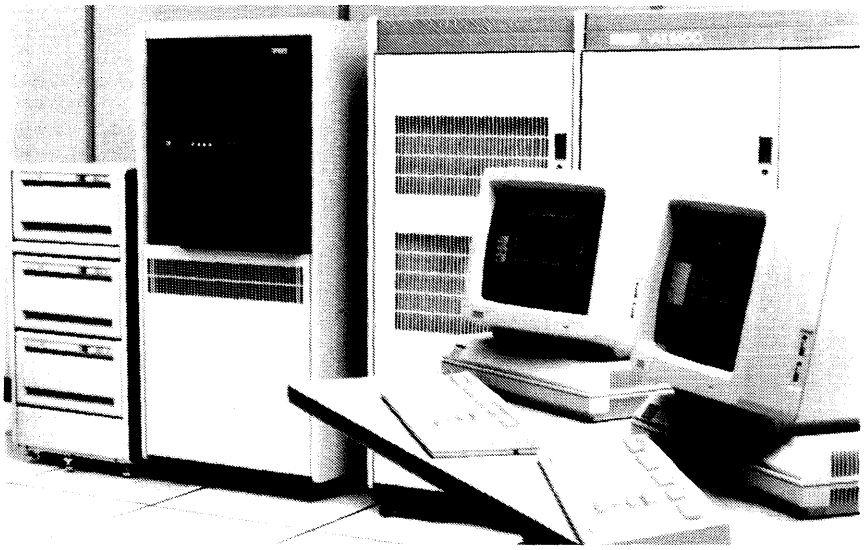
CANADIAN ADDRESS: Digital Equipment of Canada Ltd., P.O. Box 13000, 100 Herzberg Road, Kanata, Ontario, Canada K2K 2A6. Telephone (613) 592-5111.

DATA FORMATS

BASIC UNIT: 32-bit word.

FIXED-POINT OPERANDS: Integers can be 8-bit bytes, 16-bit words, 32-bit longwords, and 64-bit quadwords. All have the same general format, with the high-order bit used as the sign. Negative numbers are represented in two's complement form.

FLOATING-POINT OPERANDS: Two floating-point formats are available: single-precision (called floating) that uses a 4-byte format, and double-precision (called double ➢



The top-of-the-line VAX 8600 is now available in both standalone and expandable VAXcluster configurations. The VAX 8600 provides 4.45-MIPS processor power, and supports up to 32MB of 256K-chip main memory, 512 workstations, and 164GB of online disk storage.

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CHART A. SYSTEM COMPARISON

MODEL	VAX-11/725	VAX-11/730	VAX-11/750	VAX-11/780
SYSTEM CHARACTERISTICS				
Date of introduction	October 1983	April 1982	October 1980	October 1977
Date of first delivery	November 1983	May 1982	November 1980	January 1978
Operating system	VAX/VMS, Ultrix-32	VAX/VMS, Ultrix-32	VAX/VMS, Ultrix-32	VAX/VMS, Ultrix-32
Upgradable from	Not applicable	Not applicable	Not applicable	Not applicable
Upgradable to	Not applicable	Not applicable	Not applicable	VAX-11/782, 11/785
MIPS	—	0.36	0.72	1.06
Relative performance (based on a rating of the 11/780 at 1.0)	0.3	0.3	0.65	1.0
MEMORY				
Minimum capacity, bytes	1M	1M	2M	2M
Maximum capacity, bytes	3M	5M	8M	64M
Type	64K ECC MOS RAM	64K ECC MOS RAM	64K ECC MOS RAM	64K or 256K ECC MOS RAM
Cache memory	None	None	4KB	8KB
Cycle time, nanoseconds	810	810	400 (cache-enabled)	290 (cache-enabled)
Bytes fetched per cycle	4	4	8	8
INPUT/OUTPUT CONTROL				
Number of channels	—	—	1-5	1-8
High-speed buses	None	None	Massbus (3 optional)	Massbus (4 optional)
Low-speed buses	Unibus (1 standard)	Unibus (1 standard)	Unibus (1 std., 1 opt.)	Unibus (1 std., 3 opt.)
MINIMUM DISK STORAGE	52MB	20MB	121MB	121MB
MAXIMUM DISK STORAGE	52MB	2GB	19GB	30GB
NUMBER OF WORKSTATIONS	8	24	128	384
COMMUNICATIONS PROTOCOLS	Async, Sync, Bisync, DECnet, Ethernet, SNA, X.25, LU6.2, TCP/IP	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

ing power. The standalone configuration is available either with DEC's proprietary VAX/VMS operating system or with Ultrix-32, the company's Berkeley 4.2-based Unix alternative. This marks the first time that Ultrix-32 has been made available for the VAX 8600.

The company has also introduced two smaller VAXcluster configurations for the VAX 8600, each with 8MB of main memory. The VAXcluster SBB includes a CPU with 8MB of main memory, an HSC50 storage controller, an eight-node star coupler, associated hardware, and VAX/VMS software; this SBB provides a smaller VAXcluster alternative to the original VAX 8600 offering. The VAXcluster upgrade configuration enables users to add a VAX 8600 processor to an existing VAXcluster system; it includes a CPU, interconnection hardware, and associated VAX/VMS software.

DEC has stated that the field-installable RB86 debuted with the standalone VAX 8600 is available as an option for all VAX 8600 configurations, providing a processor-specific storage subsystem separate from HSC50-based VAXcluster system shared storage. Also offered as an option for the standalone system is a field-installable Computer Interconnect adapter, which allows the standalone system to be converted to a VAXcluster system node. The FP86 Floating-Point Accelerator is also available as an option for the new configurations. The FP86, which is

floating) that uses an 8-byte format. In both formats, the high-order bit is used as a sign and the next seven bits for the exponent. Single-precision fractions are 24 bits long, while double-precision fractions are 56 bits long. The 4-byte format provides approximately seven decimal digits of precision, while the 8-byte format provides approximately 16 decimal digits of precision. The VAX-11/785 implements G (double-precision) and H (quadruple-precision) data types, with accuracy to 33 digits.

An optional high-performance Floating-Point Accelerator (FPA) can be added to the VAX-11 systems. The FPA is an independent processor that executes in parallel with the base CPU. The FPA takes advantage of the CPU's instruction buffer to prefetch instructions and memory cache to access main memory. Once the CPU has the required data, the FPA overrides the normal execution flow of the standard floating-point microcode and forces use of its own code. Then, while the FPA is executing, the CPU can be performing other operations in parallel.

In addition to executing standard floating-point instructions, the FPA reportedly enhances the performance of a number of additional instructions including: extended multiply and integerize, polynomial evaluation, all floating-to-integer and integer-to-floating conversions, 8- and 16-bit integer multiply, and 32-bit integer multiply.

The VAX 8600 includes a floating-point accelerator called the F-Box, which executes floating-point instructions and features F, D, G, and H data types.

INSTRUCTIONS: The native instruction set is an extension of the DEC PDP-11 instruction set; it consists of 248

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CHART A. SYSTEM COMPARISON (Continued)

MODEL	VAX-11/782	VAX-11/785	VAX 8600
SYSTEM CHARACTERISTICS			
Date of introduction	February 1982	April 1984	October 1984
Date of first delivery	April 1982	June 1984	April 1985
Operating system	VAX/VMS	VAX/VMS, Ultrix-32	VAX/VMS, Ultrix-32
Upgradable from	VAX-11/780	VAX-11/780	Not applicable
Upgradable to	Not applicable	Not applicable	Not applicable
MIPS	1.9 (approx.)	1.5 (approx.)	4.45
Relative performance (based on a rating of the 11/780 at 1.0)	1.8	1.5-1.7	4.2
MEMORY			
Minimum capacity, bytes	1M	2M	4M
Maximum capacity, bytes	8M	64M	32M
Type	16K ECC MOS RAM	64K or 256K ECC MOS RAM	256K ECC MOS RAM
Cache memory	8KB	32KB	16KB
Cycle time, nanoseconds	290 (cache-enabled)	166 (cache-enabled)	560
Bytes fetched per cycle	8	8	8
INPUT/OUTPUT CONTROL			
Number of channels	—	1-8	1-11
High-speed buses	Massbus (4 optional)	Massbus (4 optional)	Massbus (4 optional)
Low-speed buses	Unibus (1 std., 3 opt.)	Unibus (1 std., 3 opt.)	Unibus (1 std., 5 opt.)
MINIMUM DISK STORAGE	121MB	121MB	456MB
MAXIMUM DISK STORAGE	30GB	30GB	164GB
NUMBER OF WORKSTATIONS	384	384	512
COMMUNICATIONS PROTOCOLS	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP	Async, Sync, Bisync, DECnet, Ethernet, SNA, 2780/3780, 3271, X.25, LU6.2, TCP/IP

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included with the 12MB VAX 8600 VAXcluster configurations, provides accelerated processing for calculations using any of the four VAX floating-point formats.

As the introduction of new VAXclusters for the VAX 8600 demonstrates, DEC has begun to place added emphasis on clustering, which it views as a vehicle for incremental system growth and enhanced reliability. In that connection, the company has also debuted the first packaged VAXcluster configurations; previously, all VAXcluster systems were custom-configured.

The VAX-11/750 Minicluster includes two 11/750 processors, each with 4MB of main memory; a four-node star coupler; an HSC50 controller; computer interconnect interfaces; and 70M bps buses. According to the vendor, the Minicluster occupies the least floor space of any VAXcluster system. The VAX-11/785 VAXcluster package comprises two 11/785 CPUs, each with 8MB of main memory and floating-point accelerator; an eight-node star coupler; and an HSC50, computer interconnect interfaces, and 70M bps buses. The 11/785 cluster reportedly delivers 3.4 times the performance of the VAX-11/780.

In a tangential hardware move, DEC has upgraded the existing features of its VT200 family of terminals, enhancing the text and graphics functions of the VT240 and VT241 and the text functions of the low-end VT220. The National Replacement Character set (NRC) has been added to all three terminals, providing complete backward

basic instructions (304 in the VAX-11/730, VAX-11/785, and VAX 8600), most of which can be applied to any one of several types of data, which can in turn be addressed in any one of nine ways. The native instruction set provides 32-bit addressing, 32-bit I/O operations, and 32-bit arithmetic.

Instructions and data need not be aligned on longword (32-bit) boundaries in physical memory, but may begin at any byte address (odd or even). Thus, instructions that do not require arguments use only one byte, while other instructions may be two, three, or up to 30 bytes in length, depending on the number of arguments and their addressing modes.

In addition to the 32-bit native instruction set, the processors can concurrently execute a compatibility-mode instruction set, which is a subset of the DEC PDP-11 instruction set. This is not done by emulation or simulation; both instruction sets are built into the microcode and logic of the processor. The compatibility-mode instruction set contains all the PDP-11 instructions except those which perform execution of floating-point instructions, use of both instruction space and data space, and execution of privileged functions.

INTERNAL CODE: ASCII for text-oriented data; binary for calculations.

MAIN STORAGE

TYPE: ECC MOS RAM. Memory on the VAX 8600 is based on 256K-bit chips. Memory on the VAX-11/780 and VAX-11/785 employs either 64K- or 256K-bit chips. The VAX-11/782 uses 16K-bit-based memory, while the VAX-11/750, VAX-11/730, and VAX-11/725 all employ memory based on 64K-bit chips.

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CHART B. MASS STORAGE

MODEL	RP07	RM05	RA81	RA60
Type	Fixed	Removable	Winchester	Removable
Controller model	Massbus Adapter	Massbus Adapter	UDA50 (Unibus), RB86, HSC50	UDA50 (Unibus), HSC50
Drives per subsystem/controller	8	8	4 per UDA50 or RB86, 24 per HSC50	4 per UDA50, 24 per HSC50
Formatted capacity per drive, megabytes	516	256	456	205
Number of usable surfaces	16	19	7	6
Number of sectors or tracks per surface	1260 data, 4 diagnostic tracks	823 tracks	2496 tracks	1600 tracks
Bytes per sector or track	512/sector	512/sector	512/sector	512/sector
Average seek time	23 ms	30 ms	28 ms	41.7 ms
Average rotational/relay time	8.3 ms	8.3 ms	8.3 ms	8.3 ms
Average access time	31.3 ms	38.3 ms	36.3 ms	50 ms
Data transfer rate	1.3 or 2.2MB/sec.	1.2MB/sec.	2.2MB/sec.	1.9MB/sec.
Supported by system models	VAX-11/750, 11/780, 11/782, 11/785, VAX 8600	VAX-11/750, 11/780, 11/782, 11/785, VAX 8600	VAX-11/730, 11/750, 11/780, 11/782, 11/785, VAX 8600	VAX-11/730, 11/750, 11/780, 11/782, 11/785, VAX 8600
Comments	VAX-11/750 supports only 1.3MB/sec. transfer rate.			

compatibility with the older VT100 family. Also, additions have been made to the terminal identification capabilities of the VT220 and VT240 terminals when they are in VT100 emulation mode. Additional capabilities for the VT240 and VT241 include facilities for color graphics print output, a polygon fill capability, and enhanced support for Tektronix 4010/4014 graphics protocols. According to Digital, existing VT200 terminals can be upgraded upon request.

On the software side, DEC has added features to Ultrix-32 to ensure broader compatibility with AT&T's Unix System V. Version 1.1 of Ultrix-32 includes the Source Code Control System (SCCS) for software development from AT&T's Unix System III, and also includes System V commands and utilities. Included as well are a diagnostic testing facility that allows the user to load and execute corrections from an Ultrix-32 file system and support for the VAX-11/780 and VAX-11/785 up to the maximum of 64MB of main memory.

In communications, DEC has debuted DECnet-Ultrix, an Ethernet-based end-node implementation of the Digital Network Architecture for the Ultrix-32 operating system. It provides for communications among both Digital and non-Digital systems. DECnet-Ultrix allows users to transfer data and files between Ultrix-and VMS-based systems, and also permits DECnet and TCP/IP protocols to share system resources, such as Ethernet communications controllers.

DEC has also added two software products that tie personal computers into DECnet networks and, thus, access VAX resources. DECnet-DOS enables IBM PCs and PC XTs to function as nodes in a DECnet network. Capabilities of DECnet-DOS include file transfer, remote data access, remote resource access, virtual disk facilities, task-to-task communication, and network management. DECnet-Rainbow provides file transfer, remote resource access, task-to-task communications, and network management facilities.

CYCLE TIME: Main memory cycle times on VAX systems range from 290 to 810 nanoseconds. Refer to Chart A for the cycle times of individual machines.

CAPACITY: Main memory capacities range from 1MB to 64MB. All VAX systems provide up to 4GB of virtual memory space. For the main memory capacities on specific VAX systems, please refer to Chart A, the System Comparison Chart.

In addition to local memory, VAX-11/780 and 11/785 systems can use the MA780 Multiport Memory, a bank of MOS semiconductor memory with error-correcting code (ECC) that can be shared by up to four systems in any combination. Each system can randomly access all of the shared memory in exactly the same way it accesses its local memory. (The MA780 is not supported on the VAX 8600.)

Each MA780 can be expanded from a minimum of 256K bytes to a maximum of 2M bytes. This storage is in addition to each system's local memory, which can be as large as 64M bytes. Because up to two MA780s can be attached to VAX-11/780 and VAX-11/785 CPUs, those systems can directly address up to 68M bytes of physical memory. CPUs accessing the MA780 can be arranged in either a parallel or pipelined manner.

The MA780 also serves as the main memory source for the VAX-11/782 attached processor system, which can support up to 8M bytes of shared memory.

CHECKING: The VAX 8600 uses ECL logic for checking. In the other VAX systems, the ECC MOS memory incorporates Schottky TTL logic technology, with automatic error checking including parity checking on Massbus data, cache, translation buffer, and CPU microcode.

STORAGE PROTECTION: The system's memory management logic divides memory into 512-byte pages. Each page is assigned a protection code specifying which, if any, access modes are to be permitted read or write access to the page. In addition, fault detection hardware causes a memory error-correcting code to detect all double-bit errors and correct all single-bit errors. The VAX 8600 features a 7-bit error correcting code per 32-bit longword.

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CHART B. MASS STORAGE (Continued)

MODEL	RA80	RL02	RC25
Type	Winchester	Cartridge	Fixed/Removable
Controller model	UDA50 (Unibus), HSC50	Integrated	Integrated
Drives per subsystem/controller	4 per UDA50, 24 per HSC50	4	—
Formatted capacity per drive, megabytes	121	10.4	26/26
Number of usable surfaces	7	2	—
Number of sectors or tracks per surface	1092 tracks	512 tracks	—
Bytes per sector or track	512/sector	256/sector	—
Average seek time	25 ms	55 ms	35 ms
Average rotational/relay time	8.3 ms	12.5 ms	10.5 ms
Average access time	33.3 ms	67.5 ms	45.5 ms
Data transfer rate	1.2MB/sec.	512KB/sec.	1.25MB/sec.
Supported by system models	VAX-11/730, 11/750, 11/780, 11/782, 11/785, VAX 8600	VAX-11/730, 11/750, 11/780, 11/782, 11/785, VAX 8600	VAX-11/725
Comments			

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

In addition, Digital has added three VAX-to-SNA communications products. DECnet/SNA VMS Advanced Program-to-Program Communications/LU6.2 Programming Interface (APPC) allows VMS-based applications to communicate with IBM host applications on a peer-to-peer basis through the DECnet/SNA Gateway; all DECnet/SNA interconnect functions are transparent to the user. In DECnet/SNA VMS Application Programming Interface (API), SNA functionality is apparent to the user. The API product is a collection of routines that allows user-written applications running on VAX systems in a DECnet network to exchange information, files, and data with IBM host applications. DECnet/SNA VMS 3270 Data Stream Program Interface, specifically designed for 3270 emulation interfaces, enables programmers to develop programs that implement Logical Unit 2 sessions for communication with IBM application programs. As in the APPC product, SNA functionality is transparent to the user.

For office communications, Digital has added External Document Exchange (EDE) with DISOSS, a software product that allows users of DECdx/VMS and WPS-Plus word processing software to access and edit text contained in an IBM DISOSS (Distributed Office Support System) document library. Documents can also be created on VAX systems, transformed into IBM final or revisable DCA (Document Content Architecture) DISOSS documents, and filed in an IBM host document library. Conversely, DEC states that EDE with DISOSS transparently converts IBM documents to WPS-Plus or DECdx formats. The EDE menus can be be integrated into the main menu system of DEC's ALL-IN-1 office software. According to Digital, EDE with DISOSS provides an interface conforming to DIA (Document Interchange Architecture)/DCA using Logical Unit 6.2, IBM's peer-to-peer communications capability.

All of the new products enhance the functionality of Digital's flagship VAX family of superminis, which consists of the VAX-11/725, VAX-11/730, VAX-11/750, VAX-11/780, VAX-11/785, VAX-11/782, and VAX 8600.

Battery backup is standard on the VAX 8600. It is also included for the 11/782 attached processor system configurations. Two backup units reside within the MA780 cabinet, and are capable of supporting 4M bytes of memory for a minimum of 10 minutes. Smaller amounts of memory are supported for longer periods of time. Optional battery backup is available on the VAX-11/780 and VAX-11/785 to provide 10 minutes of power for up to 4M bytes of memory; a maximum of two backup batteries provide power for up to 8M bytes of memory.

RESERVED STORAGE: Minimum reserved storage for the VAX/VMS operating system is 1MB on the 11/725 and 11/730, 512KB on the 11/750, 11/780, 11/785, and 11/782, and 2MB on the VAX 8600, 11/780, and 11/785 VAXcluster with CI780.

CACHE MEMORY: The VAX 8600 features a 16KB two-way associative write-back cache memory, which involves a different kind of memory write than that used by the write-through cache on the other VAX systems. Instead of immediately writing modified data through the cache and into main memory, as with a write-through cache, the VAX 8600's memory controller stores modified data in the write-back cache, updating main memory only when some significant event occurs, such as a cache miss, an I/O request, a context switch, or a power failure. Because the slower main memory is not continually updated, the processor can spend more time operating at full speed.

A 32KB bipolar cache memory is available on the VAX-11/785; the VAX-11/780 and VAX-11/782 systems both have 8KB bipolar cache. A 4KB bipolar cache is standard on the VAX-11/750, and no cache is available on the VAX-11/725 and VAX-11/730.

CENTRAL PROCESSOR

GENERAL: The VAX 8600 CPU employs ECL (Emitter Coupled Logic) macrocell gate array circuits, which are more dense than the Schottky TTL (Transistor-to-Transistor Logic) gate arrays used in other VAX systems. The CPU employs four-stage pipeline processing, which overlaps instruction fetch, decode, address calculation and operand fetch, and instruction execution to reduce the average number of machine cycles required per instruction. It also incorporates a 16K-byte write-back cache.

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CHART C. WORKSTATIONS

MODEL	VT220	VT240/VT241	VT100/VT101	VT102/VT131	VS11	VAXstation 100
DISPLAY PARAMETERS						
Max. chars./screen	3168	3168	1920	3168	512 x 512 resolution	1088 x 864 resolution
Buffer capacity	—	—	—	—	—	512KB
Screen size (lines x chars.)	24 x 80 or 132	24 x 80 or 132	24 x 80 or 14 x 132	24 x 80 or 132	—	—
Tilt/swivel screen	Tilt standard	Standard	Not applicable	Not applicable	Not applicable	Standard
Symbol formation	7 x 10 dot-matrix	8 x 10 dot-matrix	7 x 9 dot-matrix	7 x 9 dot-matrix	Not applicable	—
Character phosphor	White, green, or amber	White, green, or amber	Black on white or white on black	Black on white or white on black	—	Monochrome
Total colors/no. simult. displayed	Not applicable	—	Not applicable	Not applicable	16 colors maximum	Not applicable
KEYBOARD PARAMETERS						
Style	Typewriter	Typewriter	Typewriter	Typewriter	Typewriter	Typewriter
Character/code set	ASCII and line-drawing graphics	ASCII and line-drawing graphics	ASCII and line-drawing graphics	ASCII and line-drawing graphics	—	—
Detachable	Yes	Yes	Yes	Yes	Yes	Yes
Program function keys	15	15	—	—	—	12
TERMINAL INTERFACE	RS-232-C, RS-423, 20 ma std.	RS-232-C, RS-423, 20 ma std.	RS-232-C or 20 ma	RS-232-C or 20 ma	—	Unibus
COMMENTS		800 x 240 pixel graphics array; VT 241 includes color monitor.		VT 131 has memory space for 2 user-defined character sets.	Includes 40- routine Fortran Draw software package.	Incorporates VT100 and Tektronix 4014 emulation.

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

(The MicroVAX family, a compatible group of supermicrocomputers, runs VMS-based software and supports some of the same peripherals as the supermini grouping; the MicroVAX family is to be covered in a separate report in DATAPRO REPORTS ON MINICOMPUTERS.)

The smallest VAX system, the general-purpose, multiuser VAX-11/725, contains a VAX-11/730 central processing unit with a 52MB Winchester disk subsystem in a small cabinet designed specifically for open-office locations. The VAX-11/725 system can serve as a single-user graphics workstation or can support up to eight terminals in a multiuser environment. The VAX-11/725 console terminal can alternate as a user device, and Ethernet local area network links permit addition of more terminals.

DEC has designed the VAX-11/725 for two principal implementations: as support for technical workstations and as a multiuser system for general-purpose computing applications. Configured with a VAXstation 100 graphics display subsystem or other monochrome or color display, the VAX-11/725 computer supports medium- to high-speed graphics for integrated circuit design and logic simulation and other engineering applications.

The VAX-11/730 incorporates bit-slice and Programmed Array Logic (PAL) technology. It supports from 1MB to 5MB of main memory, 20MB to 2GB of disk storage, and up to 24 users. Connection to mass storage devices and other peripherals is provided through a Unibus adapter.

The VAX-11/750, the mid-range member of the VAX family, implements custom bipolar LSI Schottky logic. It features a 4K-byte cache memory and can support from 2MB to 8MB of main memory. The VAX-11/750 can also

The VAX 8600 CPU comprises three principal components: the I-Box, for instruction preparation; the E-Box, for instruction execution; and the F-Box, a floating-point accelerator. The four-stage pipelining scheme is implemented through the I-Box and the E-Box. The I-Box performs three types of operations: instruction fetch over the dedicated memory bus, called the MD-Bus; specifier decode operations, in which it identifies the operand type and the addressing scheme; and address calculation and operand fetch activities (two stages in the same machine cycle). The E-Box performs actual instruction execution. The F-Box works in conjunction with the E-Box, executing floating-point instructions; it features F, D, G, and H data types. The VAX 8600 achieves a CPU cycle time of 80 nanoseconds.

The VAX 8600 CPU interfaces through the MD-Bus to the memory controller. The memory controller contains the following components: the 16KB two-way set associative write-back cache, which handles 16-byte entries and provides the same error-correcting code features as main memory; the tag store, which handles 32-bit longwords; and the 512-entry translation buffer, which maps the results of virtual-to-physical address translations. The memory controller interfaces to the main memory arrays over the Array Bus, which has a bandwidth of 28MB per second.

The VAX 8600 CPU also features a system diagnostic bus, which touches most semiconductor chips. Error information is transmitted over this bus to a console subsystem with 10MB of online storage capacity. The console takes corrective action and performs error logging. The system also incorporates self-monitoring and error-testing programs.

The VAX 8600 is a unique implementation of the VAX architecture. However, it shares most of the characteristics of other VAX Family CPUs, featuring sixteen 32-bit registers, 32 priority interrupt levels, and nine addressing modes.

The VAX-11/782 is a tightly coupled asymmetric multiprocessor system based on the MA780 shared memory subsystem. It comprises two VAX-11/780 CPUs, and according to DEC, offers a performance improvement of 60 to 80 percent

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CHART D. PRINTERS

MODEL	LXY	LP25	LP26	LP27
Type	Dot-matrix	Band	Band	Band
Speed	170-600 lpm	300 or 300/215 lpm	600 or 600/445 lpm	1200/800 lpm
Bidirectional printing	No	Not applicable	Not applicable	Not applicable
Paper size	—	Up to 15 inches	Up to 15 inches	Up to 18.75 inches
Character formation	Variable	Full	Full	Full
Horizontal character spacing (char./inch)	Variable	Variable	10	10
Vertical line spacing (char./inch)	—	6 or 8	6 or 8	6 or 8
Character set	96 or 192	64 or 64/96	64 or 64/96	64/96
Controller/Interface	LP11, RS-232-C, DMF32	LP11, DMF32	LP11, DMF32	Integrated, DMF32
No. of printers per controller/interface	—	—	—	—
Printer dimensions, in. (h x w x d)	46.5 x 30 x 24.3	43.8 x 30.3 x 33.6	43.8 x 30.3 x 33.6	49 x 35 x 38
Graphics capability	Yes	No	No	No

CHART D. PRINTERS (Continued)

MODEL	LN01	LN01S	LN01B
Type	Laser	Laser	Laser
Speed	12 ppm	12 ppm	12 ppm
Bidirectional printing	Not applicable	Not applicable	Not applicable
Paper size	8.5 x 11 or 8.5 x 14 inches	8.5 x 11 or 8.5 x 14 inches	8.5 x 11 or 8.5 x 14 inches
Character formation	300 x 300 dots/sq. in.	300 x 300 dots/sq. in.	300 x 300 dots/sq. in.
Horizontal character spacing (char./inch)	13.6	Variable	Variable
Vertical line spacing (char./inch)	8.57	Variable	Variable
Character set	188	12 Courier-like fonts standard	16 Courier-like graphics labeling fonts std.
Controller/Interface	LP11, DMF32	LP11, DMF32	LP11, DMF32
No. of printers per controller/interface	—	—	—
Printer dimensions, in. (h x w x d)	36 x 25.8 x 26	36 x 25.8 x 26	36 x 25.8 x 26
Graphics capability	No	Yes	Yes
Comments			Includes PLOTLN software and 2 EPROMs.

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

accommodate up to 128 workstations and 121MB to 19GB of disk storage. One Unibus adapter (integral to the processor) and up to three Massbus adapters or one additional Unibus and two Massbus adapters may be used for connection to mass storage devices and other peripherals.

The VAX-11/780, DEC's initial VAX product offering, is designed for use with large databases by users with extensive processing needs. It features an 8KB cache memory and can support between 2MB and 64MB of local main memory. (It can also support an additional 4MB of shared memory, as can the VAX-11/785.) The VAX-11/780 can accommodate between 121MB and 30GB of disk storage, as well as 384 workstations. Up to four Unibus and four Massbus adapters may be used for connection to mass storage devices and other peripherals. The VAX-11/780 can be upgraded either to the single-processor VAX-11/785 or the dual-processor VAX-11/782.

The VAX-11/785 incorporates high-speed Schottky circuitry that, according to DEC, permits performance 50 to 70 percent greater than that provided by the VAX-11/780. The VAX-11/785, like the VAX-11/780, features a local main memory capacity of 64MB and a two-way set associative cache memory; cache size on the VAX-11/785, how-

over a single VAX-11/780. The two processors communicate through the MA780 memory. All peripheral devices are connected to one of the CPUs that functions as the primary processor. The 11/782 is available as a complete packaged system or as an upgrade option to a single-processor VAX-11/780 system.

The VAX-11/780 processor provides 32-bit addressing and 32-bit arithmetic and data paths. The processor includes the basic CPU, synchronous system bus, intelligent microcomputer console, interval and time-of-year clocks, and 8K bytes of cache memory. Up to 64 million bytes of memory, up to four Massbuses, a Unibus (one standard, three optional), and a floating-point accelerator can be included with the processor. The processor also provides sixteen 32-bit general registers and 32 interrupt priority levels. The VAX-11/780 can be upgraded to a VAX-11/782 or VAX-11/785.

Except for cache memory size and a larger translation buffer, the VAX-11/785 incorporates the characteristics of the VAX-11/780. The VAX-11/785 is essentially a higher speed version of the VAX-11/780, representing a complete revamping of the VAX-11/780 CPU board structure. The VAX-11/785 features a CPU cycle time of 133 nanoseconds (compared to 200 nanoseconds on the VAX-11/780), and incorporates high-speed Schottky circuitry that, according to DEC, permits performance 50 to 70 percent greater than that provided by the VAX-11/780. The VAX-11/785 also features an average interrupt latency of 28 microseconds.

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CHART E. MAGNETIC TAPE EQUIPMENT

MODEL	TU77	TU78	TE16	TU80
TYPE	Reel-to-reel	Reel-to-reel	Reel-to-reel	Streaming
FORMAT				
Number of tracks	9	9	9	9
Recording density, bits per inch	1600/800	1600/6250	1600/800	1600
Recording mode	PE/NRZI	PE/GCR	PE/NRZI	PE
CHARACTERISTICS				
Controller model	Massbus Adapter	Massbus Adapter	Massbus Adapter	Unibus Adapter
Drives per controller	4	32	8	1-4
Storage capacity, bytes	40M (1600 bpi); 20M (800 bpi)	145M (6250 bpi)	40M (1600 bpi); 20M (800 bpi)	40M
Tape speed, inches per second	125	125	45	100
Data transfer rate, units per second	200KB	781KB	72KB (1600 bpi) 36KB (800 bpi)	160KB
Streaming technology	No	No	No	Yes
Start/stop mode; speed	Not applicable	Not applicable	Not applicable	25 ips
Switch selectable	Yes	Yes	Yes	No

CHART E. MAGNETIC TAPE EQUIPMENT (Continued)

MODEL	TU81	TA78	TSU05
TYPE	Streaming	Reel-to-reel	Streaming
FORMAT			
Number of tracks	9	—	—
Recording density, bits per inch	1600/6250	1600/6250	1600
Recording mode	PE/GCR	PE/GCR	PE
CHARACTERISTICS			
Controller model	RB86, Integrated	HSC50	Integrated
Drives per controller	1	24	1
Storage capacity, bytes	40 MB (PE); 140MB (GCR)	145M (6250 bpi)	40M
Tape speed, inches per second	25/75	125	100 ips
Data transfer rate, units per second	468KB/sec.	200KB/sec. (PE); 781KB/sec. (GCR)	40KB or 160KB/sec.
Streaming technology	Yes	No	Yes
Start/stop mode; speed	25 ips	Not applicable	Yes; 25 ips
Switch selectable	—	Yes	—

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

ever, is 32KB. The VAX-11/785 also has 48KB of console memory, up from 16KB on the VAX-11/780. The floating-point instruction set on the VAX-11/785 features G and H data types, which are optional on the VAX-11/780.

An optional floating-point accelerator is available for the VAX-11/785. This unit reportedly increases the system's floating-point performance by an average of 47 percent. The accelerator uses the same technology and timing as the VAX-11/785 processor.

Despite differences in processor technology, the VAX-11/785 employs the same bus structure and I/O capabilities as the VAX-11/780. Like the VAX-11/780, the VAX-11/785 can handle up to 384 workstations and can support disk storage between 121MB and 30GB. The VAX-11/780 can be field-upgraded to the VAX-11/785, either with or without the floating-point accelerator.

The VAX-11/782 is a tightly coupled asymmetrical multiprocessor system that, according to DEC, improves performance up to 100 percent over a single VAX-11/780 system. Consisting of two VAX-11/780 CPUs, the VAX-11/782 attached processor computer system can support up to 8MB of shared memory. The interplay of the two processors is transparent to users. Only one copy of the

The VAX-11/785 also has 48K bytes of console memory, up from 16K bytes on the 11/780. Instruction microcode for the 11/785 is stored in RAM, rather than in ROM as on the 11/780. Despite the differences in processor technology and performance, however, the 11/785 employs the same bus structure and I/O capabilities as the 11/780.

Memory management on VAX-11/780, VAX-11/785, and VAX-11/782 systems includes four hierarchical processor access modes that are used by the system to provide read/write page protection between user software and system software. Memory is connected to the main control and data transfer path (the SBI) via a memory controller. Each memory controller includes a request buffer that substantially increases overall system throughput and eliminates the need for interleaving in most applications.

The intelligent console on the VAX-11/780, VAX-11/785, and VAX-11/782 consists of an LSI-11 microcomputer with 16K bytes (11/780 and 11/782) or 48K bytes (11/785) of read/write memory and 8K bytes of ROM, a floppy disk unit, a terminal for local operations, and an optional port for remote diagnosis.

The VAX-11/750 CPU includes sixteen 32-bit, general-purpose, user-programmable registers for data manipulation, as well as the Processor Status Word for controlling the execution states of the CPU. The processor instruction set is defined by the microcode contained in its control store. The CPU also includes a 4K-byte bipolar cache memory, 10K-byte user control store, clocks, and console. Each

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VAX/VMS operating system is required, because the two processors share the same operating system code and data structures. All I/O devices and peripherals are connected to the primary processor. The VAX-11/782 is available in packaged system configurations or as an upgrade option to a single-processor VAX-11/780 system. Like the VAX-11/780, the VAX-11/782 features an 8KB cache memory and provides support for 384 workstations and 121MB to 30GB of disk storage.

The top-of-the-line VAX 8600 retains the 32-bit VAX architecture while incorporating features that endow it with processor power up to 4.2 times that of the VAX-11/780. The VAX 8600 processes at about 4.45 MIPS and achieves a CPU cycle time of 80 nanoseconds by incorporating such features as: ECL (Emitter Coupled Logic) macrocell gate array circuits in the CPU, instead of the Schottky TTL used in other VAX systems; four-stage instruction pipelining; and a 16KB two-way associative write-back cache memory, which involves a different kind of memory write than that used by the write-through cache on other VAX systems.

The VAX 8600's 4MB memory arrays are based on 256K-bit MOS RAM chips. The VAX 8600 can support up to 32MB of main memory, all in the main cabinet, and delivers a main memory cycle time of 560 nanoseconds. The VAX 8600 also provides up to 4GB of virtual address space. A dedicated memory bus shortens main memory access time by eliminating contention between memory-to-CPU transfers and I/O traffic. In addition, the memory bus transfers addresses and data simultaneously, rather than sequentially. The dedicated memory bus relieves the system's high-speed Synchronous Backplane Interconnect (SBI) bus of the burden of controlling CPU communications, and allows it to be reserved for I/O functions. The interconnect structure can be enhanced through addition of a second SBI. The VAX 8600 can also support up to 512 workstations.

Despite a fourfold increase in processor power over the VAX-11/780, the VAX 8600, according to DEC, is only a bit more power-hungry and considerably less noisy. Maximum AC power consumption is 6.5 kilowatts, only slightly above the 6.225 kilowatts consumed by the VAX-11/780. Heat dissipation is 22,200 Btu/hour, compared to 21,230 for the VAX-11/780. The noise level on the VAX 8600 is 60 Dba—considerably lower than the 74 Dba of the VAX-11/780. Although the VAX 8600 is primarily a computer-room machine, its decibel rate, according to DEC, is only 2 Dba above OSHA's noise specification for office environments.

The VAX systems are tied together through Digital's VAX/VMS operating system. VAX/VMS is a general-purpose operating system that provides the environment for the concurrent execution of multiuser timesharing, batch, and time-critical applications.

VAX/VMS also contains special features for VAXcluster support. As previously mentioned, a VAXcluster is composed of one or more VAX 8600, 11/750, 11/780, 11/785,

VAX-11/750 system contains one Unibus adapter for standard peripherals and up to three Massbus adapters for high-speed peripherals. A second optional Unibus adapter is available for the 11/750.

The VAX-11/730 processor is implemented using bit-slice and Programmed Array Logic (PAL) technology. The standard components of the 11/730 include the CPU with its DAP (data path) module, WCS (writable control store) module, MCTC (memory controller) module; 1M-byte memory module, clocks, console subsystem, and DMF32 Unibus controller for peripheral devices. Two additional Unibus controllers may be configured with the 11/730. Massbus adapters are not available for the 11/730.

The 11/750 and 11/730 consoles enable the computer system operator to control the processor operation directly. The console subsystem consists of the console terminal, the front panel, and the user-oriented console command language, with one TU58 tape cartridge drive for the VAX-11/750 and two TU58s for the VAX-11/730. A remote diagnosis interface is optionally available for the console.

The VAX-11/725 is a packaged product that contains a VAX-11/730 processor in a cabinet designed for open-office environments.

VAX processors use two standard clocks: a programmable realtime clock used by the operating system and by diagnostics, and a time-of-year clock used for system operations. The time-of-year clock includes battery backup for automatic system restart operations.

CONTROL STORAGE: The VAX 8600 features a control store of 8K 86-bit words. The 11/782 and 11/780 have a control store size of 5K words (99-bit words), 4K words read-only memory (ROM), and 1K words user control store. The VAX-11/785 has a RAM-based control store of 8K words, with 0.5K ROM and 7.5K writable, 1K of which is user control store.

On the three 11/78X systems, 12K bytes (plus parity) of Writable Diagnostic Control Store (WDCS) are provided to allow the Diagnostic Console Microcomputer to verify the integrity of crucial parts of the CPU, the intelligent console, the SBI, and the memory controller. In addition, the WDCS can be used to implement updates to the system microcode. The optional User Control Store (UCS) on the VAX-11/750 includes 10K bytes (1K bytes of 80-bit microwords) of writable storage. This allows users to augment the speed and power of the basic machine with customized microcode functions. Such customized functions include the loadable microcode package for extended precision floating-point arithmetic operations.

Control store on the 11/730 and 11/725 is a programmable read/write memory with a basic storage capacity of 16K 24-bit microwords. An additional 1K microwords of control store is available to support the integrated disk controller. Each microinstruction is 24 bits and contains several control fields for specific CPU functions.

REGISTERS: The VAX systems provide sixteen 32-bit general registers that can be used for temporary storage, as accumulators, as index registers, and as base registers. A base register contains the address of the base of a software data structure such as a table or queue, and an index register contains a logical offset into a data structure. Whenever a register is used to contain data, the data is stored in the register in the same format as it would appear in memory. If a quadword or double floating operand is stored in a register, it is actually stored in two adjacent registers.

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or 11/782 processors or HSC50 hierarchical storage controllers running under VAX/VMS and connected by a high-speed computer interconnect bus and communication links to the user community. Each processor or HSC50 in the configuration is considered a node. The smallest VAXcluster configuration can be two VAX processors connected by an interconnect and star coupler. No HSC50 is necessary; VAX/VMS allows locally connected Unibus and Massbus disks to be shared by VAXcluster users through an MSCP server.

According to DEC, a single application can be used across every processor in a VAXcluster, with shared files. The company also claims that the addition of nodes to a VAXcluster causes little performance degradation. Digital maintains that clustering provides a measure of fault tolerance through processor failover and automatic failover for a dual-ported disk drive if an HSC50 fails.

DEC also offers Ultrix-32 as an alternative to VAX/VMS for specialized applications. Ultrix-32 is a native-mode implementation of the Unix operating system based on the University of California at Berkeley's Fourth Berkeley Software Distribution (4BSD). It is an interactive, time-sharing system that employs a demand-paging scheme to take advantage of the virtual memory architecture of VAX systems.

In addition to the new communications software products, DEC offers a range of communications products for the VAX line. The principal product is DECnet-VAX, which allows creation of Ethernet local area networks and wide area networks centered around VAX/VMS-based DEC systems. The company's Internet products permit interconnection of Digital computers and Digital networks to systems built by IBM and other manufacturers.

Also available for the VAX systems are a wide variety of system software packages, including VAX DBMS, a Codasyl-compliant database management system, and VAX/Rdb and VAX/ELN, two relational database management products. Along with a range of program development tools, DEC offers 15 languages for the VAX computers, including Fortran, Cobol, Basic, RPG II, and Lisp. A large number of proprietary and third-party applications are available for VAX systems.

COMPETITIVE POSITION

Digital's recent announcements of new clustered configurations for the VAX-11/750, VAX-11/785, and VAX 8600 show the company's increasing emphasis on delivering more powerful and flexible mid-range and high-end supermini systems to compete with the plethora of systems announced in the past six months by rival manufacturers; many of those announcements were obviously in response to DEC's November 1984 announcement of the VAX 8600. DEC's placing competitive emphasis on the upper ranges of the VAX family is also occasioned by the company's introduction of the MicroVAX II supermicro in May 1985. The new system, which reportedly delivers

Four registers have special significance: the Program Counter contains the address of the next instruction to be executed; the Stack Pointer contains the address of the base (or top) of a stack maintained for subroutine and procedure calls; the Frame Pointer contains the address of the base of a software data structure stored on the stack and called the stack frame, which is maintained for procedure calls; and the Argument Pointer contains the address of the base of a software data structure called the argument list, which is maintained for procedure calls.

In addition, the first six registers have special significance for character and packed decimal string instructions and the Polynomial Evaluation instruction. These instructions use the first six registers to store temporary results and, upon completion, leave results in the registers that a program can use as the operands of subsequent instructions.

A register's special significance does not preclude its use for other purposes, except for the Program Counter. The Program Counter cannot be used as an accumulator, as a temporary register, or as an index register.

ADDRESSING: The processor's addressing modes allow almost any operand to be in a register or in memory, or used as an immediate constant. There are seven basic addressing modes that use the general registers to identify the operand location, including:

- **Register Mode, in which the register contains the operand.**
- **Register Deferred Mode, in which the register contains the address of the operand.**
- **Autodecrement Mode, in which the contents of the register are first decremented by the size of the operand, and then used as the address of the operand. The size of the operand (in bytes) is given by the data type of the instruction operand, and depends on the instruction.**
- **Autoincrement Mode, in which the contents of the register are used as the address of the operand, and then incremented by the size of the operand. If the Program Counter is the specified register, the mode is called the Immediate Mode.**
- **Autoincrement Deferred Mode, in which the contents of the register are used as the address of a location in memory containing the address of the operand, and then are incremented by four (the size of an address). If the Program Counter is the specified register, the mode is called the Absolute Mode.**
- **Displacement Mode, in which the value stored in the register is used as a base address. A byte, word, or longword signed constant is added to the base address, and the resulting sum is the effective address of the operand.**
- **Displacement Deferred Mode, in which the value stored in the register is used as the base address of a table of addresses. A byte, word, or longword signed constant is added to the base address, and the resulting sum is the address of the location that contains the actual address of the operand.**

Of these seven basic modes, all except Register Mode can be modified by an index register. When an index register is used with a basic mode to identify an operand, the addressing mode is the name of the basic mode with the suffix "Indexed." Therefore, in addition to the seven basic addressing modes that use registers, the processor recognizes six indexed addressing modes.

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about 90 percent the performance of a VAX-11/780 and which the manufacturer says will support large disk drives by the end of calendar 1985, threatens to render obsolete the VAX-11/725 and VAX-11/730—the low-end constituents of the VAX family. It is reasonable for DEC to shift its marketing efforts toward more powerful VAX systems, rather than devote significant effort toward repackaging and selling seemingly moribund low-end machines.

The introduction of the standalone VAX 8600 configuration is an intelligent move from a price/performance standpoint. Although less hardware is included than in the initial VAXcluster offering, the standalone configuration reduces the base system price from about $112,000 to about $78,000 per MIPS and makes the VAX 8600 appear more price-competitive with the numerous rival systems emphasizing lower price/performance relative to the VAX 8600, such as Pyramid Computer's recently debuted Pyramid 98X Isoprocessor system. Moreover, the standalone VAX 8600 does not require users to buy VAXcluster equipment that they may not initially want; those users, however, always have the option of adding clustering equipment if their requirements warrant.

Given the amount of attention it has received and the number of counter-announcements it has generated, the VAX 8600 is clearly the competitive focus of the VAX family. Like other members of the family, it can be expected to encounter competition in specific vertical markets that DEC has always targeted; that competition comes largely from top-of-the-line systems announced by DEC's traditional rivals since the first of the year.

For example, in the educational computing area, the VAX 8600 comes up against Harris Computer's Unix-based HCX-7, which reportedly delivers 7.0 MIPS to the 8600's 4.45. The two systems are tied in main memory capacity, with 32MB, but the 8600 supports far more disk (164GB) than the HCX-7 (7.5GB) and over twice the number of workstations (512 versus 235 on the HCX-7).

In scientific/engineering computing, the VAX 8600 comes up against Data General's Eclipse MV/10000 SX, which delivers the same amount of main memory support, but provides fewer MIPS (3.6) and less disk storage (28.4GB) and supports fewer workstations (192) than its Digital counterpart. In another area of technical computing, CAD/CAM, the VAX 8600 competes with Prime's 4.0-MIPS 9955, which supports only 16MB of memory, 10GB of disk, and 254 workstations.

The power and configurability of the VAX 8600 enable the VAX family to compete more effectively than before in high-volume, multiuser commercial applications, such as online transaction processing, where principal competition comes from Tandem's NonStop TXP systems and the Stratus/32 Continuous Processing Systems.

Among other competitors with the VAX systems are IBM's 4300 Series in general-purpose computing, Perkin-Elmer's

The processor also provides Literal Mode addressing, in which an unsigned 6-bit field in the instruction is interpreted as an integer or floating-point constant.

INTERRUPTS: The processor recognizes 32 interrupt priority levels. The highest 16 interrupt priority levels are reserved for interrupts generated by hardware, and the lowest 16 levels are reserved for interrupts requested by software. Normal user software runs at the process level, which is interrupt priority level zero.

The interrupt service routine executes at the interrupt priority level of the interrupt request. When the processor receives an interrupt request at a level higher than that of the currently executing software, the processor honors the request and services the new interrupt at its priority level. When the interrupt service routine issues the REI (Return from Exception or Interrupt) instruction, the processor returns control to the previous level.

OPERATING ENVIRONMENT: The VAX 8600 stands 60.5 inches (153.7 centimeters) high, 73.5 inches (186.7 centimeters) wide, and 30 inches (76.2 centimeters) deep. It weighs 1,725 pounds (784 kilograms). Power requirements are 120/208 VAC, 47-63 Hz, triple-phase. Power of 240/415 VAC, 50 Hz is also available. Operating temperature is 59 to 90 degrees Fahrenheit (15 to 32 degrees Celsius), at 20 to 80 percent relative humidity. Maximum altitude is 8,000 feet (2,400 meters). Maximum AC power consumption is 6.5 kilowatts, and heat dissipation is 22,200 Btu/hour. Maximum noise generated is 60 Dba. The VAX 8600 can be positioned on either a solid or raised floor, because it can draw air under the skirt of the machine as well as through a floor.

Nominal operating environment for the other VAX-11 processors is 70 degrees Fahrenheit ±5 degrees Fahrenheit (21 degrees C ±3 degrees C) at 50 percent relative humidity (±10 percent).

The VAX-11/780, 11/785, and 11/782 processor cabinets are 60.5 inches (153.7 cm) high, 46.5 inches (118.1 cm) wide 30 inches (76.2 cm) deep, and weigh 1,100 pounds (498 kg). Power requirements are 120/280 volts. Maximum AC power consumption is 6225 watts for the 11/780 and 11/782, and 2500 watts for the 11/785. Maximum heat dissipation is 21,230 Btu/hour.

The VAX-11/750 stands 42 by 29 by 30 inches (106 by 74 by 76 cm). Maximum weight is 400 pounds. Power requirements are 120 volts at 30 amp, and 240 volts at 15 amp, single-phase. Maximum power consumption is 1700 watts, and maximum heat dissipation is 5800 Btu/hour.

The VAX-11/730 is 41.8 by 21.3 by 31.5 inches (106.2 by 54.1 by 80 cm) in size, and weighs 500 pounds (227.0 kg). Power requirements are 120 volts at 20 amp, single-phase. Maximum AC power consumption is 790 watts, and maximum heat dissipation is 2694 Btu/hour.

The VAX-11/725 is 24.5 by 17.5 by 28.5 inches (62.2 by 44.5 by 72.4 cm) in size, and weighs 205 pounds (93.0 kg). Power requirements are 120 volts at 7.1 amp, single-phase. Maximum AC power consumption is 575 watts, and maximum heat dissipation is 1955 Btu/hour.

INPUT/OUTPUT CONTROL

The input/output information provided here is for systems running under VAX/VMS; Ultrix-32 systems use the same I/O control devices, but are more restricted as to the number that can be configured.

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Series 3200 in engineering/scientific applications, and Wang's VS systems in office automation.

ADVANTAGES AND RESTRICTIONS

VAX systems have numerous advantages for users. In the first place, the systems feature a high degree of software compatibility. Because all systems run the VMS operating system, applications are transportable among systems from the bottom of the line to the top. This congruent operating environment actually provides a dual advantage: it allows users to migrate upward to more powerful single systems without altering their applications, and also permits those with networked systems to load applications up, down, and across the systems on the network as the computing requirements of the organization dictate. It also provides software compatibility with the MicroVAX systems, which run under MicroVMS, a superset of VAX/VMS.

The availability of the Unix-based Ultrix-32 operating system for VAX computers is also advantageous, for it allows users to choose between the realtime VMS and timesharing Unix environments, depending upon their application requirements. The incorporation of features from AT&T's Unix System V brings the Ultrix-32 system into closer conformity with the AT&T system, which is the version of Unix around which most supermicro, mini, and supermini vendors are converging. It also increases the possibility of application portability between Ultrix-based VAX systems and System V-based computers.

One drawback is the limited hardware upgradability available in the VAX family. Only the VAX-11/780 can be upgraded directly, to either the single-processor VAX-11/785 or the dual-processor VAX-11/782. However, the systems do demonstrate a high degree of peripheral transportability, particularly at the upper end of the family. Terminals and printers can be shifted among systems, as can Unibus disk drives, which can be configured with any system from the VAX-11/730 up, and Massbus drives, which are compatible with systems from the VAX-11/750 up. The transportability of VAX peripherals can mean a significant reduction in hardware outlay for users who want to migrate upward. That cross-system peripheral compatibility compensates somewhat for the lack of direct system upgradability, allowing the incremental development of more powerful multisystem configurations and homogenous networks.

Digital's recent emphasis on delivering IBM/SNA connectivity products and other networking software is a definite advantage, for it provides VAX users with gateways to IBM mainframes and strenghtens the position of VAX systems as department-level intermediaries between mainframe and personal computers. DEC's incorporation of the LU6.2 protocol in the APPC product is significant, for it reportedly provides a means of accessing IBM's forthcoming token ring local area network. Moreover, LU6.2 is seen by some analysts as the future linchpin in peer-to-peer communication among all types of hardware.

All VAX systems support the *Unibus*, an asynchronous bidirectional bus, which controls all Digital- and user-developed realtime peripherals other than high-speed disk drives and magnetic tape transports. The Unibus is connected to the memory interconnect through the Unibus adapter. The Unibus adapter handles priority arbitration among devices on the Unibus. Unibus adapters may be placed on the memory interconnect as follows: up to six on the VAX 8600; up to four on the VAX-11/782, 11/780, and 11/785; up to two on the 11/750; and one Unibus on the 11/730 and 11/725.

The Unibus adapter provides access from the VAX processors to the Unibus peripheral device registers by translating Unibus addresses, data transfer requests, and interrupt requests to their memory interconnect equivalents, and vice versa. The Unibus adapter address translation map translates an 18-bit Unibus address to a 30-bit memory interconnect address on the 11/782, 11/780, 11/785, and VAX 8600, and to 24 bits on the 11/750, 11/730, and 11/725.

On the 11/782, 11/780, 11/785, and VAX 8600, the Unibus adapter provides buffered DMA (NPR) devices. Each of these channels has a 64-bit buffer (plus byte parity) for holding four 16-bit transfers to and from Unibus devices. The result is that only one memory interconnect transfer (64 bits) is required for every four Unibus transfers. On the 11/750, 11/730, and 11/725 the Unibus adapter facilitates high-speed DMA transfers by providing buffered DMA data paths for up to three high-speed devices at one time. Each of these channels has a 32-bit buffer (plus byte parity) for holding two 16-bit transfers to or from Unibus devices. The result is that only one memory transfer (32 bits) is required for every two Unibus transfers. The maximum aggregate transfer rate through the buffered data path is 1.5M bytes per second.

Any number of unbuffered direct memory access transfers are handled by one direct DMA data path. Every 8- or 16-bit transfer requires one 32-bit transfer on the memory interconnect. The maximum transfer rate through the direct data path is 500,000 bytes per second on the 11/780, 11/785, 11/782, and VAX 8600, and 1M bytes per second on the 11/750, 11/730, and 11/725. The Unibus adapter permits program interrupts, unbuffered and buffered data transfers to occur concurrently.

On systems from the VAX-11/750 up, the *Massbus* adapter is used to attach high-speed disk or magnetic tape devices and perform control, arbitration, and buffering functions. Up to four Massbus adapters can be attached to the VAX 8600; up to four can be connected to the memory interconnect on the 11/782, 11/785, and 11/780; and up to three adapters can be connected to the 11/750. The VAX Massbus is not available for the 11/730 or the 11/725.

Each Massbus adapter includes its own address translation map that permits scatter/gather disk transfers. In scatter/gather transfers, physically contiguous disk blocks can be read into or written from discontiguous blocks of memory. The translation map contains the addresses of the pages, which may be scattered throughout memory, from or to which the contiguous disk transfer takes place.

Each VAX Massbus adapter includes a 32-bit silo (first in/first out) data buffer. Data is assembled in 32-bit longwords plus parity (64-bit quadwords plus parity on the 11/780 and 11/785) to make efficient use of the system bus. On transfers from memory to a Massbus peripheral, the Massbus adapter anticipates upcoming Massbus data transfers by fetching the next 32 bits (64 bits on the 11/780) from memory before all of the previous data are transferred to the peripheral. The maximum Massbus I/O throughput on the

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USER REACTION

Datapro's 1985 Computer Users Survey yielded responses from 199 VAX system users. This year we divided the family into individual models for reporting purposes; in previous years, the family was presented as a single entity. Because the VAX family is so widely installed, and because Digital aims each model group within the family at a different-sized computing environment, we decided that it would be more meaningful to provide separate results for each VAX model.

We received responses on the VAX-11/730, VAX-11/750, VAX-11/780, and VAX-11/785. Ten VAX-11/730 systems were represented, with an average installed life of 10.1 months. Eighty-seven 11/750 systems were rated; their installed life averaged 9.5 months. The 11/780 systems rated numbered 91; average installed life was 11.8 months. Eleven 11/785 systems were covered, with an average installed life of 8.2 months. The vast majority of the systems had been purchased: 90 percent of the 11/730s, 70.1 percent of the 11/750s, 76.9 percent of the 11/780s, and 90.9 percent of the 11/785s.

The respondents also provided information on their system configurations. One hundred percent of the 11/730 systems had between 100MB and 600MB of disk storage. Of the 11/750s, 41.9 percent had between 100MB and 600MB of disk and 44.2 percent had between 600MB and 1.2GB. Thirty-one percent of the 11/780s rated had between 600MB and 1.2GB of disk, while 49.4 percent had 1.2GB to 4.8GB. Of the 11/785s, 72.7 percent had between 1.2GB and 4.8GB of disk.

For local workstations, 66.7 percent of the 11/730s rated had 6 to 30. Of the 11/750s, 58.1 percent had between 16 and 60 local stations. Of the 11/780s and 11/785s, 71.5 and 82.2 percent, respectively, had between 31 and 60-plus local workstations.

The types of applications mentioned most frequently for each system show the range of commercial and technical applications in which the VAX systems are used. Sixty percent of 11/730 users and 56.1 percent of 11/750 respondents cited accounting/billing as a principal application. Engineering/scientific applications were cited by 46.2 percent of the 11/780 respondents, and educational programs were cited by 54.6 percent of the 11/785 users.

In-house development was the most frequently cited method of acquiring applications programs (although other means were used in conjunction). Seventy percent of 11/730 users, 80.5 percent of 11/750 users, 78 percent of 11/780 respondents, and 81.8 percent of 11/785 respondents employed in-house personnel to develop applications programs. Fortran was the most frequently cited programming language, mentioned by 50 percent of 11/730 respondents, 28.2 percent of 11/750 users, 33.3 percent of 11/780 respondents, and 27.3 percent of 11/785 users. (Tying Fortran for popularity on the 11/785 was Cobol.)

VAX processors is 2M bytes per second. Online diagnostics and loopback enable adapter fault isolation without requiring the use of a drive on the Massbus.

The *HSC50* (Hierarchical Storage Controller) is a Computer-Interconnect-based intelligent disk/tape server designed to provide data integrity and higher throughput and subsystem availability for high-density disk drives, which require the UDA50 (Unibus Disk Adapter) intelligent controller to function in a multiprocessing environment. The HSC50 supports high-speed disks and tapes as well as the computer interconnect (CI), and can contain up to six data channel interfaces, each channel interfacing up to four disk drives, enabling concurrent serving of multiple CI-Bus interconnected processors. The HSC50 has a CI port bandwidth of 4.25M bytes per second; a bandwidth of 3.125M bytes per second for each disk data channel; a bandwidth of 1.25M bytes per second for each tape data channel; a total data buffering bandwidth of 13.3M bytes per second, total; and a request processing overhead of 1.6 milliseconds per request.

In the VAX 8600, the interface between the memory controller and the SBIs (Synchronous Backplane Interconnects)—the TTL logic subsystems that control I/O—is handled through the DB86 SBI Adapters, which are connected to the Adapter Bus, or A-Bus. The DB86 adapters control the asynchronism between the 80-nanosecond CPU cycle and the 200-nanosecond cycle of the slower SBI. The first, standard SBI comes with two integral adapters: the DW780 Unibus adapter, which is a master/slave device, and the CI780 Computer Interconnect. The CI780 is required for building VAXclusters (loosely coupled combinations of up to 16 VAX 8600, 11/780, 11/782, 11/785, or 11/750 processors and HSC50 intelligent Hierarchical Storage Controllers connected over a dual-path Computer Interconnect, or CI, bus) and for supporting the HSC50. A second DW780 Unibus adapter can be added to the base VAX 8600. The first SBI can also support up to four more adapters in an expansion cabinet; those adapters can be either Unibus or Massbus. (An SBI, however, can support only four of any single type of adapter.) The bandwidth of a single SBI is 13.3MB/second.

The second, optional SBI can support up to eight adapters in two external cabinets; they can be Unibus (up to 4), Massbus (up to 4), Computer Interconnect (up to 2), or DR780 (up to 4) adapters. (The DR780 is a general-purpose, 32-bit adapter with a 6MB/second bandwidth.) Thus, a VAX 8600 system with two SBIs can support up to 11 adapters at an aggregate I/O bandwidth up to 20MB/second.

CONFIGURATION RULES

***System Building Blocks (SBBs)* are available for the VAX-11/730, VAX-11/750, VAX-11/780, VAX-11/782, VAX-11/785, and VAX 8600. SBBs for the 11/730 and larger systems begin with a core of components: CPU, main memory, cabinetry, and the VAX/VMS or Ultrix-32 operating system license. To this core the user must add selections from the mass storage (system device and load device), communications interface, and console terminal menus; selections from the software menu are optional. The number of components that can be added varies between VAX/VMS and Ultrix-32 SBBs; Ultrix-32 systems have more limited configurability. (See EQUIPMENT PRICES, at the end of this report, for further details on SBBs.)**

A *VAXcluster* is composed of one or more VAX 8600, 11/750, 11/780, 11/785, or 11/782 processors or HSC50 hierarchical storage controllers running under VAX/VMS and connected by a high-speed computer interconnect bus and communication links to the user community. Each processor or HSC50 in the configuration is considered a

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Reflecting the increasing integration of VAX systems into departmental and office environments, a number of the respondents mentioned that they had integrated office functions on their systems. Fifty percent of 11/730 users, 43.5 percent of 11/750 respondents, 36.8 percent of 11/780 users, and 36.7 percent of 11/785 respondents claimed that they used office functions on their systems.

The following table shows the ratings given by VAX-11/730 users to their systems.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	4	6	0	0	3.4
Reliability of system	10	0	0	0	4.0
Reliability of peripherals	7	3	0	0	3.7
Maintenance service:					
Responsiveness	8	1	1	0	3.7
Effectiveness	7	3	0	0	3.7
Technical support:					
Troubleshooting	4	2	3	0	3.1
Education	5	2	2	0	3.3
Documentation	3	4	3	0	3.0
Manufacturer's software:					
Operating system	7	3	0	0	3.7
Compilers & assemblers	7	3	0	0	3.7
Application programs	1	4	0	0	3.2
Ease of programming	3	7	0	0	3.3
Ease of conversion	3	6	1	0	3.2
Overall satisfaction	6	4	0	0	3.6

*Weighted Average on a scale of 4.0 for Excellent.

User ratings of VAX-11/750 systems are given in the following table.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	40	43	1	0	3.5
Reliability of system	56	27	1	0	3.7
Reliability of peripherals	49	34	1	0	3.6
Maintenance service:					
Responsiveness	52	21	7	0	3.6
Effectiveness	42	32	6	0	3.5
Technical support:					
Troubleshooting	33	41	8	0	3.3
Education	27	39	9	3	3.2
Documentation	35	37	11	2	3.2
Manufacturer's software:					
Operating system	57	21	2	0	3.7
Compilers & assemblers	47	28	2	0	3.6
Application programs	16	34	11	0	3.1
Ease of programming	37	37	3	0	3.4
Ease of conversion	22	45	5	1	3.2
Overall satisfaction	44	30	2	0	3.6

*Weighted Average on a scale of 4.0 for Excellent.

The following table shows users' ratings of VAX-11/780 systems.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	48	32	5	0	3.5
Reliability of system	54	28	3	0	3.6
Reliability of peripherals	35	45	4	1	3.3
Maintenance service:					
Responsiveness	46	38	7	0	3.4
Effectiveness	41	42	8	0	3.4

node. The smallest VAXcluster configuration can be two VAX processors connected by an interconnect and star coupler. No HSC50 is necessary; VAX/VMS allows locally connected Unibus and Massbus disks to be shared by VAXcluster users through an MSCP server.

In general, VAXclusters are based on VAXcluster System Building Blocks (SBBs), of which there are two types. The first type is a basic system element, which consists of a CPU with memory, CI780 or CI750 computer interconnect, HSC50 intelligent controller, SC008 star coupler, a four-port disk interface, a VAX/VMS operating system license, and a DECnet routing license. The second type of Cluster System Building Block is an upgrade to an existing VAXcluster. The upgrade consists of a CPU with main memory, CI750 or CI780 computer interconnect, VAX/VMS operating system license, and DECnet routing license. An LA12 (for the 11/750), LA100, or LA120 console terminal must be ordered. A system disk must be allocated to each processor connected to the cluster.

Although most VAXclusters are custom-configured, DEC also offers packaged VAXcluster systems for the VAX-11/750 and VAX-11/785.

GENERAL: The configuration rules provided here are for systems running under VAX/VMS. Systems operating under Ultrix-32 use the same components, but configurability is more limited.

The VAX 8600 is available in two basic configurations: a standalone System Building Block kernel or a two-node VAXcluster centered around the CPU and an HSC50 storage controller.

The standalone configuration incorporates the RB86 Integrated Disk and Tape Controller, which allows users to configure up to four disk drives (for a maximum capacity of 1.8GB) and a 140MB streaming tape drive.

The components of the VAX 8600 cluster SBB include: a CPU with integral floating-point accelerator; 8MB or 12MB of main memory; SC008 Star Coupler; HSC50 mass storage controller; associated hardware; VAX/VMS license; and DECnet license.

Options for both the VAX 8600 standalone and VAXcluster SBBs include 256K-chip MS86 memory expansion units, the DW780 Unibus Adapter, the DR780 General Purpose Adapter, the DB86 SBI Adapter, the CI780 Computer Interconnect, the FP86 Floating-Point Accelerator, and the RB86 Integrated Disk and Tape Controller, which provides a storage subsystem separate from VAXcluster system shared storage.

The VAX-11/782 and VAX-11/780 contain the CPU, with virtual memory management, bootstrap loader, standard instructions for packed decimal, floating- and fixed-point arithmetic, character and string manipulations, 8K-byte parity bipolar cache memory, programmable realtime clock, time-of-year clock (with battery backup), and 2K words of writable diagnostic control store. The CPU also includes a console subsystem composed of an RX01 floppy disk and an LSI-11 microcomputer to which the console terminal is attached.

The VAX-11/785 incorporates the same features, but includes a 32K-byte cache, 8K words of writable control store, and support for G and H floating-point data types.

Optional expansions of the 11/782, 11/780, and 11/785 can be made through the use of CPU and Unibus expansion cabinets. The following options are available for the 11/780, 11/782, and 11/785 CPUs: MA780 shared memory option;

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Technical support:					
Troubleshooting	33	41	13	3	3.2
Education	24	47	13	3	3.1
Documentation	27	50	11	1	3.2
Manufacturer's software:					
Operating system	56	28	5	0	3.6
Compilers & assemblers	45	37	3	0	3.5
Application programs	16	38	10	5	2.9
Ease of programming	42	40	3	0	3.5
Ease of conversion	29	39	10	2	3.2
Overall satisfaction	48	36	5	0	3.5

*Weighted Average on a scale of 4.0 for Excellent.

The following table gives user ratings of VAX-11/785 systems.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	6	3	2	0	3.4
Reliability of system	5	5	1	0	3.4
Reliability of peripherals	6	5	0	0	3.6
Maintenance service:					
Responsiveness	6	4	1	0	3.5
Effectiveness	7	3	1	0	3.6
Technical support:					
Troubleshooting	4	5	1	1	3.1
Education	2	6	1	0	3.1
Documentation	2	7	2	0	3.0
Manufacturer's software:					
Operating system	8	0	2	0	3.6
Compilers & assemblers	6	4	0	0	3.6
Application programs	1	3	3	0	2.7
Ease of programming	3	5	1	0	3.2
Ease of conversion	1	5	2	0	2.9
Overall satisfaction	5	3	2	0	3.3

*Weighted Average on a scale of 4.0 for Excellent.

The overall satisfaction ratings between "Good" and "Excellent" indicate that the VAX users are quite pleased with their systems. To the question, "Would you recommend this system to another user?", affirmative responses were received from 100 percent of 11/730 respondents, 98.9 percent of 11/750 users, 87.9 percent of 11/780 respondents, and 63.6 percent of 11/785 users.

To supplement our statistical results, we contacted four VAX respondents by telephone in July 1985 for follow-up comments to amplify on their ratings. Each user represented a site in a different region of the United States.

The first respondent, an 11/730 user, represented a health care/medical firm in the far West. He said that he used the system primarily for general accounting and patient accounting applications, but hoped to get it involved in laboratory functions in the future. This user said that he was very pleased with the 11/730; as he stated, "You can do just about anything you want with it." He was particularly impressed with the system's speed, reliability, and compatibility with hardware and software both from DEC and from third-party vendors. The user said that he felt the 11/730 provided a good growth path, and remarked that he hoped eventually to migrate up to an 11/750 or 11/780. He also added that his company was planning to add data communications facilities that would allow the 11/730 to act as a service bureau system for other laboratories.

64K and 256K MS780 memory modules (11/780 and 11/785 only); H7112 battery backup; FP780, FP782, or FP785 high-performance Floating-Point Accelerator; DW780 Unibus Adapter; Massbus Adapter; KE780 G & H floating-point microcode (11/780 and 11/782 only), and a remote diagnosis feature. Communications options include the asynchronous, synchronous, and Ethernet interfaces.

The basic equipment for the VAX-11/750 system includes the CPU, virtual memory management, bootstrap loader, standard instructions for floating- and fixed-point arithmetic, 4K-byte bipolar cache memory with parity, high-precision programmable realtime clock, and time-of-year clock with battery backup.

Expansion space for the 11/750 is available in both the CPU backplane and the Unibus expansion backplane within the CPU cabinet. The optional VAX-11/750 general-purpose expansion cabinet is used for expansion beyond the basic system. The following options are available for the 11/750 CPU: additional 64K chip MS750 memory modules up to a total of eight modules (8MB), DR750 General-Purpose Interface, DW750 Second Unibus Adapter, FP750 Floating-Point Accelerator, KU750 extended range G and H floating-point data type option, H7112 Memory Battery Backup, CI750 computer interconnect, and remote diagnosis feature. (The CI750 and the DR750 cannot both be present.) Also available are asynchronous, synchronous, and Ethernet communications devices.

The basic equipment for the VAX-11/730 system includes the CPU, virtual memory management, bootstrap loader, integral floating-point, packed decimal and character string instructions, interval timer, and time-of-year clock.

Expansion space for the 11/730 is available in both the CPU backplane and the Unibus expansion backplane within the CPU cabinet. The optional VAX-11/730 general-purpose expansion cabinet is used for expansion beyond the basic system. The following options are available for the 11/730 CPU: an additional 64K chip MS730 memory module to provide a system main memory total of 3MB, FP730 Floating-Point Accelerator, H7750 Memory Battery Backup, TU80 and TU81 magnetic tape controllers, LP11 printer controller, and LP32 printer via the DMF32 port. Asynchronous, synchronous, general-purpose, and Ethernet communications options are available.

DEC's VAX-11/725 is a packaged product that contains a VAX-11/730 CPU, 1M byte (expandable to 3M bytes) of 64K-chip main memory, two TU58 tape cartridge drives, and the RC25 52M-byte fixed and removable 8-inch Winchester drive, power controller and power supply, cabinet, and VAX/VMS operating system license and warranty. The 11/725 is available in three packaged systems, which support, variously, the following components: MS730 memory modules, the FP730 floating-point accelerator, DMF32 controller, DMR11 high-speed DECnet card, DZ11 communications controller, DEUNA Ethernet communications interface, VAXstation 100 hardware and software, and choice of hardcopy (LA12 or LA100) or soft copy (VT100/VT200 series) console.

WORKSTATIONS: Up to 96 terminals can be attached to each Unibus adapter on the VAX-11/780, 11/782, and 11/785. Up to 64 per Unibus adapter can be attached on the 11/750. Up to eight terminals may be configured with a single cabinet-packaged 11/730 (8 per each DMF32 controller). With the 11/730 expander cabinet, the recommended maximum number of terminals is 24. The 11/725 may be configured with up to eight terminals. The VAX 8600 supports up to 512 workstations.

DISK STORAGE: The HSC50, the principal storage controller for the VAX 8600, can support up to 24 disk drives.

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The second respondent was an 11/750 user affiliated with an engineering/scientific concern in the Middle Atlantic region. He had converted to the 11/750 from a Data General C350; after 10 years as a DG user, he had become dissatisfied. He remarked that, although his firm had benchmarked DG's Eclipse MV/6000 against the 11/750 and found it comparable in performance and price/performance, he decided to switch vendors out of general disillusionment with DG.

This user remarked that he had been displeased with the operating system on his old DG computer; it failed to zero out memory when Fortran programs were loaded, and as a result arbitrary values were assigned to variables. Secondly, he said, the service and support he received from DG were so erratic that he was driven to third-party maintenance. Digital and the 11/750, he felt, had solved those problems. The VAX/VMS operating system, he said, always performs as he expects it to and as the system documentation says it will, with no surprises. He also said that he is completely satisfied with the service he receives from Digital.

The second user also said that he was pleased with the software compatibility the VAX system provides, noting that it is possible to "develop programs with confidence and know they'll run" on other VAX systems, especially the increasingly powerful MicroVAX line. He also remarked that the operating system allowed easy software conversion for IBM programs; the necessary conversion steps, he said, are "almost trivial."

Although the second user designated the VAX-11/750 a "great system," he did see some drawbacks. He felt that VAX/VMS version 4.1 slows the machine down. Moreover, he said he felt that the 11/750 was rapidly becoming obsolete, given DEC's delivery of more powerful MicroVAX systems; he remarked that he would never buy another 11/750, but would go instead to a clusterable MicroVAX if such a machine is announced.

The third user, from a Midwestern educational institution, had a VAX-11/780. In the process of selecting a system, he had also looked at computers from IBM, Prime, and Hewlett-Packard. He settled on the VAX-11/780 both because Digital offered software packages for education (such as CAI) and because the other state-supported colleges in his state also employed VAXes, so the institutions could share software.

This user said that he was very pleased with the 11/780's reliability, maintainability, and ease of installation. He remarked that he had 3,000 users on the system, but had experienced very few operational problems. Digital, he said, was very helpful in maintaining and installing the system. He also remarked that he had been able to install the VAX/VMS operating system without documentation. Although he felt that some "nonstandard" things had been done to the compilers in VAX/VMS version 4.1, he said that he had put in fix requests and that DEC was actively working on them.

Because the VAX 8600 can be configured in a VAXcluster with up to 15 HSC50s, maximum storage capacity for the system is 164GB. Each Massbus adapter can support up to eight disk drives. Up to eight disk drives may be configured per Unibus. The VAX 8600 supports up to six Unibus adapters. The VAX-11/782, 11/785, and 11/780 support up to four Unibus adapters, the 11/750 supports up to two Unibus adapters, and the 11/730 supports one Unibus adapter. The VAX 8600 and the VAX-11/782 and 11/780 support up to four Massbus adapters; the 11/750 supports up to three adapters. VAX Massbus is not available for the 11/730 or the 11/725.

MAGNETIC TAPE: Each Massbus adapter can support up to eight tape formatters.

PRINTERS: One LP11 line printer is required on the 11/730 (a maximum of one per system). Up to four line printers can be configured on the 11/750, and up to 16 can be configured on the 11/785, 11/780, and 11/782.

MASS STORAGE

For information on available mass storage devices for VAX systems, please refer to Chart B, Mass Storage.

INPUT/OUTPUT UNITS

Refer to Chart C for terminals, Chart D for printers, and Chart E for magnetic tape equipment.

OTHER PERIPHERALS: VAX systems also support printing terminals, a pen plotter, and a voice synthesis module.

The LA12 DECwriter Correspondent is an interactive printing terminal that prints at up to 150 cps in draft mode. The LA100 is a microprocessor-controlled hardcopy terminal and printer; it can print up to 240 cps in draft mode, 30 cps in letter-quality mode, and 80 cps in memo mode. The LA120 is a 180 cps printing terminal. The LVP16, a six-color graphics pen plotter with print speeds up to 15 ips, is supported by all VAX systems that use HP-GL graphics software. The LVP16 holds up to six pens and prints up to six colors without manual intervention; it includes an RS-232-C interface.

DECtalk, a speech synthesis unit, converts standard ASCII text into speech output. The unit features eight voices (male/female, adult/child) and variable speaking rates of 120 to 300 words per minute. DECtalk uses an RS-232-C interconnection, standard operating system support, and standard terminal control sequences; it also features modular telephone connections that allow users to access a database with a standard Touch-Tone telephone. DECtalk can be configured three ways: as a talking computer device through connection to a host computer port; as a talking terminal in series with a host computer and a terminal; and as an intermediate device between a host computer and a telephone line. To host DECtalk, a computer must provide an ASCII character set, EIA RS-232-C serial interconnections, American National Standards Institute (ANSI) control codes, and X-on/X-off support.

COMMUNICATIONS CONTROL

The variety of communications interfaces supported by the VAX/VMS operating system allows VAX systems to be connected to other VAX systems, other Digital systems, and to other maufacturers' computer systems. Synchronous, point-to-point, and multipoint connections are supported for

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The third user said he felt that the 11/780 provides a good growth path for his organization. Its clustering capabilities allow the addition of new 11/780 or higher powered processors, and the available networking products allow connection to non-DEC systems. He said that he would like to see Digital provide a micro-to-supermini link that would allow the 11/780 to act as a PC server, storing a single version of a PC software package that could be shared by students on multiple PCs.

On the negative side, the third user said that the documentation for 11/780 programming languages was too costly and was difficult to understand; it posed problems even for the faculty members called on to teach those languages. (He did remark that the documentation for the VAX/VMS operating system was adequate.) When asked what advice he had for prospective 11/780 users, the respondent said he would advise them not to allow DEC's Educational Services organization to recommend what classes should be taken; those suggested for his personnel, in his opinion, did not represent maximum use of the educational credits he had been given. However, he did say that he felt Digital's software specialists would be a good source for advice on course selection.

The fourth user represented a Southern engineering/scientific concern with a VAX-11/785. He had upgraded from an 11/780 because he needed greater computing power. This user was pleased with the new system, remarking that the conversion had been accomplished overnight, immediately yielding improved CPU cycle time. He said that he would advise any prospective user that the 11/785 is a good vehicle for immediately gaining 1.4 times the power of the 11/780. He said that he was not altogether certain that the price/performance derived from the 11/785 was the best he could have gotten from any system, but did say that he considered the decision to acquire the 11/785 a good one at the time it was made and one that he does not at all regret.

The fourth user remarked that he would like to see DEC provide VAXcluster support for Unix systems. His 11/785 runs Berkeley 4.2 Unix, but VAXclustering is available only under VAX/VMS. He said that he had purchased cluster hardware in the hope that Unix support would be forthcoming, which it has not been. Thus, the clustering equipment is "physically gathering dust ... or at least metaphysically" doing so. □

interprocessor communication. For terminal-to-host communications, asynchronous connections are supported. While systems running under Ultrix-32 use the communications control devices discussed below, the models and the number of lines that can be configured vary from those available for VAX/VMS-based systems.

***Digital Network Architecture (DNA)* is a set of protocols governing the format, control, and sequencing of message exchange for all DECnet implementation. DNA controls all data that travels through a DECnet network and provides a modular design for DECnet.**

DNA consists of the following functional layers:

- **The User Layer, which includes user-written programs and services that access the network. It is the highest layer in the architecture.**
- **The Network Management Layer, which defines the functions that allow the system manager to oversee, control, maintain, and test all major facets of a network node.**
- **The Network Application Layer, which defines network functions used by the two higher layers, including remote file access, file transfer, and remote terminal capability.**
- **The Session Control Layer and Network Service Layer, which together allow a program in one node to communicate with a program in another node, via a logical link regardless of either program's location within the network.**
- **The Transport Layer, which allows a user-defined adaptive-path-routing mechanism for transporting data from one node to a specific node elsewhere in the network.**
- **The Data Link Layer, which defines a mechanism for error-free communications between nodes. The layer is independent of communications device characteristics.**
- **The Physical Link Layer, which encompasses the software device driver for each communications device plus the communications hardware.**

DNA specifies the interface by which DECnet software modules in the same system interact with one another. Within each node, a layer contains only those modules required to support modules in higher layers.

In addition to defining vertical interfaces, DNA also defines the protocols governing interaction between modules in different nodes. A module in one node communicates only with a module in the same layer that is servicing the same function in another node.

The protocols define the form and content of messages to be exchanged by modules.

Some of the DNA protocols and their functions are:

- **Network Information and Control Exchange protocol (NICE), which defines mechanisms for exchanging network, node, and configuration data and for servicing requests from modules residing in the Network Management Layer.**
- **The Data Access Protocol (DAP), which defines mechanisms for performing remote file access and remote file transfer on behalf of software modules residing in the Network Management Layer.**
- **The Network Services Protocol (NSP), which defines a mechanism for creating and maintaining logical links between modules of higher level that reside in the same or different nodes.**
- **The transport protocol (Transport), which defines a mechanism for dispatching data to any node in the network via the best possible route.**
- **The Maintenance Operation Protocol (MOP), which defines mechanisms for transmitting data over a communications channel for downline loading of a remote node, upline dumping from a remote node, testing a node and network connections, and starting up an unattended remote node.**

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- The Digital Data Communications Message Protocol (DDCMP), which defines a mechanism for ensuring the integrity and sequentiality of data transmitted over a communications channel.

The *DHU11 Asynchronous Multiplexer* interfaces up to 16 asynchronous lines to any VAX computer with an integral Unibus operating under VAX/VMS. It connects to external equipment through RS-232-C and RS-432-A interfaces, and features Direct Memory Access (DMA) and first-in/first-out (Fifo) operations to minimize CPU overhead for terminal communications. The DHU11 has a 256-character Fifo buffer that can be employed for received characters, data set status, or diagnostic information. The DHU11 can provide half- or full-duplex communications. It is programmable for split speeds on each of its lines and provides full modem control on all channels. Each channel has a 64-byte Fifo buffer for output data.

The *DMZ32 Asynchronous Multiplexer* supports up to 24 asynchronous lines to Unibus-based VAX computers. It allows a terminal distribution panel to be located as far away as 5,000 feet from the multiplexer's Unibus connection in the computer system. The DMZ32 has 24 RS-232-C connectors and allows DMA and Fifo operations; it permits half- or full-duplex communications.

The DMZ32 is a two-element unit comprising a Unibus interface module and a distribution panel with power supply, time-division multiplexing (TDM) circuitry, and EIA RS-232-C connectors, with modem control logic optional. The interface and distribution panel are connected by a shielded, two-twisted-pair wire cable that runs up to 5,000 feet. Per-line features include DMA on transit, a 256-character Fifo buffer for input, and split speed.

The *DZ11 Asynchronous Multiplexer* is an eight-line unit that provides control for up to 8 EIA RS-232-C/CCITT V.28 or 20 ma terminals. The DZ11 operates at program-selectable line speeds up to 9600 bps full-duplex. The DZ11 is compatible with Digital's family of modems and with Bell 100 and 200 series modems and their equivalents.

The *DZS11 Statistical Multiplexer* consists of one DZS11-EA (asynchronous multiplexer emulator and statistical multiplexer) and a combination of one or two VT1XX-EB remote statistical multiplexers. A maximum of eight remotely located asynchronous terminals may share a common composite communications link, when using the statistical multiplexer.

The *DFM Series* of statistical multiplexers are intelligent, standalone communications processors (ICPs) that provide DMA transfers, asynchronous and synchronous operation, support for 4800 and 9600 bps modems, and expansion from 4 to 16 lines. It features asynchronous input speeds from 50 to 9600 bps with autobaud above 150 bps, synchronous input speeds from 1200 top 9600 bps on 50 percent of the channels, and concentrated link speeds from 1200 to 19,200 bps.

The *DMF32 Multipurpose Communications Controller* is an intelligent communications controller which enables a combination of modems and terminals to communicate with Unibus VAX systems. This unit contains three basic elements: 1) an eight-line asynchronous interface for operation with modems and terminals, 2) a single-line synchronous interface for connection to a network communication facility, and 3) a parallel interface for either a line printer (in DMA mode) or a user-developed device. The DMF32 uses the Direct Memory Access (DMA) mode and Silo (first-in/first-out) buffers in the controller to permit fast data transfers and reduce CPU interrupt overhead. It is supported by VAX/VMS, DECnet/VAX, VAX PSI, VAX 2780/3780, and 3271 Protocol Emulators. Only the asynchronous lines of the DMF32 are supported under Ultrix-32.

The *DMP11 Multipoint Synchronous Interface* permits high-speed Direct Memory Access (DMA) data transfers between computer systems in distributed networks. Multipoint or point-to-point operations are allowed over common carrier on private lines, or through shielded cables. The DMP11 can be configured for half-duplex operation at transfer rates of up to one million bps or for full-duplex at 500K bps. For remote applications to common carrier lines, the DMP11 can be connected to synchronous modems conforming to EIA or CCITT standards. The DMP11 interfaces to: Digital's family of modems; Bell 200 series modems at speeds up to 19.2K bps; and Bell 500a I1/5 modems and equivalents at speeds up to 56K bps.

The *DMR11* network link is a single-line synchronous interface for local and remote support. It implements DDCMP in hardware and supports direct memory access data transfers, DECnet point-to-point configurations, and full modem control. The DMR11 can communicate with another DMR11, DMV11, DMP11, or synchronous interface implementing DDCMP.

The *DUP11 Single-Line Synchronous Interface* is full-/half-duplex and can be programmed to handle 8-bit character-oriented protocols such as DDCMP and Bisync, and bit-oriented protocols such as SDLC and HDLC. It interfaces to systems with RS-232-C/CCITT V.28 interface facilities. The hardware calculates CRC-16 when using DDCMP protocol (not BISYNC) and CRC/CCITT when using bit-oriented protocols. The DUP11 interfaces to Bell 200 series modems or equivalents at speeds up to 9600 bps.

The *KMS11 Auxiliary Communications Microprocessor* is a full-duplex, eight-line synchronous communications front-end supporting concurrent data transfers over eight lines in half- or full-duplex with full synchronous modem control at speeds up to 56K bps. Hardware calculates CRC-16 when using byte-oriented protocols, and CRC/CCITT when bit-oriented protocols are implemented. Electrical interfaces supported are RS-232-C/CCITT V.28, MIL-188-144 (unbalanced), and V.35.

The *KCT32 Communications Controller* is an intelligent front-end communications processor for the VAX-11/730 and larger systems in networking and custom communications applications. The KCT32 permits users to develop networks that, while not based on DECnet, are centered around DEC products.

The KCT32 features 56KB of user-programmable memory; it can be initialized by line for bit/byte synchronous or asynchronous data transmission and reception. It supports two lines at 64K baud per line or a single line at 130K baud, full-duplex. Line support is program-selectable. Up to four KCT32 controllers can be configured per system. The KCT32 accommodates on-board-selectable RS-232-C, RS-422, RS-423, and RS-449 standards. The unit's secondary microprocessor, used as a line accelerator, provides basic HDLC and Bisync framing capabilities; a second circuit board can be added to accommodate the V.35 standard.

The *FEPCM Front-End Processor* is a user-programmable front end designed to offload communications handling for the VAX-11/780 and VAX-11/750 systems.

The *PCL11 Parallel Communications Link* is a multidrop computer link used to connect up to 16 processors to form a local distributed network. It features full-duplex interfaces and bus speeds up to 1M bits per second.

Ethernet Communications Servers provide specific communications functions for all hosts attached to the Ethernet, freeing individual hosts from performing those functions themselves.

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Digital's Ethernet Communications Servers include: the DECnet Router Server (connects DECnet nodes in one Ethernet LAN to those in another or to remote DECnet nodes), the DECnet Router/X.25 Gateway (connects an Ethernet LAN to X.25 Packet Switched Data Networks), and the DECnet/SNA Gateway (connects an Ethernet LAN to an IBM SNA network). All Ethernet Communications Servers require a host CPU with Phase IV DECnet software running under VAX/VMS.

A Communications Server requires an Ethernet LAN including all the physical channel hardware, Phase IV DECnet host installed on the Ethernet, an H4000 transceiver or DELNI (Local Network Interconnect), and a transceiver drop cable to connect the server to the H4000 or DELNI.

The *H4000 Digital Ethernet Transceiver* is a device that provides the functional interface between the Ethernet coaxial cable and an Ethernet station. The H4000 station transmits signals onto and receives signals from the cable, and detects any message collisions that may occur.

The *DEUNA Ethernet Communications Controller* connects a Unibus system to an Ethernet local area network (LAN). Both DECnet and device driver level software support are available. The DEUNA complies with the Ethernet Specifications, transmits and receives 10M bits per second, and provides full-address filtrating to off-load the host computer.

The *DELNI Local Network Interconnect (LNI)* allows Ethernet-compatible devices to be grouped up to 50 meters away from the LNI. The LNI can be configured three ways: standalone, hierarchical standalone, and connected. The LNI LANs are connected to the Ethernet coaxial cable via H4000 Ethernet transceivers.

The *DEREP Ethernet Repeater* is a tabletop, standalone device with its own power supply, and allows for connection of multiple segments of Ethernet coaxial cable for expansion of the network. The local DEREP extends the Ethernet for 500 meters per repeater while the remote repeater extends the Ethernet for an additional 1,000 meters per repeater.

The *Terminal Server* is a network terminal switch that enables users to connect multiple computer terminals (video, hardcopy, or PCs in terminal mode) to VAXclusters and other systems, Digital or non-Digital, on an Ethernet LAN; users can access multiple hosts from the same terminal. When used with VAXclusters, the Terminal Server performs load balancing to connect users to the host node with the greatest available computing capacity. Consequently, an application can continue to execute even if the specific CPU in which it is running goes out of service. In an Ethernet environment, the server provides access to all services and hosts on the LAN for nonblocked resource distribution.

The server also has layered security features, permitting users to lock their terminals at the logic level and prevent password access by unauthorized personnel; this locking is independent of the host that the user is logged into. The Terminal Server employs the Local Area Transport (LAT) software protocol for intersystem operations; the protocol is supported under the VAX/VMS operating system. The Terminal Server is available in 16- or 32-terminal versions.

DECserver 100 is a network teminal switch that allows connection of up to eight asynchronous terminals to one or more hosts on Ethernet.

The *DECOM Broadband Ethernet Transceiver* and an associated device, the *DEFTR Broadband Ethernet Frequency Translator*, allow VAX systems to be configured in broadband Ethernet networks, providing access to nodes up to 12,464 feet (3,800 meters) apart. The devices run under DECnet networking software and are functionally equivalent to Digital's baseband Ethernet products.

DECOM provides full Ethernet functions on broadband, with a data rate up to 10M bps. It supports up to 1,024 nodes and is available for both dual- and single-cable broadband installations. When used with the DELNI clustering device, DECOM provides connection to as many as eight DECnet/Ethernet devices. DEFTR, used with DECOM in single-cable installations, enables a DECOM to transmit at one set of frequencies and receive at another.

Both broadband products attach to conventional cable television (CATV) cabling and components. They employ the Ethernet Carrier Sense Multiple Access/Collision Detection (CSMA/CD) protocol, including guaranteed collision detection, and require an 18MHz bandwidth. Broadband and baseband Digital LANs can be interconnected through DECnet routers. Broadband and baseband DECnet/Ethernet LANs can be connected to other network environments through Digital's X.25 and SNA gateways.

SOFTWARE

OPERATING SYSTEMS: Operating systems for the VAX systems are the general-purpose VAX/VMS and Ultrix-32, Digital's version of Berkeley Unix.

VAX/VMS is a general-purpose operating system that provides the environment for the concurrent execution of multiuser timesharing, batch, and time-critical applications. It also contains special features for VAXcluster support, and provides programming tools, scheduling services, and protection mechanisms for multiuser program development.

Under VAX/VMS, applications can be divided into several independent subsystems whose data and code are protected from one another but which have general communication and data sharing facilities. Jobs can communicate using general, group, or local communications facilities.

Jobs can be scheduled as time-critical jobs that have strict priorities of execution. When a time-critical job is ready to execute, it executes until it becomes blocked or until another time-critical job of higher priority needs the resources of the processor. Normal jobs can be scheduled using a modified preemptive algorithm that ensures that they receive processor and peripheral resources at regular intervals commensurate with their processing needs.

If insufficient memory is available for keeping concurrently executing jobs resident, the operating system will swap jobs in and out of memory to allocate each its share of processor time. Time-critical jobs can be locked in memory to ensure that they can be started up rapidly when they need to execute.

The I/O request processing system is optimized for throughput and interrupt response. The operating system provides the user with several data accessing methods, from logical record accessing for device-independent programming to direct I/O accessing for rapid data processing. Files can be stored in any of several ways to optimize subsequent processing.

The VAX/VMS operating system's own jobs run as independent activities. They include the Job Controller, which initiates and terminates user processes and manages spooling; the Operator Communications Manager, which handles messages queued to the system operators; and the Error Logger, which collects all hardware and software errors detected by the processor and the operating system.

A command interpreter executes as a service for interactive and batch jobs. It enables the general user to request the

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basic functions that the operating system provides, such as program development, file management, and system information services.

Both hardware-detected and software-detected exception conditions are tracked through the exception dispatcher. The exception dispatcher passes control to user-programmed condition handlers or, in the case of system-wide exception conditions or the absence of user routines, to operating system condition handlers.

The operating system's memory management routines include the virtual activator, which controls the mapping of virtual memory to system and user jobs, and the pager, which moves portions of a process in and out of memory as required. They respond to a program's dynamic memory requirements and enable programs to control their allocated memory, share data and code, and protect themselves from one another. The scheduler controls the allocation of processor time to system and user jobs.

The operating system's I/O processing software includes interrupt service routines, device-dependent I/O drivers, device-independent control routines, and user-programmed record processing services.

For system and data security, VAX/VMS provides password and login limits to control access to the system; methods of defining data access; operator interface facilities that allow different classes of operators to be defined; and security auditing capabilities for monitoring unusual or suspicious system activities.

VAX/VMS also features user and operator interfaces. The former allows special prompts and command recall and editing, while the latter permits management of batch and print queues.

VAX/VMS incorporates VAXcluster support features that allow the creation of homogenous environments providing transparent cross-cluster data access and resource sharing to loosely coupled systems. Those features include:

- The Distributed File System, which manages all files in the VAXcluster as a single entity.
- The Distributed Lock Manager, which synchronizes resource use across the VAXcluster.
- Terminal Server support, allowing terminals to be connected flexibly to VAXcluster systems and providing load balancing and availability features.
- Cluster Operator support, enabling a single person to manage an entire VAXcluster.
- The Mass Storage Control Protocol server, which allows disks connected locally to a system to be accessed from anywhere in the cluster.
- Cluster-wide balancing, through the Job Controller, of the number of jobs per system.

Ultrix-32 is Digital's native-mode implementation of the Unix operating system. It is based on the University of California at Berkeley's Fourth Berkeley Software Distribution (4BSD) with enhancements from AT&T's Unix Systems III and V. Ultrix-32 can be used on all models except the VAX-11/725. Depending upon the application, Ultrix-32 can support up to 16 users on VAX-11/730 computers, more than 32 users on VAX-11/750 computers, and over 64 users on VAX-11/780, VAX-11/785, and VAX 8600 systems.

Ultrix-32 is an interactive, timesharing system. It employs a demand-paging scheme to take advantage of the virtual memory architecture of VAX systems. It features a hierarchical file system with demountable volumes, sharing of input/output resources among processes, and asynchronous process execution.

Ultrix-32 incorporates the Source Code Control System (SCCS) from AT&T's Unix System III, along with System V commands and utilities. It also includes a diagnostic testing facility for loading and testing corrections from an Ultrix-32 file system.

Ultrix-32 supports Unix Version 7 Bourne and C shells, as well as the C, Fortran 77, Pascal, FranzLisp, and Unix assembler programming languages. Among other features, Ultrix-32 provides a file transfer utility, backup/restore, file system integrity checking, remote login and job execution, line editors (ex and ed), a screen editor (vi), and text processing utilities.

Ultrix-32 also has facilities that permit communication among Unix and non-Unix systems, including UUCP (Unix-to-Unix Copy facility), allowing point-to-point file transfer between an Ultrix-32 system and other Unix systems that use the "g" protocol; Ethernet connection between homogenous systems using DEC's Ethernet adapter; ability to communicate with Ethernet networks based on TCP/IP protocols; and a mail utility that allows communication among users in single-user or multinode environments.

Ultrix-32 has limited compatibility with Ultrix-11 (formerly called V7M11), the Unix Version 7-based operating system available for PDP-11 systems. Source programs written in the C language can be passed between the two systems; the systems' Bourne shells are also compatible. VAX processors are capable of directly executing portions of Ultrix-11-developed Unix images in compatibility mode.

DATABASE MANAGEMENT SYSTEM: The components of the VAX database management or information management architecture are arranged in layers above the operating system. On the top layer, the VAX languages and VAX FMS provide a user interface for interactive and language-callable video forms.

On the next level, the VAX Common Data Dictionary (CDD) integrates the other components of the architecture. The CDD provides a facility for storing logical data definitions. Also on this level are the VAX Datatrieve high-level and distributed data access facilities, which allow access to data without the user's having to specify the means to access it, such as the file type and keys. Datatrieve uses definitions in the CDD that contain information about data characteristics and user needs. The high-level data access facility also supports a "relational join" capability that can be used to dynamically link related records. The distributed data access facility retrieves data from remote VAX nodes running VAX Datatrieve. The process is transparent to the user.

The lowest level consists of five online multiuser data management facilities: VAX RMS (Record Management Services), VAX DBMS (Database Management System), VAX Rdb (comprising two products), and VAX ACMS (Application Control and Management System).

The VAX programming languages are integrated into the information architecture. Language support for high-level access and direct access to VAX RMS files and VAX DBMS databasesπis provided through the VAX standard calling interface to VAX Datatrieve.

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VAX FMS provides a forms management capability for programming languages and VAX Datatrieve. FMS forms are defined interactively and then stored in a FMS forms library. At runtime, VAX FMS works as a forms management software front end. It passes data between user programs and a video terminal on a per-field or per-form basis. The process works the same way when FMS forms are used with VAX Datatrieve.

VAX CDD, the keystone of the information architecture, is a prerequisite to the operation of VAX Datatrieve and VAX DBMS. VAX Datatrieve statements refer to data definitions in the CDD. The CDD is also used to store sequences of VAX Datatrieve statements as procedures that can be invoked interactively or from application programs, as well as to store database definitions that VAX DBMS needs to create, access, and maintain databases.

VAX Datatrieve is a data management facility that provides both interactive and program-callable access to data in RMS file organizations or in more complex interrelated DBMS database structures. It is a query and report writer with full update capabilities, and includes an integrated graphics capability and forms support through FMS.

VAX RMS is a file access method with an extended syntax interface to all high-level languages. It supports sequential, relative, and multikey indexed sequential file organizations, as well as concurrent file access with record-level locking and transparent file access to and from remote DECnet systems.

VAX DBMS is a multiuser, general-purpose, Codasyl-compliant database management system based on the March 1981 Working Document of the ANSI Data Definition Committee. VAX DBMS is used to administer databases ranging from simple hierarchies to complex, multisystem networks with multilevel relationships. The VAX information architecture allows DBMS data to be accessed directly from programming languages through VAX Datatrieve or DBMS utilities.

The *VAX Rdb* products are relational database management systems. VAX Rdb/ELN runs on the VAX-11/725, VAX-11/730, and VAX-11/750 in dedicated or distributed VAXELN environments. VAX Rdb/VMS runs on systems using VMS. Unlike VAX DBMS, designed for large, highly structured databases, the two VAX Rdb systems are designed for low- and medium-volume applications in which data items and relationships among records change frequently.

Both VAX Rdb systems use the Digital Standard Relational Interface, an application interface that allows application programs written for either relational product to access data managed by the other. Data is independent of application programs; users can change data definitions without modifying or recompiling their programs. The two VAX Rdb products can retrieve and update information from both local databases and from remote databases through DECnet. The VAX Rdb systems feature: a data definition language; an interactive query language; transaction management facilities; data validation functions; transaction recovery facilities; security constraints; and contention arbitration facilities that handle simultaneous attempts to access the same information. VAX Rdb/VMS can work with VAX Datatrieve to access the VAX Rdb/VMS database interactively; VAX Datatrieve can also be used to access VAX Rdb/ELN databases on the same Ethernet as a VAX/VMS system. VAX Rdb/VMS can work in conjunction with other VAX information management tools.

VAX ACMS (Application Control and Management System) is a transaction processing software product set for comprising two components: VAX ACMS/AD, for developing and maintaining applications; and VAX ACMS, for monitoring and controlling execution of applications developed with VAX ACMS/AD as well as those developed with existing VMS tools. VAX ACMS and DEC's ALL-IN-1 menu-driven office automation software package can be combined on one VAX system to provide users with both office functionality and transaction processing capabilities. ALL-IN-1 software can be modified to run ACMS under the ALL-IN-1 menu, or ALL-IN-1 and VAX ACMS can be installed without modification and run separately where common access to office and data processing functions is not required.

LANGUAGES: VAX/VMS provides a native programming environment which consists of language processors that produce native object code and program development tools that support native program development. VAX Fortran, RPG II, Lisp, Cobol, Basic, PL/1, Pascal, Coral 66, Bliss-32, DSM, C, and Ada are native-mode language processors that produce native object code and take advantage of the native instruction set and 32-bit architecture of the VAX hardware.

VAX Fortran is an implementation of full-language Fortran 77 based on American National Standards Institute (ANSI) Fortran X3.9-1978. The shareable, reentrant compiler operates under the VAX/VMS operating system to take full advantage of the VAX floating-point and character string instruction set and the VAX/VMS virtual memory operating system.

VAX RPG II, DEC's native-mode implementation of the RPG II programming language, comprises a compiler, an editor, and a runtime support component. The compiler operates at speeds up to 3000 lines per minute. The full-screen editor is tailored to the columnar structure of the RPG II language and is keypad-controlled; it contains an online help facility.

VAX Lisp is a language for development of artificial intelligence (AI) programs; it requires a minimum half-megabyte of physical memory per simultaneous user. Developed to manipulate symbolic values and perform numerical computations, VAX Lisp is an implementation of Common Lisp. Among the features of VAX Lisp are interpreter and compiler modes available to the user; dynamic linking of compiled and interpreted code; lexically scooped variables; a user-extensible, multiwindow editor; and integrated debugging facilities.

VAX Cobol is an interactive language processor based on the ANSI X3.S3-1974 standard. It includes full implementations of nine ANSI modules, including SORT/MERGE. Utilities are included to aid users in migrating other Cobol programs to VAX Cobol.

VAX Basic, a native-mode language processing system, is a superset of the standard Dartmouth Basic language. VAX Basic produces shareable native object code and is itself shareable.

VAX Pascal is a reentrant, native-mode compiler designed to take advantage of the VAX hardware floating-point and character instruction sets and the virtual memory capabilities of the VAX/VMS operating system.

VAX Coral 66 is a block-structured programming language designed to replace assembly-level programming in a number of commercial, process control, research, and military applications.

VAX PL/1 supports scientific computation, commercial data handling and data organization, and string manipulation. It is an extended implementation of the ANSI X3.74 PL/1 General-Purpose Subset.

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VAX Bliss-32 is designed to facilitate programming of real-time and hardware-independent applications. VAX Bliss-32 is especially intended for the development of operating systems, compilers, runtime system components, database file systems, communications software, and utilities.

VAX DSM (Digital Standard Mumps) is a multiuser data management system and interpretive language. VAX DSM conforms to the ANSI Mumps specification X11.1-1977 with extensions. The DSM language is directed primarily toward the processing of variable-length string data in interactive database systems. The shareable, reentrant interpreter takes advantage of the VAX/VMS packed decimal and character string instruction set, virtual memory, and I/O capabilities of the operating system. VAX DSM provides a language precompiler to optimize routine execution in an application environment.

VAX C is a general-purpose programming language that features: enumerated (user-defined) data types; a library of runtime support routines, including standard I/O, math, and string functions; access to the VAX Common Run Time Library; and runtime support to aid Unix-to-VAX/VMS migration, including emulation of many Unix-specific routines.

VAX Ada, fully validated by the U.S. government, is an optimizing compiler integrated into the VMS Common Language environment. It provides full symbolic debugging capabilities, support for Record Management Services, ability to call routines written in other languages, and support for other languages to call routines written in Ada. The compiler provides full access to VMS system services, utilities, and tools.

Fortran IV/VAX-to-RSX Cross Compiler is a software tool for development and execution of RSX-11M or RSX-11S Fortran programs on local or remote VAX systems with VAX RSX facilities.

The *VAX Macro* assembler accepts one or more source modules written in Macro assembly language and produces a relocatable object module and optional assembly listing.

COMMUNICATIONS: *DECnet-VAX* permits suitably configured VAX/VMS-based systems to participate as routing or end nodes in DECnet computer networks. DECnet-VAX is a Phase IV network product warranted only for use with other DEC Phase III and Phase IV products. It offers task-to-task communications, file management, downline system and task loading, network command terminals, and network resource-sharing capabilities through Digital Network Architecture (DNA) protocols. DECnet-VAX communicates with adjacent and nonadjacent Phase III and Phase IV nodes. Among its features, DECnet-VAX permits area routing for development of networks containing several thousand processors. DECnet-VAX interfaces are standard with VAX/VMS.

DECnet-VAX provides task-to-task communication, access control, remote file acess, terminal-to-terminal communication, network command terminals facilities, and network management.

Task-to-task communication is a method of creating a logical link between two tasks, exchanging data between the tasks, and disconnecting the link when the communication is complete.

Access control is the method by which network users are screened before gaining access to network facilities. With the appropriate access control information, a user program can log into a remote system and access any of the remote system's resources. The accessing program must have either an account or access to a guest account on the remote system, to log in successfully.

Remote file access permits exchange of sequential ASCII or binary files. The DECnet software translates the file syntax of the sending node into a common network syntax and then retranslates at the receiving end appropriately for that node. The transfer of file types other than ASCII can also be supported between particular operating systems.

For terminal-to-terminal communication, a DECnet/VAX utility enables a user to send messages to any VAX system. Messages can be directed to any specific terminal or to the operator's console at the destination node. With the Network command terminal software facility, local users can log onto and use remote VAX systems as though they were local. For network management, the Network Control Program (NCP) displays statistical and error information, controls network components, and tests network operation.

Nodes communicate based on some combination of physical and logical capabilities. The physical capabilities for DECnet-VAX are point-to-point, multipoint, and adaptive routing. A point-to-point node communicates only with adjacent nodes to which it is directly connected. A multipoint network party line shares time on one line with several nodes. Routing is a method for sending messages from source to destination through intermediate nodes. DECnet Phase III and Phase IV provide adaptive routing, wherein messages are routed through the network over the least-cost path defined by the user.

DECnet-Ultrix is a Phase IV Ethernet-based end-node implementation of the Digital Network Architecture for the Ultrix-32 operating system. It provides for communications among Digital systems using DNA Phase III or IV protocols and for communications, including electronic mail, with non-Digital systems using TCP/IP protocols.

DECnet-Ultrix allows users to transfer data and files between Ultrix-and VMS-based systems, and also permits DECnet and TCP/IP protocols to share system resources, such as Ethernet communications controllers.

Other capabilities of DECnet-Ultrix are: remote resource access from other Digital systems; a network command terminal facility, allowing the user to logically connect any multiuser DECnet Phase IV system and act as a locally connected VT100-class terminal; task-to-task communication between programs on different systems; and interface to network management facilities for administration and troubleshooting of Ultrix-based nodes.

Digital's *Internet* family of products supports the interconnection of Digital computers and Digital networks to systems built by IBM and other manufacturers. Members of the Internet family are DECnet/SNA Gateway, DECnet/SNA VMS DISOSS Document Exchange Facility (DDXF), DECnet/SNA VMS Distributed Host Command Facility (DHCF), DECnet/SNA VMS Printer Emulator (PrE), VAX 2780/3780 Protocol Emulator, VAX 3271 Protocol Emulator, and MUX200/VAX.

DECnet/SNA Gateway allows a DECnet network and an IBM Systems Network Architecture (SNA) network to be connected. One version of this product links Digital local area networks to SNA networks, and another connects Digital wide area networks to SNA nets.

The *DECnet/SNA VMS DISOSS Document Exchange Facility (DDXF)* allows VMS-based VAX systems to exchange documents with an IBM host and office systems running in a DISOSS (Distributed Office Support System) environment. It allows both DEC and IBM users to participate in a common office network in which documents can be transferred, edited, and deleted.

The *DECnet/SNA VMS Distributed Host Command Facility (DHCF)* allows IBM 3270-class displays connected

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to an IBM host running the HCF (Host Command Facility) program product in an SNA network to access VMS-based VAX systems; DEC refers to this connection as the IBM-to-DEC equivalent of 3270 terminal emulation. Through this connection, an IBM network manager can control both the IBM and DEC networks from an IBM display; IBM users can also access mail and perform program development tasks on a VAX system.

The *DECnet/SNA VMS Printer Emulator (PrE)* allows bulk data transfers from an IBM system to a DEC system for printing. Either an IBM or a DEC terminal user operating in 3270 emulation mode can have a document printed on a DEC printer attached to a local VMS-based VAX system.

The *VAX 2780/3780 Protocol Emulator* allows data files to be transferred between VAX systems and other host computer systems capable of using 2780 or 3780 communications protocol. VAX 2780/3780 emulates binary synchronous communications (BSC) protocol, appearing to be an actual IBM 2780 or 3780 remote batch terminal on a point-to-point line. The product can run concurrently on up to four lines, each with a different set of attributes at speeds up to 9600 bps per line. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communications interface.

The *VAX 3271 Protocol Emulator* permits user programs running on VAX systems to communicate interactively with user tasks running on an IBM System/370 (including 303X processor systems). The IBM application program may run under either the IMS/VS or CICS/VS DB/DC systems. The VAX 3271 package makes it possible for VAX users to have online access to IBM databases for the purpose of information entry, retrieval, and update. The communications discipline used by the VAX 3271 Protocol Emulator is BSC.

Mux200/VAX is a VAX-based software package that allows communication with a CDC Cyber series or other host computer systems capable of using the 200UT communications protocol. It can be configured to support either the ASCII or the extended BCD versions of the protocol.

DECnet/SNA VMS Advanced Program-to-Program Communications/LU6.2 Programming Interface (APPC) allows VMS-based applications for VAX systems to communicate with IBM host applications on a peer-to-peer basis through the DECnet/SNA Gateway; all DECnet/SNA interconnect functions are transparent to the user.

In *DECnet/SNA VMS Application Programming Interface (API)*, SNA functionality is apparent to the user. The API product is a collection of routines that allows user-written applications running on VAX systems in a DECnet network to exchange information, files, and data with IBM host applications; it is designed for users doing more advanced applications programming with SNA resources and requiring a flexible interface to an IBM application system.

DECnet/SNA VMS 3270 Data Stream Program Interface, specifically designed for 3270 emulation interfaces, enables programmers to develop programs that implement Logical Unit 2 sessions for communication with IBM application programs, build a color graphics interface, and intercept preprocess/postprocess terminal data. In the 3270 Data Stream Program Interface, as in APPC, SNA functionality is transparent to the user.

VAX PSI (Packetnet System Interface) allows a VAX system to connect to Public Packet Switched Networks (PPSNs) conforming to the CCITT recommendation X.25. Access to VAX PSI is supported for VAX/VMS user programs written in VAX Macro and native-mode high-level languages. VAX PSI supports process-to-process and remote terminal communications via the network. VAX PSI is the prerequisite software to operate the KMS11 multiple-line communications interface.

UTILITIES: Available for VAX systems are two environmental aids for program development and execution, VAX RSX and VAXELN; also available are a number of utility programs (or, as DEC categorizes them, program development tools), including text editors, a linker, a librarian, a common runtime procedure library, a symbolic debugger, a code management system, an application development environment (ADE) package, a DECalc spreadsheet package, a ReGIS graphics library (RGL) package, and a graphical kernel system. These tools are available to the programmer through the VAX/VMS command language.

The text editors can be used to create memos, documentation, and data files, as well as source program modules for any language processor. The linker, librarian, debugger, and runtime procedure library described below are used only in conjunction with language processors that produce native code.

VAX RSX allows a VAX system to simulate the operating environment provided by a PDP-11 computer running the RSX-11M or RSX-11M-Plus operating system. Thus, VAX users can run PDP-11 programs on VAX systems and develop programs for downline loading to PDP-11s. VAX RSX incorporates an application migration executive, a user interface, and utilities.

VAXELN acts as a compatible subsystem to the VMS operating system for development of applications in realtime control and distributed computing environments. It consists of development utilities for creating target applications and a runtime kernel of device drivers and service code that becomes a part of each application. Finished programs are entirely memory-resident, although optional disk support is available for data files.

VAXELN applications are written in an optimizing, native-mode version of Pascal. Completed applications can be downline-loaded across network (local or wide area) links or transferred to target systems by disk or tape. While DEC's MicroVAX systems are the principal target systems for VAXELN applications, VAX-11/750 and VAX-11/730 systems are also supported.

DEC/Shell is a command line interpreter that provides VAX/VMS users with an interface similar to that of a Unix Version 7 operating system; the DEC/Shell environment appears like the Version 7 Bourne Shell to the user.

SOS is an interactive text editor that enables the programmer to create and modify text files using commands entered from either a hardcopy or video terminal.

SLP is a programmed text editor that enables the user to modify an existing file by supplying a command file containing a list of the modifications to be made. SLP provides a formal record of changes made to files, both in the source file and in an audit-trail listing.

The *EDT* editor, shipped as part of VAX/VMS, lets users enter and manipulate text and programs. It features a help facility, as well as line, character, screen, and keypad editing facilities, a startup command file, and a journaling facility.

VAX Runoff is a document formatter. A Runoff-processed document can be updated without extensive retyping because text changes, via the text editors, do not affect the basic design. It is shipped as part of VAX/VMS.

The *VAX/VMS Linker* accepts one or more native object modules produced by an assembler or compiler, resolves the

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symbols and procedure references between them, and produces an executable program image.

The *Librarian* enables a programmer to create, update, modify, list, and maintain library files. A library file can be a collection of object modules or shareable images.

The *Runtime Procedure Library (RTL)* is a collection of general-purpose and language-specific libraries available to any native program, regardless of the source language in which the program was written. The runtime library is a shareable program that allows the choice of either incorporating procedures from the library into an executable image or mapping the global sections into a process virtual address space at runtime. A single copy of the library can be shared by all processes, and a new library can be installed without the need to relink existing programs. The runtime library includes a mathematical library, a general utility library, a condition-handling facilities library, a language-independent support library, and a Fortran IV-PLUS language-specific support library.

The *Symbolic Debugger* can be linked with a native program image either interactively or through a command procedure file to control program execution during development. Debugging commands allow users to start and interrupt program execution, step through instruction sequences, call routines, set break or trace points, set default modes, define symbols, and deposit, examine, or evaluate virtual memory locations.

DEC/CMS (Code Management System) is a set of commands to help software developers manage the files of an ongoing project. CMS enables users to keep ASCII text files in a project library, retrieve previous file generations, get reports of modified files, learn the origin of each line of a file, manage and merge concurrent or separately developed modifications, and keep related files together as a single element.

The *Application Development Environment (ADE)* is designed for the nonprogrammer. ADE provides facilities for users to create their own databases; add, change or delete data; and produce simple bar graphs and write reports—without waiting for formal programming and report generation.

VAX DECalc is an interactive spreadsheet package that executes in native mode under VAX/VMS.

The *VAX ReGIS Graphics Library (RGL)* is a collection of subroutines conforming to the standard VAX/VMS calling interface and designed to support the graphics capabilities of the VT125. RGL is written in Fortran and executes under the VAX/VMS operating system.

VAX GKS/0b (Graphical Kernel System) is a subroutine library for VAX/VMS that implements the International Standards Organization (ISO) and ANSI GKS standard for two-dimensional, device-dependent graphics. VAX GKS/0b conforms to level 0b of the GKS standard, providing direct output (level 0) and synchronous input (level b) capabilities. This system can be used to produce computer-generated pictures. Because it is an integral part of the VAX/VMS architecture, VAX GKS/0b can be called from any VAX language that supports the VMS calling convention.

VAX GKS/0b supports DEC's VT125, VT240, and VT241 raster graphics terminals and the Tektronix 4014 direct view storage terminal. It also supports DEC's LA100, LA50, and LA34 hardcopy devices, as well as the Tektronix 4611 Hard Copy Unit connected to the Tektronix 4014 display terminal.

VAX Bisync Terminal Support (BTS) is a VAX-based software package that enables VAX/VMS systems to support blockmode synchronous terminals using the Binary Synchronous Communications (BSC) protocol. Bisync terminal users can then either run applications on the VAX system, or use the VAX as a pass-through device to access applications on an IBM mainframe.

OFFICE AUTOMATION: *DX/VMS* is a VAX Fortran software package that enables distributed standalone WPS-8 systems and the host VAX system to be linked together for system resource use and data sharing.

VAX DECmail is a standalone, single-node mail and filing system that runs under the VAX/VMS operating system. DECmail can create, edit, send, and process messages on a single VAX computer system.

VAX ALL-IN-1 Office Menu provides office applications such as electronic mail, document processing, desk management, and forms development on VAX/VMS-based systems. The system also features voice messaging support, DECTalk mail access through Touchtone telephones, and integrated computer-based instruction for all major functions. A flow-control facility allows a user at a VT100 or VT200 family terminal to select from an option menu, moving from one application to another. The ALL-IN-1 software requires a VAX/VMS system with at least 2M bytes of dedicated main memory.

WPS-Plus/VMS, in ALL-IN-1 application, provides users with DECmate-style "gold key" full-function word processing. It includes scientific/technical character sets accessible from a word processing keyboard and a standard two-dimensional text editor that allows building and editing of equations, diagrams, matrices, and charts.

DECpage is an ALL-IN-1 application that unites the features of Digital word processing with the capabilities of DEC LN01 laser printers to produce stylized documents using a variety of print styles and fonts and combining text and graphics.

DECdx/VMS is an exchange facility that allows two-way transfer of documents between Digital word processing systems and VAX systems while fully preserving document content and format.

External Document Exchange (EDE) is a VAX-based software package that permits full, two-way document transfer and conversion between a Digital VAX system and a Wang OIS.

External Document Exchange with DISOSS is a software product that allows DECdx/VMS and WPS-Plus users to search for, retrieve, file, edit, or delete text contained in an IBM DISOSS (Distributed Office Support System) document library. Documents can also be created on VAX systems, transformed into IBM final or revisable DCA (Document Content Architecture) DISOSS documents, and filed in an IBM host document library. Conversely, DEC states that EDE with DISOSS transparently converts IBM documents to WPS-Plus or DECdx formats. Both final form and revisable IBM documents can be accessed through EDE menus. Those menus can also be integrated into the ALL-IN-1 main menu system. EDE with DISOSS also includes online help facilities.

According to Digital, EDE with DISOSS provides an interface conforming to DIA (Document Interchange Architecture)/DCA using Logical Unit 6.2, IBM's peer-to-peer communications capability. Prerequisite software includes DECnet-VAX, Gateway Access Routines (incuding those for Gateway Management and DDXF), and DECnet/SNA VMS DDXF.

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APPLICATIONS: Digital offers both proprietary and third-party applications packages for VAX systems. The company's External Applications Software (EAS) Library service acquires software from third parties and makes it available through the company's software distribution channels. Software is tested by Digital for operation, documentation, and ease of installation prior to being included in the EAS Library. Software products from the EAS Library are sold on an "as is" unsupported basis, although the author of the software may offer a separate maintenance agreement.

Among DEC's applications is *VAX VTX*, a videotex system that runs under the VMS operating system. VAX VTX requires no special video delivery equipment, being supported on DEC's VT100 and VT200 series terminals, as well as on VT100- and VT200-compatible terminals and the DECtalk text-to-speech terminal. VAX VTX comprises three modular components: terminal control/concentrator software, database access software, and database update software.

The terminal control software links user terminals to the database access component and supports Prestel and NAPLPS graphics display protocols, and can be modified to support additional protocols and video display terminals. The database access software controls all requests for information and provides a menu-based interface for users. The database update software component, called the Information Provider Assistance Tool (IPAT), allows office workers without any programming knowledge to create and maintain VAX VTX databases.

VAX VTX is compatible with DECnet communications software. Each of the system's three software components can reside on one or more systems in a DECnet network, with access transparent to the user. Multiple IPATs can be distributed throughout the network. Also, VAX VTX can be used as part of the ALL-IN-1 office information system and can be called from the ALL-IN-1 menu.

Capabilities of VAX VTX include: creation of a personal menu for direct access to frequently used pages; an unlimited keyword search facility; support for the DECtalk speech synthesis device; updating of videotex pages located on remote systems; a Closed User Group facility, limiting access to specified pages; and an Automatic Page Management System (APMS), which controls creation of videotex pages, menus, and indices. A set of applications tools, VAX Valu (VTX Application Link Utilities) allows programmers to provide videotex access to databases and applications.

PRICING

POLICY: DEC provides VAX systems on a purchase basis, with separately priced maintenance agreements. Leasing arrangements are available through DEC's U.S. Customer Finance Group.

DEC software is licensed rather than sold. Users purchase licenses and distribution rights separately. Customers ordering the Ultrix-32 product receive a Unix binary license directly from DEC. For new VAX system purchasers, an Ultrix-32 license can be ordered as part of a VAX System Building Block. Current users of DEC's VAX/VMS operating system and VAX users with third-party Unix licenses can order the Ultrix-32 license as an add-on product.

SUPPORT: DEC's Field Service organization offers both on-site and off-site support services for VAX-11 systems.

Standard on-site services include the Basic Service Agreement, the DECservice Agreement, and Per Call service. The basic service agreement includes the following components:

- On-call remedial maintenance from 8 a.m. to 5 p.m. Monday though Friday, excluding locally observed Digital holidays.
- A planned preventive maintenance program.
- All material and labor required to complete repairs.
- Installation of engineering changes.
- Priority response during hours of coverage (typically next day).
- An assigned account representative responsible for system maintenance.
- A Site Management Guide.
- A problem escalation system.
- A fixed monthly charge.
- A minimum term of one year.
- A remote diagnostics capability.

The DECservice Agreement, for higher-level support, incorporates the features of the Basic Service Agreement and adds the following provisions:

- An option for extended coverage to 12-, 16-, and 24-hour workdays, as well as for Saturdays, Sundays, and holidays.
- Defined response for calls placed within the contracted hours of coverage.
- Continuous remedial service until the system is fully operational, as long as the call is received within a specific period immediately following system failure.

DECservice is available in the United States without distance restrictions.

Per Call Service is available to customers without service agreements, or as a supplementary program for service agreement customers requiring remedial maintenance outside their normal hours of coverage. Per Call Service is available on a best-efforts basis 24 hours a day, 7 days a week. Customers are billed for time and materials; charges are portal-to-portal, with labor, parts, and travel expenses rated separately.

An optional adjunct to DEC's on-site field service, Recover-all, provides full product repair or replacement for equipment damage caused by accidents or incidents normally not covered under service agreements, such as fire or water damage, power failures, and natural disasters. The cost of Recover-all ranges from 7 to 10 percent of the total monthly service charge of each covered contract line item. Actual charges depend on system configuration and type of service coverage.

Special customer-runnable diagnostics, remote support, and hardware monitoring products are available for the VAX-11/730.

Off-site maintenance is available through DEC's Customer Returns Center, Product Repair Center, and Digital Service centers, which are all equipped with parts inventories, special diagnostic systems, and repair kits.

The Customer Returns Center, in Woburn, MA, provides service for all products under return-to-factory warranties, as well as for products requiring post-warranty work. The

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Customer Returns Center services products returned under the DECmailer agreement, which guarantees users a replacement within five working days for any defective board shipped to the center; it also provides as-needed service for modules and subassemblies under DEC's Loose Piece Module Repair Service plan.

The worldwide Product Repair Centers fix and refurbish modules, subassemblies, options, and systems for customers who have some technical expertise but who require additional field service assistance.

Digital Servicenters provide carry-in service for terminal products on a contractual or per-call basis; they also permit over-the-counter module swaps for users who prefer to perform maintenance themselves.

Software support is provided through DEC's Software Services organization; installation, training, telephone support, newsletter, and on-site support services are available.

Digital also offers the DECompatible Service program, through which the company's Field Service organization provides maintenance for over 120 specific non-DEC hardware products linked to Digital systems. The company claims that the designated products receive the same response time and service coverage as Digital hardware under standard service agreements.

All warranted VAX software products are covered under a policy for 16- and 32-bit packages guaranteeing that the product conforms to the Software Product Description (SPD) shipped with it. The warranty is included with most VAX software products at no extra charge. Delivery of the warranty is provided through automated and manual problem reporting. Services included in warranty prior to January 2, 1984 have been unbundled; customers can purchase added-value services such as installation, training, telephone support, newsletters, and on-site support separately, or they can select a System Startup Service Package.

System Startup Service Packages provide customers with the system-level support and training required to start up and manage their systems. Currently available only in the United States, the packages provide training, documentation, and software service. The user selects from among three levels of support, based on a number of factors, including computer experience and system use. All three levels include dial-in telephone support, and both the operating system and associated software products purchased with the system are supported. Prices are based on the size and complexity of the system and the level of support required.

Another software support service is the Digital Software Information Network, which enables customers to access informational data bases for help with software problems. The network provides messages that alert users to critical software problems and their solutions, a symptom/solution data base to answer questions on software problems, and a means of submitting questions to Digital support personnel. The network is available at no extra charge to customers in the United States with systems currently under warranty or covered by a DECsupport or Basic Support service contract.

For general support, DEC also sponsors the Digital Equipment Computer Users Society (DECUS), a voluntary, nonprofit users' group. DECUS provides an extensive program library, users' groups, special interest groups, and workshops/symposia. The society is responsible for maintaining the DECUS program library and publishing a library catalog, the proceedings of symposia, and a periodic newsletter.

TRAINING: DEC maintains 27 training centers worldwide. Courses covering both Digital equipment-related and non-product-related topics are offered. A variety of instructional methods are used, including DEC's Ivis (Interactive Video Information System), which provides system-based instruction. DEC's Educational Services division publishes a digest listing available courses four times a year.

TYPICAL CONFIGURATIONS: Typical small, medium, and large VAX System Building Block components can be configured as follows:

VAX-11/730 System Building Block Configuration

730XA-AE(AJ)	VAX-11/730 CPU, 2MB ECC MOS memory, dual TU58 cassette, VAX/VMS license and warranty	$21,500
RUA80-AA(AD)	RA80 121MB fixed disk and UDA50 controller	19,500
TU80-AA(AB)	TU80 magnetic tape	11,000
DMF32-LP	Multipurpose communications interface	3,500
LA100-BA	One Hardcopy Terminal	2,195
VT220-A2(A3)	10 Video Terminals	8,800
VT22K-AA	10 VT220 data entry keyboards	2,150
LP11-AA	Two 300 lpm printers	16,700
Total Price		$85,345

VAX-11/750 System Building Block Configuration

750XA-AE(AJ)	VAX-11/750 CPU, 2MB ECC MOS memory, VAX/VMS license and warranty	$ 54,000
MS750-CA	1MB ECC MOS expansion memory	4,900
RUA80-AA(AD)	RA80 121MB fixed disk and UDA50 controller	19,500
REM05-FA(FB)	RM05 256MB removable disk	46,000
TU80-AA(AB)	Two TU80 magnetic tapes	22,000
DZ11-HP	8-line 20 ma async serial communications interface	2,500
LA100-BA	One Hardcopy Terminal	2,195
VT220-A2(A3)	20 Video Terminals	17,600
VT22K-AA	20 VT220 data entry keyboards	4,300
LP11-EA	Two 600 lpm printers	27,200
Total Price		$200,195

VAX 8600 VAXcluster System Building Block Configuration

861CB-AE(AJ)	Main cabinet containing: CPU Console processor Three MS86-BA 4MB main memory arrays (12MB) FP86-AA floating-point accelerator DW780-MA first Unibus adapter DB86-AA first SBI adapter CI780-MA Computer Interconnect adapter and cables VAX/VMS license	$500,000

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Console/Unibus cabinet containing: RL02 10MB console disk BA11-Ax Unibus box containing DMF32-LP with eight async lines, LP interface, and sync line; DEUNA-AA Ethernet interface; and four DMZ32-M and four multiplexer boards (96 additional async lines) SC008-AC Star Coupler HSC50-AA(AB) Hierarchical Storage Controller HSC5X-BA disk interface HSC5X-CA tape interface Computer Interconnect cables Full DECnet license	RA81-AA(AD)	456MB rack-mounted RA81 fixed disk drive	19,000
	RA81-EA(ED)	Three RA81 456MB fixed disk drives in cabinet	50,000
	TA78-BF(BJ)	TA78 PE/GCR magnetic tape subsystem	52,000
	LP27-UA(UB)	1200/800 lpm printer	29,990
	LN01B-CA(CB)	12 ppm laser printer	22,500
	LA50-RA	Ten 100/50 cps dual-mode workstation printers	6,950
	VT220-A2(A3)	40 VT220 video terminals	35,200
	VT22K-AA	40 VT220 data entry keyboards	8,600
	VT241-AA	24 VT241 text/graphics terminals	71,520
	Total Price		$795,760

EQUIPMENT PRICES

		Purchase Price ($)	Monthly Maint. ($)
VAX PACKAGED SYSTEMS			
SV-CXWEB-GK	VAX-11/730 System Package; includes 1MB main memory, integrated disk and tape controllers, R80 fixed disk drive, TSU05 streaming tape drive, DMF32 communications controller, LA100 console terminal, VAX/VMS operating system license only	48,995	383
SU-CXWEB-GK	Same as SV-CXWEB-GK, but with Ultrix-32 license	50,995	383
SV-CXNZA-EK(EN)	VAX-11/725 System Package; includes 1MB of memory, two TU58 tape cartridge drives (for system startup, diagnostics, and as alternate load devices), RC25 disk subsystem, cabinet, power controller and power supply, console cable, and VAX/VMS operating system license and warranty	24,950	141
SV-CXNZB-EK(EN)	VAX-11/725 System Package; includes 2MB of memory, DMF32 communications interface, two TU58 tape cartridge drives, RC25 disk subsystem, cabinet, power controller and power supply, console cable, and VAX/VMS license and warranty	29,950	229
SU-CXNZB-EK (EN)	Same as SV-CXNZB-EK, (EN), but with Ultrix-32 license	31,950	218
SV-CXNZC-EK(EN)	VAX-11/725 System Package; includes 2MB of memory, DMF32 communications interface, floating-point accelerator, DEUNA Ethernet adapter, two TU58 tape cartridge drives, RC25 disk subsystem, cabinet, power controller and supply, console cable, DECnet license, and VAX/VMS license and warranty	36,800	301

VAX SYSTEM BUILDING BLOCKS

VAX System Building Blocks (SBBs) are available for the VAX-11/730, 11/750, 11/780, 11/782, 11/785, and VAX 8600. SBBs for the VAX-11/730 and larger systems begin with a core of components: CPU, main memory, cabinetry, and the VAX/VMS or Ultrix-32 operating system license. To this core the user must add selections from the mass storage (system device and load device), communications interface, and console terminal menus. Selection from the software menu is optional.

861XA-AE (AJ)	VAX 8600 CPU, 4MB main memory, RB86 integrated disk and tape controller, VAX/VMS license	350,000	760
861XA-BE (BJ)	Same as 861XA-AE (AJ), but with Ultrix-32 license	355,500	760
785XA-AE(AJ)	VAX-11/785 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet, and VAX/VMS license and warranty	195,000	506
785XA-BE(BJ)	Same hardware as 785XA-AE(AJ), but with Ultrix-32 license only	200,500	506
785XC-AE	11/785 CPU, 16MB of 256K memory, Unibus expansion cabinet, VAX/VMS license and warranty	268,000	659
782XA-AE(AJ)	VAX-11/782 dual CPU, 4MB ECC MOS shared memory, H9652 Unibus expansion cabinet with BA11-K and DD11-K, and VAX/VMS license and warranty	320,000	1,907
780XA-AE(AJ)	VAX-11/780 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet, and VAX/VMS license and warranty	145,000	427
780XA-BE(BJ)	Same components as 780XA-AE(AJ), but with Ultrix-32 license only	150,500	427
780XC-AE	11/780 CPU, 16MB of 256K memory, Unibus expansion cabinet, VAX/VMS license and warranty	218,000	650
750XA-AE(AJ)	VAX-11/750 CPU, 2MB ECC MOS memory, and VAX/VMS license and warranty	54,000	237
750XA-BE(BJ)	Same hardware as 750XA-AE(AJ), but with Ultrix-32 license only	59,500	237
730XA-AE(AJ)	VAX-11/730 System Building Block; includes VAX-11/730 CPU, 2MB ECC MOS memory, dual TU58 cassette, and VAX/VMS license and warranty	21,500	130
730XA-BE(BJ)	Same hardware as 730XA-AE(AJ), but with Ultrix-32 license only	23,500	130

**NC—No charge.*
***NA—Not applicable.*

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		Purchase Price ($)	Monthly Maint. ($)
VAXCLUSTER BUILDING BLOCKS			

A VAXcluster is composed of one or more VAX-11/750, 11/780, 11/785, 11/782, or 8600 processors running on VAX/VMS connected by a high-speed bus, one or more mass storage servers (HSC50), and communication links to the user community. Each cluster element connected to the high-speed bus is referred to as a cluster node. Cluster nodes interconnect via an SC008-AC star coupler. here are two types of VAXcluster SBBs. The first type is a basic system element connecting of a VAX-11/750, 11/780, or 11/785 with 4MB or 64K ECC MOS memory, or a VAX 8600 with 12MB of 256K MOS memory; CI750 or CI780 Computer Interconnect; SC008-AC star coupler; HSC50 intelligent I/O server; one HSC5X-BA disk interface with 4 ports; VAX/VMS operating system license; and a DECnet license. (Other components are included with the 8600 VAXcluster SBB.) The second type of cluster SBB is an upgrade to an existing VAXcluster. It consists of a VAX-11/750, 11/780, or 11/785 CPU with 4MB of 64K ECC MOS memory, or a VAX 8600 CPU with 12MB of 256K MOS memory; CI750 or CI780 Computer Interconnect; VAX/VMS operating system license; and DECnet license. An LA12 (for 11/750), LA100, or LA120 console terminal must be added, along with a system disk for each processor in the cluster if none is already attached.

861CB-AE(AJ)	VAX 8600 VAXcluster System Building Block; includes a main CPU cabinet with CPU, console processor, 12MB of main memory, FP86-AA Floating Point Accelerator, DW780-MA Unibus adapter, DB86-AA SBI adapter, CI780-MA Computer Interconnect adapter; Computer Interconnect cables; VMS license. Also includes a console/Unibus cabinet containing a 10MB RL02 console disk, and a BA11-AX Unibus box with a DMF32-LP communications interface with 8 asynchronous lines, LP interface, and synchronous line; DEUNA Ethernet interface; and 4 DMZ32-M multiplexer boards for 96 additional asynchronous lines. Additional components include: SC008-AC star coupler; HSC50-AA(AB) storage controller; HSC5X-BA disk interface; HSC5X-CA tape interface; Computer Interconnect cables; and full DECnet license	500,000	1,659
861CB-AP(AT)	VAX 8600 VAXcluster Upgrade; includes components listed for main CPU cabinet and console/Unibus cabinet of 861CB-AE(AJ), along with DECnet cluster license	450,000	1,492
861CA-AE(AJ)	VAX 8600 VAXcluster SBB. Includes CPU, 8MB main memory, Computer Interconnect adapter, star coupler, HSC50 I/O controller, and VAX/VMS license	446,000	1,051
861CA-AP(AT)	VAX 8600 VAXcluster upgrade. Includes CPU 8MB main memory, Computer Interconnect adapter, and VAX/VMS license	385,000	884
785CA-AW(AZ)	Dual VAX-11/785 VAXcluster System Building Block. Two VAX-11/785 CPUs, each with 8MB ECC MOS memory, Floating Point Accelerator, Unibus expansion cabinet, CI780 Computer Interconnect, cables, VAX/VMS license and warranty, and DECnet license (license for second processor is for VAXcluster). First CPU includes HSC50 intelligent I/O controller, interface for four disk ports, and star coupler.	509,000	1,854
785CC-AE(AJ)	VAX-11/785 VAXcluster Building Block; includes VAX-11/785 CPU, 4MB ECC MOS memory, CI780 Computer Interconnect and cables, SC008-AC star coupler, HSC50 intelligent disk controller, disk interface (four RA ports), VAX/VMS operating system license and warranty, DECnet license, and Unibus expansion cabinet with expander box and backplane	280,700	832
785CC-AP(AT)	VAX-11/785 VAXcluster upgrade; includes VAX-11/785 CPU, 4MB ECC MOS memory, H9652 Unibus expansion cabinet with BA11-K expander box and DD11-DK backplane, computer interconnect and cables, VAX/VMS license, and DECnet license	227,950	690
780CB-AE(AJ)	VAX-11/780 VAXcluster Building Block; includes VAX-11/780 CPU, 4MB ECC MOS memory, computer interconnect and cables, star coupler, intelligent disk controller, interface to four RA disks, VAX/VMS license and warranty, DECnet license, and Unibus expansion cabinet with BA11-K expander box and DD11-DK backplane	230,700	757
780CB-AP(AT)	VAX-11/780 VAXcluster Upgrade; includes VAX-11/780 CPU, 4MB ECC MOS memory, Unibus expansion cabinet with expander box and backplane, computer interconnect and cables, VAX/VMS license and warranty, and DECnet license	177,950	615
750CA-AE(AJ)	VAX-11/750 VAXcluster Building Block; includes VAX-11/750 CPU, 4MB ECC MOS memory, CI750-BA(BB) Computer Interconnect and cables, SC008-AC star coupler, HSC50-AA(AB) intelligent disk server, HSC5X-BA disk interface, VAX/VMS license and warranty, and DECnet license	137,675	576
750CA-AP(AT)	VAX-11/750 VAXcluster Upgrade; includes VAX-11/750 CPU, 4MB ECC MOS memory, CI750-BA(BB) Computer Interconnect and cables, VAX/VMS license and warranty, and DECnet license	84,925	434
750CB-AW(AZ)	VAX-11/750 Minicluster System Building Block. Includes two VAX-11/750 CPUs, each with 4MB ECC MOS memory; two CI750 Computer Interconnects; four-node star coupler; HSC50 intelligent I/O server; disk interface; cables; two VAX/VMS licenses and warranties; DECnet license; and DECnet VAXcluster license.	213,530	800
750UB-AW(AZ)	VAX-11/750 Minicluster installed unit upgrade. Includes VAX-11/750 CPU with 4MB ECC MOS memory; two CI750 Computer Interconnects; four-node star coupler; HSC50 intelligent I.O server; disk interface; cables; VAX/VMS license and warranty; DECnet VAXcluster license.	148,280	618

PROCESSOR AND MEMORY OPTIONS

FP86-AA	Floating-Point Accelerator for VAX 8600	20,000	65
FP785-AA(AB)	High-performance floating-point accelerator for single- and double-precision floating point instructions plus POLY, EMOD, and MULL; power supply included; for VAX-11/785	14,000	53
FP782-AA(AB)	Two FP780 high-performance floating-point accelerators for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; power supply included; for VAX-11/782	22,400	101

**NC—No charge.*
***NA—Not applicable.*

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		Purchase Price ($)	Monthly Maint. ($)
FP780-AA(AB)	High-performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; power supply included; for VAX-11/780	11,200	53
FP750	High-performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; for VAX-11/750	8,500	47
FP730	High-performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; for VAX-11/730	3,995	26
E75VC-AG	One FP750 high-performance floating-point accelerator, 1MB of ECC MOS memory, and VAX Fortran; for VAX-11/750	15,000	78
E75VC-DZ	Same as E75VC-AG, except VAX Fortran license only	12,000	78
E75VD-AG	One FP750 high-performance floating-point accelerator, 2MB of ECC MOS memory, and VAX Fortran; for VAX-11/750	18,500	108
E75VD-DZ	Same as E75VD-AG, except VAX Fortran license only	15,500	108
E782A-DZ	Two FP782-AA, 1MB ECC MOS memory, and VAX Fortran license only	32,700	279
E782B-AY	Same as E782A-DZ, except uses FP782-AB, requires 240 V/50 Hz power, and includes VAX Fortran	36,700	279
E782B-DZ	Same as E782B-AY, except VAX Fortran license only	32,700	279
E782C-AY	Two FP780 high-performance floating-point accelerators, 2M bytes of ECC MOS memory, and VAX Fortran with support; for VAX-11/782	41,700	395
E782C-DZ	Same as E782C-AY, except VAX Fortran license only	37,700	395
E782D-AY	Same as E782C-AY, except uses FP782-AB and requires 240 V/50 Hz power	41,700	395
E782D-DZ	Same as E782D-AY, except VAX Fortran license only	37,700	395
CI780-AA(AB)	Optional microcoded intelligent adapter to the dual path computer interconnect; supported by DECnet-VAX and VAX/VMS; for VAX-11/780, 11/785, and 11/782	21,450	158
CI780-MA	Computer interconnect adapter for VAX 8600	21,450	150
CI780-SA(SB)	CI780 Starter Kit; includes two CI780-ABs, cables, and one star coupler	44,000	322
CI750-BA(BB)	Microprocessor-controlled, fully buffered high-speed interface between the memory interconnect (MI) of the CPU and the dual path CI bus; the CI750 is mounted in a 101.6 cm.(40.6 in.) high, freestanding cabinet; the unit consists of three extended-length, Hex-height modules, an associated backplane, and a power supply contained within a 26.6 cm. (10.5 in.) high mounting enclosure; the CI750 adapter operates together with the SC008 Star Coupler option to form the CI bus; a VAX-11/750 processor option	19,425	150
CI750-SA(SD)	Two node starter kit containing two CI750-BA(BB), SC008 Star Coupler, and cables; for VAX-11/750	40,950	322
SC008-AC	Star coupler; 8-node with cabinet	8,250	23
SC008-AD	Upgrade to Star Coupler; for 9 to 16 nodes	6,050	23
BNCIA-10	CI cable set; 32 ft. (10 m.)	600	*NC
BNCIA-20	CI cable set; 65 ft. (20 m.)	830	NC
BNCIA-45	CI cable set; 145 ft. (45 m.)	1,460	NC
DR750-F	An intelligent, high-performance, general-purpose interface which can be used to connect customer-designed devices to a VAX-11/750, to connect two VAX-11/750 systems together, or to connect a VAX-11/750 to a VAX-11/780 using a DR780; includes a 3.2MB/sec. transfer rate, command and data chaining, dynamic memory mapping, separate data and control paths; for VAX-11/750	7,000	58
DR780-FA(FB)	Intelligent interface to connect customer-designed devices to a VAX-11/780 or 11/785, to connect two VAX-11/780 or 11/785 systems, or to connect a VAX-11/750 system with DR750. Includes interface logic, power supply, and 25 ft. of cable	18,700	92
DW750	VAX-11/750 second Unibus adapter	7,000	21
DW780-AA(AB)	Unibus adapter; for the VAX-11/780 and 11/785	12,900	41
DW780-MB	Unibus adapter; for VAX 8600	12,900	39
KE780-A	Extended range G & H floating-point data type option; includes microcode, single-user license and support hardware; two required on VAX-11/782 systems (one per CPU); for VAX-11/780	1,500	NC
KU780-A	2K words (99-bit words) User Control Store; for VAX-11/780 and 11/785	11,000	56
KU750-YG	1K words (88-bit words) User Writable Control Store plus Extended G and H floating-point type supported in KU750-loadable microcode; for the VAX-11/750	6,000	49

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
MA780-BA(BB)	Additional MA780 Multiport Memory subsystem	34,600	197
MA780-D	VAX-11/780 and 11/785 Multiport Memory Selective Cache Invalidate option	9,900	64
MA780-EA(EB)	MA780 Multiport memory port interface not supported on 11/782 systems	10,600	27
MA780-JA(JB)	256KB ECC MOS Multiport Memory subsystem, which can be shared by up to four VAX-11/780 or 11/785 systems	39,500	197
MA780-JF	Comprises one H9504-XE filler cab assembly kit and one H9604-AA VAX-11/780 left-hand cab expansion; used to connect three or four VAX-11/780 or 11/785 systems to the same MA780	4,900	NC
MA780-KA(KB)	VAX-11/782 expansion memory subsystem; for expansion from 4MB to 8MB; includes 1MB of 16K chip ECC MOS memory, dual memory controllers, battery backup, cache invalidate options, MA780 cabinet, and power supplies	70,000	624
MS730-CA	1MB ECC MOS expansion memory (one 64K chip arrays); for VAX-11/730 and 11/725	4,900	30
MS730-CB	2MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730	9,000	61
MS730-CC	3MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730	13,000	91
MS730-CD	4MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730	17,000	122
MS730-CF	10MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730	34,000	**NA
MS730-CH	25MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730	75,000	761
MS730-CJ	50MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730	137,500	1,523
MS750-CA	1MB ECC 64K MOS expansion memory; for VAX-11/750	4,900	30
MS750-CB	2MB ECC 64K MOS expansion memory; for VAX-11/750	9,000	61
MS750-CC	3MB ECC 64K MOS expansion memory; for VAX-11/750	13,000	91
MS750-CD	4MB ECC 64K MOS expansion memory; for VAX-11/750	17,000	122
MS750-CF	10MB ECC 64K MOS expansion memory (single-system maximum is 8MB); for VAX-11/750	34,000	305
MS750-CH	25MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX-11/750	75,000	761
MS750-CJ	50MB ECC MOS memory Multiple System Memory Expansion Package; for VAX-11/750	137,500	1,523
MS750-DA	Memory controller, plus 1MB ECC MOS expansion memory (64K arrays) to replace 16K controllers; for 11/750	10,000	30
MS750-DC	Memory controller and backplane, plus 1MB ECC MOS expansion memory (64K arrays) to replace 16K controller; for 11/750	10,000	30
MS780-CH(CJ)	1MB ECC MOS, 16K chip memory with MS780-C controller; for VAX-11/780	23,400	254
MS780-DA	256KB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	2,400	64
MS780-DB	512KB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	4,000	108
MS780-DC	1MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	7,000	188
MS780-DD	2MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	13,000	309
MS780-DE	3MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	18,000	399
MS780-DF	4MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780	22,000	483
MS780-EA(EB)	4MB ECC MOS, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX-11/780 and 11/785	36,000	193
MS780-EC(ED)	2MB ECC MOS memory, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX-11/780 and 11/785	28,900	132
MS780-FA	2MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 and 11/785	9,000	61
MS780-FB	4MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 and 11/785	17,000	122
MS780-FC	6MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 and 11/785	24,000	183
MS780-FF	10MB ECC MOS memory (in 64K arrays); for VAX-11/780 and 11/785	34,000	305
MS780-FH	25MB ECC MOS expansion memory (in 64K arrays); for VAX-11/780 and 11/785	75,000	761
MS780-FJ	50MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX-11/780 and 11/785	137,500	1,523
MS780-HC(HD)	8MB, 256K-chip memory upgrade for VAX-11/780 and 11/785; includes SBI interface, dual memory controller, memory backplane, and power regulator	57,900	212
MS780-JA	8MB memory expansion for VAX-11/780 and 11/785 (two 4MB, 256K-chip arrays)	38,000	144
MS86-BA	4MB memory array (256K-chip) for VAX 8600	28,800	84
MS86-BB	12MB expansion memory for VAX 8600 (three 4MB, 256K-chip arrays)	72,000	252
MS86-BC	20MB expansion memory for VAX 8600 (five 4MB, 256K-chip arrays)	110,000	420
MS86-BD	40MB expansion for VAX 8600 (ten 4MB, 256K-chip arrays)	200,000	840
H7112-A(B)	MOS memory battery backup; for VAX-11/750, 11/780, and 11/785	1,800	13
782UP-FA(FD)	VAX-11/782 Upgrade Package; for upgrading a VAX-11/780 to a VAX-11/782; includes a processor unit, multiport memory subsystem, cache invalidate option, 1MB of memory, and an LA120 console terminal	180,000	1,080
11780-VC(VD)	VAX-11/780 Upgrade Package; includes VAX-11/780 processor unit, 2MB memory, LA120 console terminal, two MBAs, one UBA, VAX-11/780 expansion cabinet, and VAX/VMS license only	145,600	461
11750-VH(VJ)	VAX-11/750 Upgrade Package; includes VAX-11/750 CPU with 1MB memory, TU58 magnetic tape cartridge, and VAX/VMS license	53,200	255

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
730XA-VE(VJ)	VAX-11/730 SBB Upgrade with 1MB ECC MOS (64K chip) memory, TU58 magnetic tape cartridge, and VAX/VMS license; physically identical to 730XA-AE(AJ) SBB; should be ordered by users already possessing one or more products from the SBB menu	21,500	130
DB86-AA	SBI (Synchronous Backplane Interconnect) adapter; for VAX 8600	10,000	30
MASS STORAGE			
HSC50-AA(AB)	HSC50 intelligent I/O server with space for six HSC5X-BA; cables not included	34,500	100
HSC5X-BA(BB)	Data channel interface for interfacing up to four disk drives	8,100	26
HSC5X-EA(EB)	Second power supply for over three HSC5X-BA on the HSC50	3,000	26
RB86-AA	RB86 integrated disk and tape controller; for VAX 8600	18,400	110
RA60-AA	205MB rack-mounted RA60 drive (no cabinet); requires UDA50 or HSC50 with HSC5X-BA and cabinet for mounting	16,000	105
RA60-CA(CD)	205MB cabinet-mounted RA60-AA add-on drive; requires UDA50 or HSC50 with HSC5X-BA	18,500	105
RUA60-AA	205MB RA60 drive and UDA50 controller without cabinet	21,500	116
RUA60-CA(CD)	205MB RA60-AA cabinet-mounted drive and UDA50 controller	24,000	116
RUA60-JA(JD)	205MB RA60 drive mounted in a cabinet and two UDA50 controllers	29,500	147
RA80-AA(AD)	121MB rack-mounted RA80 drive (no cabinet); requires UDA50 or HSC50 with HSC5X-BA and cabinet for mounting	14,000	85
RA80-CA(CD)	121MB cabinet-mounted RA80 add-on drive; requires UDA50 or HSC50-BA with HSC5X-BA	16,500	85
RUA80-AA(AD)	121MB RA80 rack-mounted drive (no cabinet) and UDA50 controller	19,500	117
RUA80-CA(CD)	121MB RA80 cabinet-mounted drive and UDA50 controller	22,000	117
RUA80-JA(JD)	RA80 cabinet-mounted drive with two UDA50 controllers	27,500	148
RUA80-UA(UD)	UDA50 controller for dual-porting RA80, RA81, and RA60 disks; includes cable	5,500	32
RA81-AA(AD)	456MB RA81 rack-mounted drive (no cabinet); requires UDA50 or HSC50 with HSC5X-BA and cabinet for mounting	19,000	95
RA81-CA(CD)	456MB cabinet-mounted RA81 drive; requires UDA50 or HSC50	21,500	95
RA81-EA(ED)	Three 456MB RA81 drives mounted in a cabinet. Requires a UDA50 or an HSC50	50,000	284
RUA81-AA(AD)	456MB RA81 rack-mounted drive and UDA50 controller	24,500	126
RUA81-CA(CD)	456MB RA81 cabinet-mounted drive and UDA50 controller	27,000	126
RUA81-EA(ED)	Three 456MB RA81 disk drives in cabinet with UDA50 controller	56,000	315
RUA81-JA(JD)	456MB RA81 disk drive in cabinet with two UDA50 controllers	32,500	158
RL02-AK	10.4MB RL02 add-on cartridge drive; requires RL211-AK	3,600	72
RL02K-DC	10.4MB cartridge for the RL02	210	NA
RL211-AK	10.4MB RL02 top-loading, rack-mounting, removable cartridge drive and controller with interconnect cabling	6,900	75
REM05-FA(FB)	Single-ported, 256MB removable disk pack drive and VAX-11/780 Massbus adapter (MBA)	46,000	342
REM05-FC(FD)	Dual-ported, 256MB removable disk pack drive and two VAX-11/780 Massbus adapters	60,600	436
REM05-FE(FF)	RM05 dual-port conversion kit with power supply, VAX-11/780 Massbus adapter; to convert REM05-FA(FB) to REM05-FC(FD)	16,700	93
REP07-FB	Single-ported, freestanding 516MB fixed Winchester disk drive and VAX-11/780 Massbus adapter, 1.3- or 2.2-megabyte-per-second peak transfer rate	50,000	252
REP07-FD	Dual-ported, freestanding 516MB fixed Winchester disk drive and two VAX-11/780 Massbus adapters, 1.3- or 2.2-megabyte-per-second peak transfer rate	64,600	336
REP07-FF	RP07 dual-port conversion kit with RP07-C dual-port kit and VAX-11/780 MBA with power supply to convert REP07-FA to REP07-FC	16,700	84
RGP07-FB	Single-ported, freestanding 516MB fixed Winchester disk drive and VAX-11/750 Massbus adapter, 1.3 megabytes per second peak transfer rate	46,000	252
RM05-FA(FB)	Single-ported, 256MB removable disk pack drive packaged in one freestanding disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter; requires VAX-11/750 or 11/780 series Massbus adapter	34,000	265
RM05-FC(FD)	Single-ported, 256MB removable disk pack drive and adapter packaged in freestanding disk drive cabinet only; requires VAX-11/750 or 11/780 series Massbus adapter	34,000	265
RM05-FE(FF)	Dual-ported, 256MB removable disk pack drive packaged in one freestanding disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter; requires VAX-11/750 or 11/780 series Massbus adapter	39,140	281
RM05-FH(FJ)	Dual-ported, 256MB removable disk pack drive and adapter packaged in freestanding disk drive cabinet only; requires VAX-11/750 or 11/780 series Massbus adapter	39,140	281

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
RM05-ZC(ZD)	RM05-FA plus RM05-FC	49,900	504
RGM05-FA(FB)	Single-ported 256MB RM05 drive and one VAX-11/750 Massbus adapter; the drive adapter is contained in a separate utility cabinet	46,000	326
RM05-P	256KB removable disk pack for RM05	1,215	NA
RM05-PX	RM05 disk pack, hard error (flag) free	1,435	NA
RP07-AB	Single-ported, freestanding 516MB fixed Winchester disk drive with interconnect cabling	38,000	207
RP07-BB	Dual-ported, freestanding 516MB fixed Winchester disk drive with interconnect cabling	43,140	230
RP07-C	RP07 dual-access kit containing drive logic and cables to convert REP07-FA to REP07-FC	5,150	20
RP07-D	1.3 to 2.2MB transfer rate upgrade kit, requires RP07-based VAX-11/780 with interleaved memory	NC	NC
RUC25-AA(AB)	Tabletop 26MB/26MB RC25 fixed/removable disk drive with Unibus controller	12,500	39
RUC25-BA(BB)	Rack-mounted 26MB/26MB RC25 fixed/removable disk drive with Unibus controller	12,500	39
RUC25-CA(CB)	Rack-mounted dual RC25 disk drive with Unibus controller	21,000	72
RC25-DA(DB)	Tabletop add-on RC25 disk drive	8,500	33
RC25-EA(EB)	Rack-mounted add-on RC25 disk drive	8,500	33
MAGNETIC TAPE EQUIPMENT			
TA78-BF(BJ)	TA78 PE/GCR DSA (Digital Storage Architecture) tape subsystem	52,000	357
TA78-UG	Upgrade to connect TU78 to TA78	15,000	NC
TE16-AE(AJ)	Program-selectable, 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport; prerequisite: TGE16 or TEE16	15,900	102
TEE16-FA(FD)	TE16 magnetic tape transport, formatter, and VAX-11/780 MBA	27,000	171
TEU77-FB(FD)	Program-selectable, 800 or 1600 bpi, 9-track, 125 ips magnetic tape transport, formatter, and VAX-11/780 Massbus adapter	36,800	272
TEU78-FB(FD)	Single-access, program-selectable, 6250 or 1600 bpi, 9-track, 125 ips, automatic loading magnetic tape transport, formatter, and VAX-11/780 Massbus adapter	54,000	357
TEU78-FF(FJ)	Dual-ported TU78 magnetic tape transport, formatter, and two VAX-11/780 MBAs	68,600	441
TGE16-FA(FD)	TE16 magnetic tape transport, formatter, H9604-AC standalone option expansion kit, and VAX-11/750 MBA	27,000	163
TGU77-FB(FD)	TU77 magnetic tape transport, formatter, and VAX-11/750 MBA	36,800	272
TGU78-FB(FD)	TU78 magnetic tape transport, formatter, and VAX-11/750 MBA	54,000	357
TM78-C	TU78 dual-port kit containing drive logic and cables to provide dual-porting capability to TEU78-FD or TU78-AD; prerequisite: TEU78-FD or TU78-AD	5,150	21
TU77-AF(AJ)	TU77 magnetic tape transport; prerequisite: TGU77, TEU77, or TJU77	23,800	222
TU78-AB(AD)	TU78 magnetic tape transport and formatter (master); requires an MBA and a TM78-C for dual-porting capability	48,000	322
TU78-AF(AJ)	TU78 magnetic tape transport (without formatter); prerequisite: TGU78, TEU78, or TU78 Master	25,500	196
TU80-AA(AB)	1600 bpi; 9-track, 25 ips (100 ips streaming) magnetic tape subsystem, Unibus adapter and power controller in a dedicated cabinet	11,000	89
TU81-AA(AB)	6250/1600 bpi GCR/PE 9-track streaming tape subsystem; includes Unibus-compatible controller	25,500	140
HSC5X-CA	Tape interface for HSC50 I/O controller	8,100	26
UNIBUS EXPANSION OPTIONS			
H9642-FA(FB)	Front loading expander cabinet and power control, with space for one BA11-K expander box and one 10.5-in. (26.6 cm.) disk; I/O connection panel space to mount three groups of four panels each and one additional panel unit; for VAX-11/750 and VAX-11/730	2,200	NC
H9642-FC(FD)	Expander cabinet and power control, with space for one BA11-K expander box; I/O connector panel space to mount seven groups of four panel units each and one additional panel unit; for VAX-11/750 and VAX-11/730	2,050	NC
H9652-HA(HB)	VAX-11/780 and VAX-11/785 CPU expansion cabinet; four option panel spaces for additional memory (MS780-C/D or E/F), DW780, DR780, CI780, MBAs, and MA780 multiport interfaces; also includes space for an H7112-A(B) battery-backup option	5,000	NC
H9652-MF(MH)	Single-width, high-boy general-purpose Unibus expansion cabinet, with space for two additional BA11-K expander boxes; for VAX-11/780 and 11/785	3,700	NC

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
BA11-KU(KV)	Rack-mountable expansion box with bezel and slides for Unibus expansion cabinet; provides mounting space for five system units and is compatible with DD11-CK/DK expansion backplanes	3,500	25
DB11-MP	Unibus repeater; adds 19 unit bus loads and up to 50 ft. (15.2 m.) of additional Unibus length to the system	2,240	8
DD11-CK	Expansion backplane mounting for BA11-K box; provides for two hex- and two quad-slot modules; mounts in one system unit	470	NC
DD11-DK	Same as DD11-CK except for providing seven hex- and two quad-slot modules; mounts in two system units	940	NC
MULTIPURPOSE COMMUNICATIONS CONTROLLERS			
DMF32-LP	Direct Memory Access Unibus communications controller; system option; external cables for terminals not included	3,500	58
DMF32-M	DMF32 upgrade option; base module only; requires selection of appropriate external cables and cabinet kit	2,225	58
UNIBUS ASYNCHRONOUS OPTIONS			
Multiplexers			
DZ11-DP	System option; eight-line multiplexer with distribution panel for EIA/CCITT terminals; with modem control; external cables not included	2,175	35
DZ11-HP	System option; eight-line multiplexer for use with 20 ma current loop terminals; terminal cables not included	2,500	35
DZ11-M	Upgrade option; RS-232 interface; includes base module only	1,560	35
DZ11-N	Upgrade option; 20 ma interface; base module only	1,635	35
DHU11-AP	16-line multiplexer with direct memory access for EIA/CCITT terminals	3,495	45
DMZ32-AP	24-line multiplexer with direct memory access for EIA/CCITT terminals	7,200	90
UNIBUS SYNCHRONOUS OPTIONS			
Point-to-Point Interfaces			
DUP11-AP	System option; interfaces to Bell 200 series modems or equivalent; includes data set control and BC22f-25 cable	1,575	13
DUP11-M	Upgrade option; includes only the base module	1,230	13
DMR11-AP	System option; interfaces to EIA RS-232/CCITT synchronous modems	4,400	41
DMR11-BP	System option; interfaces to CCITT V.35/DDS synchronous modems	4,400	41
DMR11-CP	System option; includes integral modem for local interconnection	4,400	41
DMR11-EP	System option; interfaces to EIA RS-422/RS-429 V.24 synchronous modems	4,400	41
DMR11-FP	System option; interfaces to EIA RS-423/RS-429 V.24 synchronous modems	4,400	41
DMR11-M	Upgrade option; includes base module only	4,110	41
Multipoint Interfaces			
DMP11-AP	System option; interfaces to EIA RS-232/CCITT synchronous modems	6,900	78
DMP11-BP	System option; interfaces to CCITT V.35/DDS synchronous modems	6,900	78
DMP11-CP	System option; includes integral modem for local interconnection	6,900	78
DMP11-EP	System option; interfaces to EIA RS-422/RS-449 V.24 synchronous modems	6,900	78
DMP11-FP	System option; interfaces to EIA RS-423/RS-449 V.24 synchronous modems	6,900	78
DMP11-M	Upgrade option; includes base module only	6,450	78
DEUNA-AA	Ethernet communications controller; connects Unibus system to an Ethernet local area network	3,500	46
Auxiliary Communications Microprocessors			
KMS11-BD	Intelligent, full-duplex, eight-line, synchronous, communications, front-end interface	12,500	102
KMS11-BE	8-line mux expansion for KMS11-BD	12,200	102
KMS11-PX	High-performance network link for interconnection of VAX and PDP-11 computers; includes EIA RS-232-C and EIA RS-423-A/CCITT V.10 interfaces	6,000	80
KMS11-PY	High-performance network link for interconnection of VAX and PDP-11 computers; includes ISO 2593/CCITT V.35 interface	6,000	80
KMS11-PZ	High-performance network link for interconnection of VAX and PDP-11 computers; includes CCITT V.11 interface	6,000	80
KMS1P-M	Includes microprocessor and line unit modules	5,710	80
STATISTICAL MULTIPLEXERS			
DZS11-EA	Interface between Unibus and up to two terminal multiplexers	3,250	40

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
MULTIPOINT PARALLEL INTERFACE			
PCL11-B	Multidrop computer link used to connect up to 16 processors to form a local distributed network	9,300	73
FEPCM FRONT-END PROCESSOR			
FEPCM-AA	Rack-mountable PDP-11/23-Plus-based front-end processor; includes FEPCM and RSX-11S binary license only. Requires cable kit for mounting in DEC FCC-compliant cabinet	19,490	209
FEPCM-BA	Rack-mountable PDP-11/24-based front-end processor; includes FEPCM and RSX-11S license only. Requires cable kit for mounting in DEC FCC-compliant cabinet	21,490	265
FEPCM-NA	PDP-11/23-Plus-based front-end processor; includes H9642 cabinet, FEPCM, RSX-11S license only, and cable kit	21,490	209
FEPCM-PA	PDP-11/24-based front-end processor; includes H9642 cabinet, FEPCM, RSX-11S license only, and cable kit	23,490	265
KCT32 DUAL-LINE COMMUNICATIONS CONTROLLER			
KCT32-AB	Dual-line communications sync/async controller; includes 56KB of user-programmable memory, on-board diagnostic testing, and VMS-supported software	7,400	80
ETHERNET COMMUNICATIONS			
H4000	Digital Ethernet transceiver	300	4
DELNI-AA	Local Network Interconnect; supports up to eight systems	995	10
DEREP-AA	Ethernet Repeater; tabletop device with power supply	1,500	22
DEREP-RA	Same as DEREP-AA, but remote	4,400	44
DECSA-EA	One-line DECnet router server; includes one DCSAX-LA line card	13,500	152
DECSA-CA	DECnet router server unit and eight DCSAX-LC line cards	14,000	201
DECSA-DA	DECnet router server unit and 16 DCSAX-LC cards	20,000	354
DECSA-FA	One-line DECnet/SNA Gateway for Ethernet; includes one DCSAX-LA line card (could also be configured with a DCSAX-LB card)	13,900	152
DCSAX-LA	One-line synchronous EIA RS-232-C/CCITT V.24 line card	415	11
DCSAX-LB	One-line synchronous CCITT V.35 line card	650	11
DCSAX-LC	Two-line asynchronous EIA RS-232-C/CCITT line card	375	7
DECOM-AA	Dual-cable broadband Ethernet transceiver	4,250	70
DECOM-BA	Single-cable broadband Ethernet transceiver	4,250	70
DEFTR-AA	Ethernet broadband frequency translator	4,500	42
REALTIME OPTIONS			
Digital I/O Options			
DRS11-A	Digital output device (TTL) for Unibus systems; includes one RC filtered interrupt unit, two 19.6 ft. (3 m.) flat ribbon cables (50 conductors) terminated into 50 pin Berg connectors for connection to field output signals	2,145	23
DRS11-B	Digital output device with open collector drivers; same components as DRS11-A	2,365	23
DRS11-MP	Optically isolated DC drivers with open collectors; requires DRS11-B	1,000	18
DSS11-A	Digital input device (TTL); includes two 19.6 ft. (3 m.) ribbon cables (50 conductors) terminated into 50 pin Berg connectors for connection to field input signals	2,670	21
DSS11-B	Digital input device; same components as DSS11-A	2,890	21
DSS11-MP	Contact sense input; requires DSS11-A	1,400	15
General-Purpose Unibus Interface			
DRE11-CC	General-purpose interface	2,595	26
DRE11-CD	Same as DRE11-CC, but incorporates a signal conditioning module	3,635	41
DR11-C	General-purpose digital interface; upgrade option, including DR11 base option module	340	8
DR11-W	General-purpose VAX Unibus digital interface; upgrade option; included only with DR11 base option module	1,350	14
DR11-WC	Long-line general-purpose interface; includes differential adapter module, interconnect cables, test connectors, and FCC-compliant user I/O panel	3,295	42
DR11-WD	Long-line upgrade bit for DR11-W; includes all items in DR11-WC except DR11-W interface module	1,795	24
Industrial I/O Options			
CMR21-AA(AB)	Industrial I/O processor to interface field analog and digital signals; hardware only; includes processor, 16KB memory, four serial communications ports, maintenance mode and base mode firmware, and power supply	3,900	46

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
CMR21-BA(BB)	Same as CMR21-AA(AB), plus library of software utilities	4,050	50
CMR21-AC(AD)	Same as CMR21-AA(AB), but can also operate at 12 VDC	4,300	46
CMR21-BC(BD)	Same as CMR21-BA(BB), but can also operate at 12 VDC	4,450	50
DYX02-A	Optional interface (signal converter and repeater) for fiber optic branches in DECdataway industrial LANs	2,500	26
DYT01-EA	Asynchronous EIA single-line interface to DECdataway industrial LAN	1,400	27
DYT01-MA	20 ma version of DYT01-EA	1,400	27
General-Purpose Massbus Interface			
DR70-C	Basic Massbus interface; mounted in a system unit, includes connector panel and cabling	7,300	38
LINE PRINTERS			
LP11-AA	132-column, 64-character band printer and control unit; 300 lpm	8,350	105
LP11-BA	132-column, 64- and 94-character band printer and control unit; 300 lpm when using 64-character set and 215 lpm when using 96-character set	8,950	105
LP11-EA	Freestanding line printer operating at a speed of 600 lines/min. for 64-character set	13,600	150
LP11-EB	Same as LP11-EA; also operates at 445 lines/min. for 96-character set	14,400	150
LP27-UA(UB)	132-column line printer with 30 ft. (9.5 m.) data cable and controller	29,990	259
LP27-DA(DB)	Line printer with 50 ft. (15.2 m.) data cable and long-line controller	32,990	310
LP27-VA(VB)	Line printer with data cable and controller; requires DMF32	28,990	252
LP32-AA	132-column, 64-character printer and universal power supply, 300 lpm; prerequisite, DMF32 Unibus controller	8,350	98
LP32-BA	Same as LP32-AA, but can also operate at 215 lpm with a 96-character set	8,950	98
LP32-EA	132-column, 64-character printer and universal power supply, 600 lpm; prerequisite, DMF32 Unibus controller	13,600	143
LP32-EB	132-column, 64- and 96-character printer and universal power supply, 600/445 lpm; prerequisite, DMF32 Unibus controller	14,400	143
LASER PRINTERS			
LN01-CA(CB)	Nonimpact 12-ppm laser-quality page printer; compatible with standard line printer interface (LP11)	19,995	310
LN01-DA(DB)	Same as LN01-CA(CB), but includes DMF32-compatible cable	19,995	310
LN01S-CA	12-ppm laser printer, 12 resident Courier fonts; includes LP11 interface and 30 ft. (9.1 m.) cable	29,995	353
LN01S-DA	Same as LN01S-CA, but with DMF32-compatible interface	29,995	353
LN01B-CA(CB)	12-ppm laser printer with 16 resident Courier-like fonts; includes PLOTLN VMS software, two EPROMs, LP11 interface, and 30 ft. (9.2 m.) cable	22,500	310
LN01B-DA(DB)	Same as LN01B-CA(CD), but with DMF32 interface	22,500	310
WORKSTATION PRINTER			
LA50-RA	Tabletop 100 cps/50 cps dual-mode printer with graphics capability; 110 VAC power supply	695	8
LA50-RB	Same as LA50-RA, but with 220 VAC power supply	715	8
LA50-RC	Same as LA50-RA, but with 240 VAC power supply	715	8
PRINTERS/PLOTTERS			
LXY12-CA(CB)	Freestanding line printer/plotter; 170, 240, or 300 lpm; with LP11 controller for Unibus interface	11,250	104
LXY12-DA(DB)	Same as LXY12-CA(CB); with RS-232-C interface	11,250	104
LXY12-EA(EB)	Same as LXY12-CA(CB); with DMF32 interface	11,250	104
LXY22-CA(CB)	Freestanding line printer/plotter; 320, 465, or 600 lpm; with LP11 controller for Unibus interface	15,800	135
LXY22-DA(DB)	Same as LXY22-CA(CB); with RS-232-C interface	15,800	135
LXY22-EA(EB)	Same as LXY22-CA(CB); with DMF32 interface	15,800	135
COLOR GRAPHICS PEN PLOTTER			
LVP16-AA(BA)	Six-color graphics pen plotter; 15 ips; includes RS-232-C interface, documentation, and initial supplies. Requires interface cable	1,995	10
TERMINALS			
LA12-AB	Hardcopy terminal with integral 1200 baud dial-through keyboard modem, 300-baud coupler, EIA interface, and carrying case	2,195	21
LA12-CB	Hardcopy terminal with 300-baud coupler, EIA interface, and carrying case	1,595	21
LA12-DB	Tabletop and console hardcopy terminal with EIA interface only	1,495	21

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
LAX12-U2	Dial-through-keyboard 1200 baud integral modem upgrade for LA12-A/-C/-D	600	NC
LAX12-U4	300 baud acoustic coupler upgrade for LA12-B/-D	100	NC
LAX12-U5	Microcode upgrade for LA12-A/-C/-D	75	NC
LA100-BA	KSR 30/80/240 cps hardcopy terminal with keypad, tractors, cable, ribbon cartridge, roll of paper, and Courier-10/Orator-10 fonts in US/UK character sets only	2,195	27
LA100-BB	Same as LA100-BA, but with Courier-10 font only, international overlay, and VT100 line drawing set	2,195	27
LA100-CA	Same as LA100-BA, but with multiple font option added	2,295	27
LA100-CB	Same as LA100-BB, but with multiple font option added	2,295	27
LA120-DA	Freestanding DECwriter III KSR hardcopy terminal; 180 cps bidirectional	2,800	34
LA120-RA	DECprinter III RO hardcopy terminal; for use with 1- to 6-part forms	2,420	39
LA120-RB	DECprinter III RO hardcopy terminal; for use with 4- to 9-part forms	2,600	39
VT220-A2(A3)	VT220 terminal with white phosphor nonglare screen	880	9
VT220-B2(B3)	VT220 terminal with green phosphor nonglare screen	880	9
VT220-C2(C3)	VT220 terminal with amber phosphor nonglare screen	880	9
VT22K-AA	Data entry keyboard for VT220	215	NC
VT22K-BA	Word processing keyboard for VT220	215	NC
VT240-A2(A3)	VT240 text/graphics terminal; includes monochrome monitor, system box with logic and power supply, and keyboard; white phosphor nonglare screen	1,980	19
VT240-B2(B3)	VT240 terminal with green phosphor nonglare screen	1,980	19
VT240-C2(C3)	VT240 terminal with amber phosphor nonglare screen	1,980	19
VT241-AA	VT241 color text/graphics terminal; includes monitor, system box with logic and power supply, and keyboard	2,980	26
VT24K-AA	Data entry keyboard for VT240/VT241 terminals	215	NC
VT24K-BA	Word processing keyboard for VT240/VT241 terminals	215	NC
VT24X-AA	Optional 300-/1200-baud autoanswer/autodial integral modem	495	6
VT100-AA(AB)	Tabletop hardcopy receive-only terminal	1,945	18
VT100-WA(WB)	Video display terminal for DECmail applications; includes word processing features	2,140	22
VT101-AA(AB)	Video display terminal of VT100 family	1,350	15
VT102-AA(AB)	Video display terminal of VT100 family	1,595	22
VT102-WA(WB)	Video terminal with advanced features and word processing keyboard	1,595	22
VT131-AA(AB)	Video display terminal with conversational block-mode transmission capability	1,695	25
VT1XX-AB	Advanced video option; adds 10 additional lines of 132-column data for a total of 132 columns x 24 lines	180	4
VT1XX-AA	20 ma current loop adapter for VT100	140	4
VT1XX-AC	Printer port option for connection of a VT100 to a hardcopy printer	350	7
RT137-AA	RT100 console, bar code reader and keyboard, VT100 keyboard, light pen; 120 V; RS-232	5,625	52
RT137-AE	RT100 console, bar code reader and keyboard, light pen; 120 V; RS-232	5,250	52
RT137-AK	RT100 console, bar code reader, light pen, bar code, and RT100 keyboard; 120 V; RS-232	6,215	72
RT7XX-AC	Bar code ruby wand	199	NC
RT137-SR	Slot reader	565	10
RT037-AA	Bar code reader and decoder	2,150	32
RT037-BA	Bar code reader, decoder, and keypad	2,395	32
RT100-AA(AB)	Industrial VT100 with membrane keyboard; EIA interface	4,300	35
RT100-BA(BB)	Industrial VT100 with membrane keyboard; 20 ma interface	4,300	40
RT102-AA(AB)	Industrial VT102 with membrane keyboard; EIA interface	4,300	35
RT102-BA(BB)	Industrial VT102 with membrane keyboard, 20 ma interface	4,300	40
RT102-EA	Completely sealed version of RT102-AA(AB) with tactile feedback keyboard	4,500	35
RT102-FA	Completely sealed version of RT102-BA(BB) with tactile feedback keyboard	4,500	40
RT1XX-AE	Plastic and Mylar membrane keyboard compatible with VT100	1,100	10
RT1XX-AF	VT100-compatible environmentally sealed keyboard with typewriter-like keys	1,250	13
RT1XX-AC	RT100- and VT-100-compatible industrial membrane keyboard	1,250	12
COLOR GRAPHICS SYSTEM			
VS11-FA	High-performance, 16-color and monochrome raster graphics system; prerequisite, VAX/VMS system configuration and VAX/VMS driver	5,435	77

**NC—No charge.*
***NA—Not applicable.*

DEC VAX Systems

		Purchase Price ($)	Monthly Maint. ($)
VAX STATION 100 GRAPHICS WORKSTATION			
VS100-AA	VAX station 100 primary (VR100-AA) monochrome 19-in. (48 cm.) monitor, 1088H x 864V resolution; includes UNIBUS interface, multibox with Graphics Processor, power supply and DS11-FA VAX Unibus-window/fiber-optic transceiver card	11,305	89
VS10X-BA	One 11 x 11-in. graphics tablet and one 5-button puck	2,000	24
VS10X-EA	Three-button mouse and cable	500	11
LK201-CA	Keyboard with 12 ft. cord	245	3
BN25B-15	15-m. optical cable with terminators	200	NC
BN25B-30	30-m. optical cable with terminators	350	NC
BN25B-60	60-m. optical cable with terminators	650	NC
VOICE SYNTHESIS MODULE			
DTC01-AA	DECtalk voice synthesis module; translates ASCII text into speech output	4,000	22

**NC—No charge.*
***NA—Not applicable.*

SOFTWARE PRICES

		License Fee* ($)
OPERATING SYSTEMS		
QX001-UZ	VAX/VMS operating system (11/725, 11/730, 11/750, 11/780, and 11/782)	10,000
QC821-UZ	Ultrix-32 maximum 16-user binary license only; for VAX-11/730 and 11/725	12,000
QD821-UZ	Ultrix-32 maximum 32-user license only; for VAX-11/750	15,500
QE821-UZ	Same as QD821, but for VAX-11/780, 11/785, and 11/782	15,500
QD822-UZ	32-user to 64-user Ultrix-32 upgrade; for VAX-11/750	4,000
QE822-UZ	Same as QD822, but for VAX-11/780, 11/785, and 11/782	4,000
QE823-UZ	64-user to 65+-user Ultrix-32 upgrade; for VAX-11/780, 11/785, and 11/782	5,000
QE824-UZ	32-user to 65+-user Ultrix-32 upgrade; for VAX-11/780, 11/785, and 11/782	7,500
QX825-UZ	Ultrix-32 encryption license	200
LANGUAGES		
QX100-UZ	VAX Fortran for VAX-11/725 through 11/785	5,170
QK100-UZ	VAX Fortran for VAX 8600	7,755
QX099-UZ	VAX Cobol for VAX-11/725 through 11/785	7,970
QX095-UZ	VAX Basic for VAX-11/725 through 11/785	5,300
QK095-UZ	VAX Basic for VAX 8600	7,950
QX126-UZ	VAX Pascal for VAX-11/725 through 11/785	4,725
QK126-UZ	VAX Pascal for VAX 8600	7,100
QX067-UZ	VAX Coral 66 for VAX-11/730 through 11/785	7,500
QX114-UZ	VAX PL/1 for VAX-11/725 through 11/785	7,970
QK114-UZ	VAX PL/1 for VAX 8600	11,950
QX014-UZ	VAX Bliss-16 for VAX-11/730 through 11/785	5,500
QX106-UZ	VAX Bliss-32 for VAX-11/730 through 11/785	5,775
QK106-UZ	VAX Bliss-32 for VAX 8600	8,665
QX107-UZ	Fortran IV/VAX-to-RSX Cross Compiler for VAX-11/730 through 11/785	700
QX075-UZ	Coral 66/VAX-to-RSX Cross Compiler for VAX-11/730 through 11/785	4,050
QX015-UZ	VAX C for VAX-11/725 through 11/785	4,725
QK015-UZ	VAX C for VAX 8600	7,100
QX020-UZ	VAX APL for VAX-11/730 through 11/785	7,970
QK020-UZ	VAX APL for VAX 8600	11,950
QX018-UZ	VAX Dibol for VAX-11/725 through 11/785	4,150
QX631-UZ	VAX RPG II for VAX-11/725 through 11/785	3,150
QK631-UZ	VAX RPG II for VAX 8600	4,725
QX917-UZ	VAX Lisp for VAX-11/730 through 11/785	8,000
QK917-UZ	VAX Lisp for VAX 8600	12,000

**Non-hardware-dependent single-use license and warranty. An "X" in an order number stands for the following specific Digital ordering designations: "C" for VAX-11/725 and 11/730, "D" for VAX-11/750, and "E" for VAX-11/780, 782, and 785.*

DEC VAX Systems

		License Fee* ($)
COMMUNICATIONS		
QXD05-UZ	DECnet-VAX for VAX-11/725 through 11/785	3,250
QX727-UZ	DECnet Router/X.25 Gateway for VAX-11/730 through 11/785	2,660
QX545-UZ	DECnet/SNA Gateway for VAX-11/725 through 11/785	2,000
QX070-UZ	Mux200/VAX for VAX-11/750 through 11/785	5,800
QX071-UZ	VAX PSI for VAX-11/725 through 11/785	3,300
QX111-UZ	VAX 2780/3780 Protocol Emulator for VAX-11/730 through 11/785	4,620
QX112-UZ	VAX 3271 Protocol Emulator for VAX-11/730 through 11/785	5,500
QK112-UZ	VAX 3271 Protocol Emulator for VAX 8600	8,250
QX731-UZ	VMS Message Router for VAX-11/730 through 11/785	550
QX726-UZ	Ethernet Terminal Server for VAX-11/725 through 11/785	1,000
DATA MANAGEMENT		
QX897-UZ	VAX Common Data Dictionary for VAX-11/730 through 11/785	1,320
QK897-UZ	VAX Common Data Dictionary for VAX 8600	1,980
QX898-UZ	VAX Datatrieve for VAX-11/730 through 11/785	6,600
QK898-UZ	VAX Datatrieve for VAX 8600	9,900
QX706-UZ	VAX TDMS for VAX-11/730 through 11/785	2,750
QX899-UZ	VAX DBMS for VAX-11/730 through 11/785	13,200
QK899-UZ	VAX DBMS for VAX 8600	19,800
QX130-UZ	VAX DSM for VAX-11/730 through 11/785	9,000
QX076-UZ	VAX ACMS for VAX-11/730 through 11/785	3,300
QK076-UZ	VAX ACMS for VAX 8600	4,950
QX354-UZ	VAX Rdb/VMS for VAX-11/725 through 11/785	9,000
QK354-UZ	VAX Rdb/VMS for VAX 8600	13,500
QXD07-UZ	VAX Rdb/ELN for VAX-11/725 through 11/785	7,500
APPLICATIONS AND UTILITIES		
QX007-UZ	DEC/CMS for VAX-11/730 through 11/785	8,675
QK007-UZ	DEC/CMS for VAX 8600	13,000
QX425-UZ	VAX ADE for VAX-11/725 through 11/785	2,700
QX902-UZ	VAX ALL-IN-1 Office Menu for VAX-11/730 through 11/785	15,000
QX310-UZ	VAX DECalc for VAX-11/730 through 11/785	3,400
QK310-UZ	VAX DECalc for VAX 8600	5,100
QX400-UZ	VAX DECmail for VAX-11/730 through 11/785	12,000
QX800-UZ	VAX FMS for VAX-11/725 through 11/785	2,625
QK800-UZ	VAX FMS for VAX 8600	3,950
QX118-UZ	VAX ReGis Graphics Library for VAX-11/730 through 11/785	3,500
QC451-UZ	VAX Decor for VAX-11/730	3,000
QD451-UZ	VAX Decor for VAX-11/750	4,500
QE451-UZ	VAX Decor for VAX-11/780, 782, and 785	6,000
QX650-UZ	DECspell Verifier/Corrector for VAX-11/730 through 11/785	1,850
QK650-UZ	DECspell Verifier/Corrector for VAX 8600	2,775
QX360-UZ	VAX DECgraph for VAX-11/725 through 11/785	2,500
QK360-UZ	VAX DECgraph for VAX 8600	3,750
QX361-UZ	VAX DECslide for VAX-11/730 through 11/785	2,500
QK361-UZ	VAX DECslide for VAX 8600	3,750
QX038-UZ	VAX DECtype for VAX-11/730 through 11/785	2,000
QX031-UZ	VAX VTX for VAX-11/725 through 11/785	25,000
QK031-UZ	VAX VTX for VAX 8600	37,500
QX760-UZ	EDE for VAX-11/730 through 11/785	3,500
QX521-UZ	DECpage for VAX-11/730 through 11/785	5,000
QK521-UZ	DECpage for VAX 8600	7,500
QX810-UZ	VAX GKS/0b for VAX-11/725 through 11/785	2,100

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