DEC VAX-11 Systems

MANAGEMENT SUMMARY

DEC's VAX–11 Systems first gained popularity as high-powered 32-bit engines for computation-intensive applications in the engineering and scientific fields. As the VAX product line has grown, however, the scope of its applicability has also expanded; VAX–11 systems are now marketed and used not only for technical applications, but also for a broad range of commercial applications, from general accounting to office automation.

DEC has engineered this broad market penetration with the stated purpose of transforming itself from a minicomputer manufacturer to an information systems supplier capable of satisfying all computing needs. To achieve that goal, DEC has implemented a product strategy that commits the company to providing four key elements through the VAX family: 1) a wide range of products for desktop, departmental, and organizational computing; 2) a single, compatible architecture for all systems under the VAX/VMS operating system; 3) interconnection of systems in a homogenous network environment; and 4) a variety of products to develop critical and unique applications.

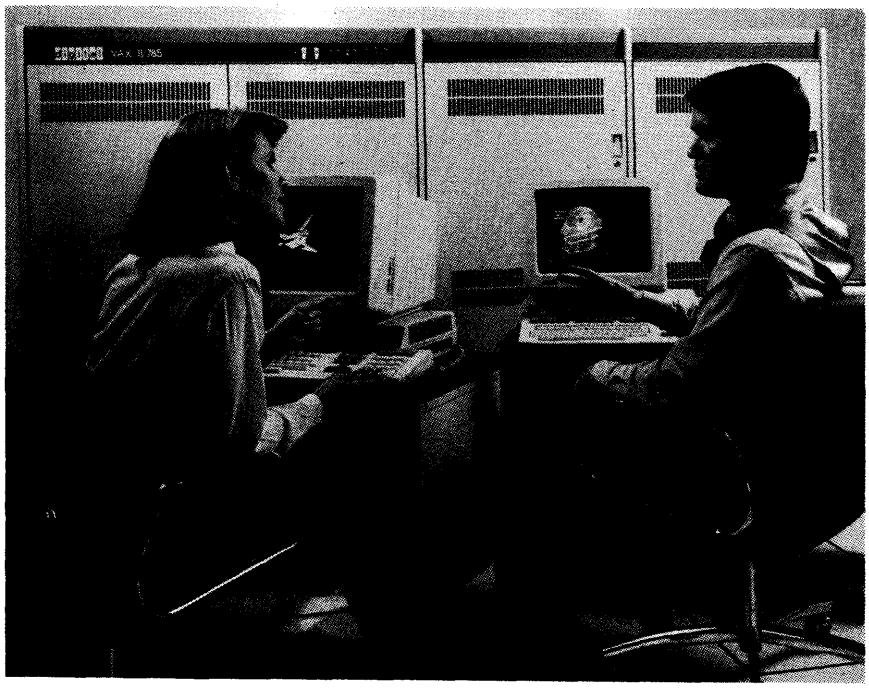
Throughout 1984, DEC has made software and hardware enhancements to the VAX product family that touch on each of those strategic areas. The company addressed the first point when it introduced the VAX–11/785, another system for departmental and organizational computing. The new system, which represents a complete revamping of the VAX-11 CPU, succeeds the VAX–11/780 as the most powerful single-processor system in the VAX–11 family. The VAX–11/785 features a CPU cycle time of 133 nanoseconds, compared to 200 nanoseconds on the

DEC continues to enhance the VAX–11 family of 32-bit superminicomputers. The company has debuted the VAX–11/785, successor to the popular VAX–11/780 as the most powerful single-processor system in the line. A new version of the VAX/VMS operating system increases application compatibility among all VAX–11 systems, and, combined with enhancements to DECnet software, provides greater support for Ethernet and DECnet communications. New languages, information management tools, and peripherals also contribute to the company's goal of providing a single-user, single-system solution for computing needs at all organizational levels.

MODELS: MicroVAX I, VAX–11/725, VAX–11/730, VAX–11/750, VAX–11/780, VAX–11/782, and VAX–11/785.
MAIN MEMORY: 256KB to 36MB (32MB local and 4MB shared).
DISK CAPACITY: 10.8MB to 30GB.
WORKSTATIONS: Up to 384 (96 per Unibus).
PRICE: $9,995 to $370,000 (base system packages).

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation (DEC), 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897–5111.



The VAX–11/785 succeeds the VAX–11/780 as the most powerful single-processor system in DEC's VAX–11 family. The VAX–11/785 CPU, incorporating high-speed Schottky circuitry, features a 32KB cache memory and a CPU cycle time of 133 nanoseconds. Featuring the same bus structure and I/O capabilities as the VAX–11/780, the VAX–11/785 can support up to 36MB of main memory (32MB local and 4MB shared), up to 30GB of disk storage, and up to 384 workstations.

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CHART A. SYSTEM COMPARISON

MODEL	Micro VAX I	VAX–11/725	VAX–11/730	VAX–11/750
SYSTEM CHARACTERISTICS				
Date of introduction	Oct. 1983	Oct. 1983	April 1982	Oct. 1980
Date of first delivery	March 1984	Nov. 1983	May 1982	Nov. 1980
Operating system	MicroVMS, Ultrix–32M	VAX/VMS	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	Not applicable
MIPS	—	—	0.36	0.72
Relative performance (based on a rating of the 11/780 at 1.0)	0.3	0.3	0.3	0.65
MEMORY				
Minimum capacity, bytes	256K	1M	1M	2M
Maximum capacity, bytes	2.5M	3M	5M	8M
Type	64K RAM	64K ECC MOS RAM	64K ECC MOS RAM	64K ECC MOS RAM
Cache memory	8KB	None	None	4KB
Cycle time, nanoseconds	500	810	810	400
Bytes fetched per cycle	4	4	4	8
INPUT/OUTPUT CONTROL				
Number of channels	—	—	—	1-5
High-speed buses	None	None	None	Massbus (3 optional)
Low-speed buses	Q-Bus (1 standard)	Unibus (1 standard)	Unibus (1 standard)	Unibus (1 std., 1 opt.)
MINIMUM DISK STORAGE	10.8MB	52MB	20MB	121MB
MAXIMUM DISK STORAGE	28.8MB	52MB	2GB	19GB
NUMBER OF WORKSTATIONS	8	8	24	128
COMMUNICATIONS PROTOCOLS	See Communications Control	See Communications Control	See Communications Control	See Communications Control

CHART A. SYSTEM COMPARISON (Continued)

MODEL	VAX–11/780	VAX–11/782	VAX–11/785
SYSTEM CHARACTERISTICS			
Date of introduction	Oct. 1977	Feb. 1982	April 1984
Date of first delivery	Jan. 1978	April 1982	Sept. 1984
Operating system	VAX/VMS, Ultrix–32	VAX/VMS	VAX/VMS, Ultrix–32
Upgradable from	Not applicable	VAX–11/780	VAX–11/780
Upgradable to	VAX–11/782, 11/785	Not applicable	Not applicable
MIPS	1.06	—	1.5 (approx.)
Relative performance (based on a rating of the 11/780 at 1.0)	1.0	1.8	1.5-1.7
MEMORY			
Minimum capacity, bytes	2M	1M	2M
Maximum capacity, bytes	36M	8M	36M
Type	64K ECC MOS RAM	16K ECC MOS RAM	64K ECC MOS RAM
Cache memory	8KB	8KB	32KB
Cycle time, nanoseconds	290	290	166
Bytes fetched per cycle	8	8	8
INPUT/OUTPUT CONTROL			
Number of channels	1-8	—	1-8
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., 3 opt.)
MINIMUM DISK STORAGE	121MB	121MB	121MB
MAXIMUM DISK STORAGE	30GB	30GB	30GB
NUMBER OF WORKSTATIONS	384	384	384
COMMUNICATIONS PROTOCOLS	See Communications Control	See Communications Control	See Communications Control

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

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VAX-11/780. The new system also incorporates high-speed Schottky circuitry that, according to DEC, permits performance 50 to 70 percent greater than that provided by the VAX-11/780 in timesharing, computation-intensive, and realtime environments. The improved CPU performance reportedly endows the VAX-11/785 with the fastest interrupt response of any processor in the family; interrupt latency averages 28 microseconds.

The VAX-11/785, like the VAX-11/780, features a main memory capacity of 32MB and a two-way set associative cache memory; cache size on the VAX-11/785, however, is 32KB, compared to 8KB on the VAX-11/780. According to DEC, the larger cache reduces bus traffic, allowing enhanced I/O performance in large timesharing applications. The VAX-11/785 also has 48KB of console memory, up from 16KB on the VAX-11/780; the increase reportedly improves console performance for system monitoring and error reporting. Instruction microcode for the VAX-11/785 is stored in RAM, rather than in ROM as 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 the differences in processor technology, however, the VAX-11/785 employs the same bus structure and I/O capabilities as the VAX-11/780. Special synchronization circuitry on the VAX-11/785 allows it to use the same Synchronous Backplane Interconnect (SBI) interfaces, controllers, and peripheral equipment as the older system without modification. 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-11/785 also shares operations and connectivity features with the VAX-11/780 and with other members of the VAX-11 family. The VAX-11/785 is fully software-compatible with other VAX-11 systems, using all VMS operating system utilities and all VAX-11 family layered information management products, languages, and software tools. The VAX-11/785 supports DECnet, Ethernet, and gateway communications facilities. In addition, the VAX-11/785 can be configured into VAXcluster systems for intensified computing power. VAXclusters, introduced in 1983, are high-performance, high-availability combinations of loosely coupled VAX-11/750, 11/780, 11/785, and 11/782 processors operating with globally shared, intelligent mass storage subsystems. The processors and storage subsystems, called cluster nodes, are interconnected through a high-speed bus.

DEC addressed the second and third points by releasing Version 4.0 of the VAX/VMS operating system. The new

CANADIAN ADDRESS: Digital Equipment of Canada, Ltd., P.O. Box 13000, 100 Herzberg Road, Kanata, Ontario, K2K 2A6, Canada.

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 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 7 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 with substantial improvement, the FPA 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.

INSTRUCTIONS: The native instruction set is an extension of the PDP-11 instruction set that consists of 248 basic instructions (304 in the VAX-11/730 and VAX-11/785), 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. The instructions can be grouped into related classes based on their function and use: instructions to manipulate arithmetic and logical data types, instructions to manipulate special kinds of data, instructions to provide basic program flow control, instructions to perform special operating system functions, and instructions provided specifically for high-level language constructs.

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 its 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 the following functions:

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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), HSC50	UDA50 (Unibus), HSC50
Drives per subsystem/controller	8	8	4 per UDA50, 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-11/750, 11/780, 11/782, 11/785	VAX-11/725, 11/730, 11/750, 11/780, 11/782, 11/785	VAX-11/725, 11/730, 11/750, 11/780, 11/782, 11/785
Comments	VAX-11/750 supports only 1.3MB/sec. transfer rate.			

CHART B. MASS STORAGE (Continued)

MODEL	RA80	RL02	RD51	RC25
Type	Winchester	Cartridge	Winchester	Fixed/Removable
Controller model	UDA50 (Unibus), HSC50	Integrated	RQDX1	Integrated
Drives per subsystem/controller	4 per UDA50, 24 per HSC50	4	—	—
Formatted capacity per drive, megabytes	121	10.4	10	26/26
Number of usable surfaces	7	2	4	—
Number of sectors or tracks per surface	1092 tracks	512 tracks	1200 tracks	—
Bytes per sector or track	512/sector	256/sector	512/sector	—
Average seek time	25 ms	55 ms	76.7 ms	35 ms
Average rotational/relay time	8.3 ms	12.5 ms	8.3 ms	10.5 ms
Average access time	33.3 ms	67.5 ms	85 ms	45.5 ms
Data transfer rate	1.2MB/sec.	512KB/sec.	5MB/sec.	1.25MB/sec.
Supported by system models	VAX-11/725, 11/730, 11/750, 11/780, 11/782, 11/785	VAX-11/725, 11/730, 11/750, 11/780, 11/782, 11/785	MicroVAX I	VAX-11/725

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

release incorporates features both to enhance program compatibility across all individual members of the VAX family and to allow users to build a homogenous environment around VAXcluster configurations.

Enhanced cross-system compatibility has been effected in VAX/VMS Version 4.0 by the removal of PDP-11 compatibility-mode utilities, which had been intrinsic to prior versions of VAX/VMS. Those utilities are now offered as part of a separate package called VAX-11 RSX, which allows simulation of the RSX-11M and RSX-11M-Plus environments for execution and development of PDP-11 programs. The removal of the compatibility-mode utilities from VAX/VMS makes the system more architecturally congruent with MicroVMS, the operating system for the low-end MicroVAX I, which lacks PDP-11 compatibility features. Because the two versions of VMS are now congruent, VAX applications can be transported among systems

- **Execution of floating point instructions.**
- **Use of both instruction space and data space.**
- **Execution of privileged functions such as 1) HALT, RESET and special instructions, such as traps and WAIT, which are normally reserved for operating system usage; 2) direct access to internal processor registers such as the Processor Status Word and the Console Switch Register; 3) direct access to the trap and interrupt vectors, which must be initialized for interrupt servicing; and 4) execution in any mode other than user-mode, along with the corresponding access to the alternate general register set.**

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

MAIN STORAGE

TYPE: ECC MOS RAM.

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all along the line, from the smallest MicroVAX I to the largest VAXcluster configuration, without recompiling or relinking.

According to DEC, the networking extensions incorporated into Version 4.0 of VAX/VMS represent the second phase in the implementation of the VAXcluster program. They provide VAXcluster users with completely distributed resources by allowing transparent access to all systems in a network. The new 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.
- 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.
- Terminal Server support, allowing terminals to be connected flexibly to VAXcluster systems and providing load balancing and availability features.

Version 4.0 of VAX/VMS provides terminal support through the Local Area Transport (LAT) protocol. The Terminal Server itself is a new piece of hardware; it 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 using the LAT protocol on an Ethernet LAN. This device allows multiple terminals to be connected in configurations independent of specific host or nodal processing units and permits users at terminals connected to the server to establish virtual circuits to one or more hosts. Input and output from the terminals appear identical to those from directly connected terminal and host nodes.

Additional networking capabilities have been implemented through the release of Version 4.0 of Digital's DECnet VAX networking software. This new version, which provides support for both local and wide area networks, is available in packages for MicroVMS and VAX/VMS. The most significant feature of the new release is an extended routing algorithm that allows development of networks containing several thousand processors, multiplying the 1023-processor limit previously permitted.

DEC has addressed the fourth point in its VAX strategy through several significant software products for application development and information management. The most important of these is the Ultrix-32 operating system for the VAX-11/730, 11/750, 11/780, and 11/785; it had previously been available only for the MicroVAX I.

CYCLE TIME: The VAX-11/785 has main storage cycle times of 600 nanoseconds per 64-bit read and 700 nanoseconds per 64-bit write.

The VAX-11/782 and 11/780 have an 800-nanosecond cycle time per 64-bit read, 1400 nanosecond cycle time per 64-bit write. The VAX-11/780 processor includes an 8K-byte write-through memory cache that results in an effective 290 nanosecond memory access time. On the VAX-11/750, effective memory access time is 400 nanoseconds. The read/write cycle time is 810 nanoseconds for the 11/730 and 11/725, and 250 nanoseconds for the MicroVAX I.

CAPACITY: Main memory capacities range from 256K bytes on the MicroVAX I to 36 megabytes (32 megabytes on-board and 4 megabytes shared) on the VAX-11/780 and VAX-11/785. 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.

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 32M bytes. Because up to two MA780s can be attached to VAX-11/780 and 11/785 CPUs, those systems can now directly address up to 36M 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 system's 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.

Battery backup support is included for the 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 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 11/780 and 11/785 VAXcluster with CI780.

CACHE MEMORY: A 32KB bipolar cache memory is available on the VAX-11/785; the VAX-11/780 and 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 11/730. The MicroVAX I has an 8KB direct-mapped cache memory.

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CHART C. TERMINALS

DEVICE	DESCRIPTION
VT220–A, –B, –C	VT200 monochrome video display terminal; white (A), green (B), or amber (C) phosphor screen; advanced video features; programmable function keys; line drawing character set; 24 lines x 80 or 132 characters; communication speeds to 19,200 baud; EIA and mA standard interface; VT100 and VT52 compatibility modes
VT240–A, –B, –C	VT240 monochrome video display terminal; white (A), green (B), or amber (C) screen; shares features VT220–A, –B, –C; of comprises monitor, keyboard, and system box with power supply and logic; integral modem optional; VT100, VT52, and Tektronix 4010/4014 compatibility modes; word processing keyboard available
VT241–AA	VT241 color graphics terminal; shares characteristics of VT240
VT100–AA(AB)	VT100 tabletop video display terminal; operates on full duplex asynchronous communications lines; standard EIA interface; 50 to 19,200 bps baud rate; 24 lines x 80 characters or 14 lines x 132 characters (selectable); 7 x 9 dot matrix, 2 dot descenders; 94-character ASCII and 32 special graphics characters
VT100–WA(WB)	VT100 tabletop video display terminal with advanced video and word processing keyboard
VT101–AA(AB)	VT101 tabletop video display terminal; operates on full-duplex, asynchronous communications lines; standard EIA interface; 50 to 19,200 bps baud rate; 24 lines x 80 characters ASCII with 32 special graphic characters; 83-key detachable unit; standard numeric/function keypad
VT102–AA(AB)	VT102 tabletop video terminal; 50 to 19,200 bps baud rate; 24 lines x 80 characters or 132 characters; 7 x 10 dot matrix with 2 dot descenders; 94-character ASCII set with 32 special graphics characters; US and British character sets standard, others optional; normal or reverse video, blinking, underline, and bold characters on a character-by-character basis; standard numeric/function keypad
VT102–WA(WB)	VT102 tabletop video display terminal with word processing keyboard
VT125–AA(AB)	VT125 tabletop graphics terminal; EIA/CCITT interface; 50 to 19,200 bps baud rates; even, odd or none (keyboard selectable parity); 768 x 240 pixel graphics resolution; printer port for graphics mode; 24 lines x 80 characters or 14 lines x 132 characters; 7 x 10 dot matrix with descenders; 96-ASCII character set (upper-/lowercase; numeric and punctuation) with 32-character special graphics set; split-screen capability
VT125–WA(WB)	VT125 tabletop graphics terminal with advanced video capability and word processing keyboard
VT131–AA(AB)	VT131 video terminal with full VT102 capability plus local editing and block mode transmission
RT100–AA(AB), –BA(BB)	RT100 ruggedized video terminal for industrial environments; includes sheet-steel case, filtration system, and hinged keyboard; –AA(AB) has EIA interface, –BA(BB) has 20 mA interface
RT102–AA(AB), –BA(BB)	RT102 ruggedized video terminal for industrial environments; –AA(AB) has EIA interface, –BA(BB) has 20 mA interface
RT137–AA, –BA	RT137 bar code terminal; includes RT100 video terminal with bar code reader, bar code keyboard, VT100 keyboard, and light pen; –AA includes EIA interface, –BA includes 20 mA interface
VS11–AA (AB)	VS11 Unibus systems color raster graphics display station; includes image processor, image memory and synchronous generator module, joystick, and optional 19-inch monitor; 16 discrete colors; 512 x 512 resolution
VS11–FC(FD)	VS11 Unibus systems color raster graphics display station; shares features of VS11–FA and includes second frame buffer
LA12–AB	LA12 DECwriter Correspondent hardcopy terminal; includes 80/150 cps printer; integral 1200 baud dial-through-keyboard modem; 300 baud coupler; EIA interface; carrying case
LA12–CB	LA12 DECwriter Correspondent hardcopy terminal; same as LA12–AB, but without 1200 baud modem
LA12–D	LA12 DECwriter Correspondent hardcopy terminal with RS–232–C interface
LA100–BA, –CA	LA100 Letterwriter 100 keyboard send/receive hardcopy terminal; includes 30/80/240 cps printer; –CA includes multiple font option
LA120–DA	LA120 DECwriter keyboard send/receive hardcopy terminal; includes 180 cps bidirectional printer

Ultrix–32 is a native-mode implementation of the Unix operating system. It is based on the University of California at Berkeley's Fourth Berkeley Software Distribution (4BSD). It is an interactive, timesharing system that employs a demand-paging scheme to take advantage of the virtual memory architecture of VAX–11 systems. It supports Unix Version VII Bourne and C shells, as well as the C, Fortran 77, Pascal, FranzLisp, and Unix assembler programming languages. Ultrix–32 also has facilities that permit communication among Unix and non-Unix systems. Ultrix–32 also has limited compatibility with V7M–11, the Unix Version VII-based operating system available for PDP–11 systems. DEC is marketing Ultrix–32 not as a

CENTRAL PROCESSOR

GENERAL: 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 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. Both VAX–11/780s must be at the same revision level and the same version of microcode.

The VAX–11/780 processor has a 32-bit architecture based on the DEC PDP–11 family of 16-bit minicomputers. While

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CHART D. PRINTERS

MODEL	LQP02	LXY	LP25	LP26	LP27	LN01
Type	Daisywheel	Dot-matrix	Band	Band	Band	Laser
Speed	32 cps	170-600 lpm	300 or 300/215	600 or 600/445 lpm	1200/800 lpm	12 ppm
Bidirectional printing	Yes	No	Not applicable	Not applicable	Not applicable	Not applicable
Paper size	Up to 13.5 inches	—	Up to 15 inches	Up to 15 inches	Up to 18.75 inches	8.5 x 11 or 8.5 x 14 inches
Character formation	Full	Variable	Full	Full	Full	300 x 300 dots/sq. in.
Horizontal character spacing (chars./inch)	10 or 12	Variable	Variable	10	10	13.6
Vertical line spacing (lines/inch)	6 or 8	—	6 or 8	6 or 8	6 or 8	8.57
Character set	Over 25 different sets	96 or 192	64 or 64/96	64 or 64/96	64/96	188
Controller/Interface	RS-232-C	LP11, RS-232-C, DMF32	LP11, DMF32	LP11, DMF32	Integrated, DMF32	LP11, DMF32
No. of printers per controller/interface	—	—	—	—	—	—
Printer dimensions, in. (h x w x d)	7 x 25 x 16	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	36 x 25.8 x 26
Graphics capability	No	Yes	No	No	No	No

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

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

general alternative to VAX/VMS, but as a useful adjunct for specialized applications, including software development, academic computer science research, computer-aided design, and robotics.

The company also released VAX Rdb/ELN and VAX Rdb/VMS, the first relational database management products for VAX-11 systems. VAX Rdb/ELN runs on the MicroVAX I, VAX-11/725, VAX-11/730, and VAX-11/750 in dedicated or distributed VAXELN (formerly VAXElan) environments. VAX Rdb/VMS runs on systems using VMS or MicroVMS. The two VAX Rdb systems are designed for low- and medium-volume applications in which data items and relationships among records change frequently. They complement VAX-11 DBMS, the Codasyl-compliant database management system designed for large, highly structured databases.

The two VAX Rdb products use a standard relational application interface that allows application programs written for either product to access data managed by the other. The two products can also retrieve and update information from both local and remote databases. Databases on re-

using address modes and stack structures similar to those of the PDP-11, the VAX-11/780 provides 32-bit addressing for a large program address space, and 32-bit arithmetic and data paths for increased processing speed and accuracy. 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 12 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 provides 32-bit addressing, sixteen 32-bit general registers, and 32 interrupt priority levels. The instruction set operates on integer and floating point operands, character and packed decimal strings, and bit-field data. The instruction set supports nine fundamental addressing modes. The VAX-11/780 can be upgraded to a VAX-11/785.

Except for cache memory size, 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 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 in timesharing, computation-intensive, and realtime environments. The 11/785 also features an

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mote systems can be accessed through DECnet communications links; the database can reside on one system in a network and be accessed transparently by all other systems.

Two recently introduced VAX program development languages are RPG II and Lisp. VAX RPG II is a native-mode implementation of the RPG II programming language, enhancing industry-standard specifications common to RPG II implementations. VAX RPG II can call both routines written in other VAX languages and services provided by the VMS operating system or the Runtime Procedure Library. According to DEC, VAX RPG II also permits a number of nonarchitecturally dependent programs written in other versions of RPG II to compile and execute unaltered on VAX/VMS systems.

VAX Lisp is intended for development of artificial intelligence (AI) programs that simulate human behavior and thought through representation of real-world properties and objects and the relationships among objects. Developed to manipulate symbolic values and perform numerical computations, VAX Lisp is an implementation of Common Lisp, the most widely used AI language.

Also, DEC has enhanced VAX Fortran, long the language of choice among VAX-11 users. The compiler now includes a multiphase optimizer that performs optimizations across entire program units. The sharable, reentrant compiler optimizes source programs while taking advantage of the VAX character string and floating point instruction sets. According to DEC, the enhancements improve the runtime performance of Fortran application programs by 10 to 50 percent over that provided by previous versions.

In addition to carrying through its specific product strategy for the VAX-11 family, DEC has also continued generally to enhance the peripherals available for the VAX-11 family; many of those peripherals are also PDP-11-compatible. Among the most recent additions to the peripheral roster are the VT200 family of terminals, the DECtalk voice synthesis module, and the LVP16 graphics pen plotter.

The VT200 series terminals extend the features of, and will eventually replace, the popular VT100 family (which will remain in new production at least through 1985). The VT200 family comprises the VT220, VT240, and VT241. The low-end VT220 is a monochrome text terminal. The mid-range VT240 and the high-end VT241 are interactive terminals that generate text and medium-resolution bit-map graphics. The VT240 has a monochrome monitor, while the VT241 employs a color monitor. All three VT200 terminals feature VT100 emulation capabilities.

DECtalk 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. It 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.

average interrupt latency of 28 microseconds, reportedly fastest in the VAX-11 family.

The VAX-11/785, like the 11/780, features a main memory capacity of 32 megabytes and a two-way set associative cache memory; cache size on the 11/785, however, is 32K bytes. According to DEC, the larger cache reduces bus traffic, allowing enhanced I/O performance in large time-sharing applications. 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. The floating point instruction set on the 11/785 features G and H data types, which are optional on the 11/780, for double- and quadruple-precision operations, respectively. A floating point accelerator that uses the same technology and timing as the VAX-11/785 processor can be added to enhance the CPU's floating point performance.

Despite the differences in processor technology and performance, however, the VAX-11/785 employs the same bus structure and I/O capabilities as the 11/780. Special synchronization circuitry on the 11/785 allows it to use the same Synchronous Backplane Interconnect (SBI) interfaces, controllers, and peripheral equipment as the older system without modification. The 11/785 can handle up to the same number of workstations and the same amount of disk storage as the 11/780.

The VAX-11/750 CPU performs the logical and arithmetic operation requested of the computer system. Its user-programmable registers include sixteen 32-bit general-purpose registers for data manipulation, and 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. Up to 4M bytes of main memory can be added. Each VAX-11/750 system contains one Unibus adapter for standard peripherals and up to a maximum of 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 VAX-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.

DEC's entry-level VAX-11/725 is a packaged product that contains a VAX-11/730 processor.

The MicroVAX I implements a subset of the VAX architecture that retains all key elements of the family. These include: full virtual memory management with address capability of more than four billion bytes; sixteen 32-bit general registers; 32 hardware and software interrupt priority levels; and all native-mode instructions for byte, word, longword, quadword, and single- and double-precision floating point data types. The MicroVAX I central processor resides on two quad-height modules that occupy adjacent slots in the Q22 backplane. One module contains the 32-bit data path, microsequencer, and control store. The second is a memory management and cache module, which provides the logic for interfacing the Q-Bus to the internal 32-bit VAX architecture. The new system uses standard Q-Bus memory modules and performs all memory data transfers in block mode for optimal performance.

Memory management on VAX-11/780, 11/785, and 11/782 systems includes four hierarchical processor access modes that are used by the system to provide read/write page

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The LVP16, a six-color graphics pen plotter with print speeds up to 15 ips, is supported by all VAX-11 systems that use HP-GL graphics software. The LVP16 holds up to six pens and prints up to six colors without manual intervention.

The foundation of DEC's VAX strategy, of course, is provided by the computers themselves. In addition to the new VAX-11/785, the family consists of the MicroVAX I, VAX-11/725, VAX-11/730, VAX-11/750, VAX-11/780, and VAX-11/782.

The MicroVAX I is a two-board microcomputer contained in a small, floor-standing or rack-mountable package. With CPU performance averaging 35 percent that of the VAX-11/780, the MicroVAX I is intended for machine and process control applications in industry, for OEM systems, and for single-user and small, multiuser computing requirements in business and scientific fields. The MicroVAX I system implements a subset of the VAX architecture that retains all key elements of the family, including full virtual memory management with address capability of more than four billion bytes. It employs the Q-Bus for I/O control.

The MicroVAX I features an 8K-byte cache memory and supports from 256K bytes to 2.5 megabytes of main memory. It can accommodate up to eight workstations and supports from 10.8 to 28.8 megabytes of on-line disk storage. Storage options include a 5¼-inch, 10-megabyte Winchester disk subsystem and a dual floppy diskette drive with total storage of 800K bytes. A 28-megabyte Winchester disk is also available. The system uses the same enclosure as the Micro/PDP-11 computer.

DEC's smallest Unibus-based VAX system, the general-purpose, multiuser VAX-11/725, contains a VAX-11/730 central processing unit with a 52-megabyte 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 graphic display subsystem or other monochrome or color display, the VAX-11/725 computer will support medium- to high-speed graphics for integrated circuit design and logic simulation and other engineering applications. As a multiuser system, the VAX-11/725 can be used for a variety of applications, including material requirements planning and inventory control, scientific word processing, drafting, and general accounting.

The VAX-11/730 incorporates bit-slice and Programmed Array Logic (PAL) technology. It supports from one to five megabytes of memory, 20 megabytes to 2 gigabytes of disk

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 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.

The "intelligent" console on the VAX-11/780, 11/785, and 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 console operator uses keyboard commands for diagnosis, bootstrapping, and incorporating software maintenance modifications.

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 11/730. A remote diagnosis interface is optionally available for the console.

CONTROL STORAGE: 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 these three 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. The processor offers a variety of addressing modes that use the general registers to identify instruction operand locations, including an indexed addressing mode that provides a true post-indexing capability.

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.

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storage, and up to 24 users. The VAX–11/730 can be used as a standalone processor or as a remote DECnet data communications node, allowing its users access to higher-performance members of the VAX family, when necessary. 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 two to eight megabytes of main memory. The VAX–11/750 can also accommodate up to 128 workstations and 121 megabytes to 19 gigabytes 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 8K-byte cache memory and can support between 2 and 32 megabytes of local main memory; it can also support an additional four megabytes of shared memory (as can the VAX–11/785). The VAX–11/780 can accommodate between 121 megabytes and 30 gigabytes 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–11/782 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 eight million bytes of shared memory. The interplay of the two processors is transparent to users. Only one copy of the 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 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 8K-byte cache memory and provides support for 384 workstations and 121 megabytes to 30 gigabytes of disk storage.

COMPETITIVE POSITION

In pursuing its four-part strategy for the VAX–11 family, DEC has made itself a formidable competitor in the information systems marketplace by providing both unity and diversity in its product line. The VAX–11 computers themselves provide a broad range of computing power, from the MicroVAX I for single-user and office-level multiuser applications to the high-end VAXcluster configurations for mainframe-like computational power and storage. These diverse systems are linked through the common VMS operating system architecture, which ensures that applica-

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. In general, however, most users do not use the Stack Pointer, Argument Pointer, or Frame Pointer for purposes other than those designated.

Registers can be used for temporary storage, accumulators, base registers, and index 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.

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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tions are transportable among all systems in the family, regardless of size. The systems are further linked through the connectivity provided by DECnet, which permits creation of a homogenous distributed environment in which the heterogeneous computer systems can be linked to share resources and address computational and informational needs at all levels of an organization. The result is a closely integrated, single-system, single-vendor solution that reduces the risk of system obsolescence and instead provides, in DEC's phrase, "planned, economical, and incremental growth."

DEC's future success in marketing this integrated solution will depend in large measure upon its ability both to provide and to support appropriate systems solutions packages to organizations with very complex production/data processing/communications/MIS environments. Because DEC has chosen such a wide market scope for its VAX-11 systems strategy, it will face head-to-head market-specific competition from such data/transaction/office information processing vendors as IBM, Tandem, and Wang, as well as from a still-expanding group of 32-bit systems, including AT&T's 3B Computer family, Perkin-Elmer's Series 3200, the Gould Concept/32 Series, Data General's Eclipse MV/Family, the Prime 50 Series, Harris's 60, 600, 700, 800, and 1000 systems, Wang's VS systems, IBM's 4300 Series, Tandem's NonStop TXP system, Apollo's Domain Series, Hewlett-Packard's HP 9000, and the high ends of the Honeywell DPS 6, NCR I-9000, and Hewlett-Packard HP 3000 lines.

ADVANTAGES AND RESTRICTIONS

VAX-11 systems have numerous advantages for users. In the first place, the systems feature a high degree of software compatibility. Because all systems run a VMS operating system, applications are transportable among systems from the bottom of the line to the top. This congruity of operating systems 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. (A program developed or modified on a MicroVAX I, for instance, can be executed on a VAX-11/785 to take advantage of the greater processor speed of the high-end system.)

The availability of the Ultrix-32 operating system for VAX-11 systems is also advantageous, for it allows users to choose between the realtime VMS and timesharing Unix environments, depending upon their application requirements.

VAX-11 systems also demonstrate a high degree of hardware upgradability and compatibility, particularly at the upper end of the family. For example, the VAX-11/780 can be field upgraded to the more powerful single-processor

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.

To handle interrupt requests, the processor enters a special system-wide context. In the system-wide context, the processor executes in kernel mode, using a special stack called the interrupt stack. The interrupt stack cannot be referenced by any user-mode software because the processor selects the interrupt stack only after an interrupt, and all interrupts are trapped through system vectors.

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: Nominal operating environment for the 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 1100 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 is 42 by 29 by 30 inches (106 by 74 by 76 cm) in size, approximately one-third the size of a VAX-11/780. 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 Dual RL02 System 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.

The MicroVAX I is 24.5 by 10 by 27 inches (62.3 by 25.4 by 68.5 cm) in size in a floor-standing position, and its chassis weighs under 50 pounds (22.68 kg). Power requirements are 120 volts at 4.4 amp, single phase. Maximum AC power consumption is 320 watts.

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.

I/O CHANNELS: The VAX-11/785 and 11/780 support one to eight I/O channels, while the VAX-11/750 supports from one to five.

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VAX–11/785 or to the multiprocessor VAX–11/782. In addition, 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.

On the negative side, the VAX–11 family suffers from a slight shortage of single-processor power at the high end of the line, and that deficiency puts it at a slight competitive disadvantage. The VAX–11/785 does provide a single-processor upgrade path for the older VAX–11/780; however, it operates at only about 1.5 MIPS, significantly slower than a number of its major competitors. (Data General's Eclipse MV/10000, for example, performs at about 2.5 MIPS.) Although the VAX–11 systems are indisputably powerful, the line is slightly stagnant as far as processor power goes, particularly in relation to certain competitors; it is likely to remain so until DEC comes out with the long-awaited superVAX, which will reportedly operate at 5 MIPS.

Users who want full PDP–11/VAX–11 compatibility have also been placed at a disadvantage by the removal of the PDP–11 compatibility utilities from Version 4.0 of VAX/VMS. Those utilities only provided compatibility with RSX–11 operating environments even when they were intrinsic to VAX/VMS. (Migration tools were required for other PDP–11 applications to move into the VAX/VMS environment.) Now that the utilities have been integrated into a separate package, VAX–11 RSX, that somewhat limited compatibility can be acquired only at extra cost.

USER REACTION

Datapro's 1984 Computer Users Survey brought responses from 242 VAX–11 users; the respondents' systems had an average installed life of 36.9 months. One hundred and eighty-one users (75.4 percent) had purchased their systems, forty-eight leased from a third party, and eleven leased their systems from DEC.

One hundred and twenty-three users (50.8 percent) were running accounting/billing applications on their systems; one hundred and seven (44.2 percent) ran engineering/scientific programs. Eighty-seven users employed their systems to run payroll/personnel applications, and another seventy-five used theirs for education/scheduling/administration packages. Sixty-five users ran mathematics/statistics packages on their VAX systems; fifty-nine reported running order processing/inventory. Forty-three users reported running purchasing applications, thirty-six reported manufacturing programs, and thirty-two reported using sales/distribution applications. Other applications men-

Q–BUS: A four-row, eight-slot backplane incorporates the 22-bit Q–Bus for I/O with a variety of options on the MicroVAX I. Block mode data transfers allow data rates up to 2.5M bytes per second. The backplane can accept either quad- or double-height modules. There is a choice of two quad-height families of Digital memory modules, 256K bytes or 512K bytes of RAM storage.

The MicroVAX I CPU communicates with peripheral devices on the Q–Bus through standard Q–Bus pinning. Four patch panels allow device connection and data transmission rate selection from 50 to 19.2K baud without opening the system unit. One panel connects the console terminal, two panels are available to support four EIA communication lines each, and another panel is available for attaching communication gear such as Ethernet.

UNIBUS: All devices other than the high-speed disk drives and magnetic tape transports are connected to the Unibus, an asynchronous bidirectional bus. These include all Digital- and user-developed realtime peripherals. The Unibus is connected to the memory interconnect through the Unibus adapter. The Unibus adapter does priority arbitration among devices on the Unibus. Unibus adapters may be placed on the memory interconnect as follows: 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, and 11/785, and to 24 bits on the 11/750, 11/730, and 11/725.

On the 11/782, 11/780, and 11/785, 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, and 11/782, 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.

MASSBUS: Used to attach high-speed disk or magnetic tape devices, the Massbus adapter performs control, arbitration, and buffering functions. Up to four Massbus adapters can be connected to the memory interconnect on the 11/782, 11/785, and 11/780, and up to three adapters on the 11/750. 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.

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tioned included process control, health care/medical, construction/architecture, insurance, and petroleum/fuel analysis.

Fortran, cited by 85 users, was the programming language used most often. Fifty-one users employed Basic, and forty-one used Cobol. Seventeen respondents reported using Pascal. Assembler and PL/1 were other languages mentioned. Two hundred and nine users (86.4 percent) reported that their application programs were developed by in-house personnel. Programs from third-party suppliers were used by 145 respondents; 94 users reported employing packaged programs from DEC. Forty users said they resorted to contract programming, while five reported using custom programs developed by DEC personnel.

Main memory capacities on the installed systems ranged from 512K bytes to more than 32 megabytes. Thirteen users reported a memory capacity between 512K bytes and one megabyte; thirty reported between one and two megabytes. Seventy-one users reported main memory between two and four megabytes, while ninety-seven reported a capacity between four and eight megabytes. Twenty-six users reported between 8 and 16 megabytes, three reported between 16 and 32 megabytes, and two reported over 32 megabytes.

Disk storage on the respondents' systems ranged from less than 10 megabytes to more than 4.8 gigabytes. Two users had less than 10 megabytes of disk; three had between 10 and 50 megabytes. Six users had between 50 and 100 megabytes of disk. Eighty-one users reported disk capacities between 100 and 600 megabytes, while ninety-six reported capacities between 600 megabytes and 1.2 gigabytes. Forty-three users cited disk storage capacities between 1.2 and 4.8 gigabytes; only four reported storage capacities in excess of 4.8 gigabytes.

Eleven users reported between one and five local workstations. Fifty-five reported between 6 and 15 local stations, sixty-five reported between 16 and 30, and seventy-three reported between 31 and 60. Thirty-seven users had more than 60 local workstations. Forty-four users had no remote workstations. Seventy-nine had between one and five remote stations, while forty-eight had between 6 and 15. Twenty-four users reported between 16 and 30 remote workstations, sixteen had between 31 and 60, and twenty had over 60 remote stations.

Ninety-eight users employed a database management system, while one hundred and four did not; thirty-five said they planned to implement one in 1984. Only 18 users employed a communications monitor; 193 (83.9 percent) did not, and only 19 planned to install one in 1984. Ninety-seven users had integrated office automation functions on their VAX systems, while one hundred and six had not; 28 planned to add office automation capabilities in 1984. One hundred and fourteen users had disaster recovery plans, eighty-one had none, and forty-four intended to implement recovery plans in 1984.

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

INTELLIGENT CONTROLLER: The HSC50 (Hierarchical Storage Controller) is a Computer-Interconnect-based intelligent disk/tape server that offers full architectural support for and optimizes data integrity, throughput, and subsystem availability of high-density disks such as the removable RA60 disk drive, and the RA80 and RA81 fixed (Winchester) 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 disk data-channel bandwidth of 3.125M bytes per second, each; a tape data-channel bandwidth of 1.25M bytes per second, each; a data buffering bandwidth of 13.3M bytes per second, total; and a request processing overhead of 1.6 millisecond per request.

CONFIGURATION RULES

SYSTEM BUILDING BLOCKS (SBBs) begin with a core of components: CPU, two or four megabytes of 64K or 16K ECC MOS 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, console terminal, and software menus (*see* Equipment Prices and Software Prices, below). The number of components that can be added varies between VAX/VMS and Ultrix–32 SBBs; Ultrix–32 systems have more limited configurability. SBBs are available for the VAX–11/730, 11/750, 11/780, 11/785, and 11/782.

VAXclusters: A VAXcluster is composed of one or more VAX–11/750, 11/780, 11/785, or 11/782 processors running on VAX/VMS connected by a high-speed bus, one or more mass storage servers, and communication links to the user community. VAXcluster systems are configured by starting with a standard Building Block system and adding a CI750 or CI780 Computer Interconnect. There are two types of System Building Blocks. The first type is a basic system element, which, for the 11/78X CPUs, consists of a VAX–11/780 or 11/785 CPU with 2MB of memory, or a VAX–11/782 CPU with 4MB of memory, CI780 computer interconnect, HSC50 intelligent controller, and two disk and tape interfaces (each with four ports), an SC008–AC star coupler, and a VAX/VMS operating system license. The second type of Cluster System Building Block is an upgrade to an existing VAXcluster. The 11/78X series CPU upgrade consists of a VAX–11/780 or 11/785 CPU with 2MB of memory or a VAX–11/782 with 4MB of memory, and the CI780 computer interconnect and VAX/VMS operating system license. To this must be added an LA120 console terminal, and an optional system disk such as the RA60, RA80, or RA81 disk drive.

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The following table shows the ratings that the survey respondents gave to their VAX-11 systems.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	131	97	7	0	3.5
Reliability of system	150	78	11	0	3.6
Reliability of peripherals	94	125	16	0	3.3
Maintenance service:					
Responsiveness	101	107	26	5	3.3
Effectiveness	80	120	31	4	3.2
Technical support:					
Troubleshooting	48	128	47	11	2.9
Education	43	131	50	6	2.9
Documentation	57	127	40	10	3.0
Manufacturer's software:					
Operating system	129	95	8	0	3.5
Compilers & assemblers	114	105	10	0	3.5
Applications programs	37	111	29	4	3.0
Ease of programming	93	114	22	0	3.3
Ease of conversion	54	125	28	6	3.1
Overall satisfaction	103	122	6	0	3.4

*Weighted Average based on a scale of 4.0 for Excellent.

Citing advantages, 202 users (88.6 percent) gave high marks to the VAX-11 systems for ease of conversion and reconfiguration; 169 (79.8 percent) gave high ratings to the systems' ability to support peripherals and terminals transported from other systems. One hundred and sixty-five users (77.5 percent) praised the power and energy efficiency of their systems. Also, commenting on support, 208 users (87.4 percent) remarked that they found it very easy to keep up with and implement changes made by DEC to VAX-11 hardware and software.

While most users responded favorably, some negative responses surfaced. Eighty-nine users (36.8 percent) remarked that they found their systems to be noisy. Sixty-six (30.4 percent) gave low ratings to the compatibility of programs and data transported from other systems. Eighty-one (34.7 percent) complained about late delivery or installation of equipment.

To supplement the assessments provided in response to the survey, we contacted four respondents in June 1984; each represented a different type of enterprise in a different section of the United States.

The first user contacted represented a college in the Middle Atlantic region. He said that he was very pleased with his VAX-11 system, and particularly with the VAX/VMS operating system. He remarked that he found VAX/VMS to be user-friendly and the command language very easy to use. He also praised security features in the operating system that prevent unauthorized personnel from accessing restricted system routines. Feeling that the system provides a good base for expansion, he remarked that memory was being upgraded from four to eight megabytes and that optical scanning equipment was being added.

The first user gave DEC high marks for hardware and software support. He said that he routinely receives software updates from the company. Also, he said that he usually receives a service call within two hours of reporting

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-11/782 and VAX-11/780 contain the CPU, with virtual memory management, bootstrap loader, standard instructions for floating- and fixed-point arithmetic, 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 VAX-11/785 incorporates most of 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.

The VAX-11/782, 11/780, and 11/785 systems also include in the standard System Building Block configuration an integral diagnostic console subsystem for use in both local and remote operations. This subsystem consists of an LSI-11 microcomputer to which an RX01 floppy disk unit and an LA120 console terminal are connected.

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 11/782 CPU: shared memory option, H7112 Memory Battery Backup, FP782-AA(AB) high performance Floating-Point Accelerator with power supply, DW780 Unibus adapter, KE780 G & H floating point microcode, CI780 interface, and a serial line unit for remote diagnosis.

VAX-11/782 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, and the DMP11, DMR11 and DUP11 Communications Interfaces.

The following options are available for the 11/780 and 11/785 CPUs: additional 64K chip MS780 memory modules up to a total of 32MB, DR780 General Purpose Interface, MA780 Multiport Memory Controller, H7112 Memory Battery Backup, FP780 or FP785 Floating Point Accelerator, DW780 Unibus Adapter, KE780 G & H floating point microcode (11/780 only), KU780 User Writable Control Store, CI780 interface, and a serial line unit for remote diagnosis.

VAX-11/780 and 11/785 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, and the DMP11, DMR11 and DUP11 Communications 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. Also included in the standard System Building Block configuration is the console subsystem made up of an integral TU58 tape cartridge unit and an LA100 or LA12 terminal.

Expansion space for 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 User Writable Control Store, H7112 Memory Battery Backup, CI750 computer interconnect, and a serial line unit for remote diagnosis.

VAX-11/750 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchro-

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a serious hardware problem; moreover, the DEC service representative stays on site until the problem is completely solved. His system receives remote diagnostic support, he said, so the service representative frequently knows what the problem is before arriving.

The second user, representing a manufacturing concern in the South, provided a more mixed reaction. He remarked that he was very happy with the operational features and configurability of his VAX-11. "Hardware-wise," he said, "it's a super system.... The expansion capabilities are very good." He remarked that he had recently expanded modem support and had added a multiplexer for four additional communications lines. He also commented that the hardware support he receives from DEC—aided by a remote diagnostic facility—is very good.

He expressed a lower opinion of the sales and software support he received. He said that the initial configuration that DEC proposed was insufficient for his needs; even though both parties knew that, the sales representatives resisted changing the order so that they could put it through. He also said that he had had an order for memory unfilled for nine months; at one point, he had to cancel the initial order and submit another one. He characterized the telephone center that provides software support as "useless," saying he never receives an adequate response to a reported problem.

The third user, representing a federal government installation in a Rocky Mountain state, was unhappy with the performance he receives from his two VAX-11 systems. He said that the systems are down more than up, and attributed the problem to an intrinsic imbalance in the system design. He said he feels that the system will support far more memory than is warranted by the computational power of the processor; although a number of programs can be loaded into memory simultaneously, he said, the first one can cause the system to halt and thus negates the advantage of the large main storage capacity. He also said that he felt the I/O bus on his system provided insufficient throughput. He said that he would be switching from four megabytes to eight megabytes of interleaved memory on each system, and had been told that the switch would increase each system's performance by 15 percent; he said, "I'll believe it when I see it."

The third user also expressed displeasure with the system support he receives from the DEC service center. He said that the service center will only take calls from specifically authorized personnel at his site; in his opinion, that policy of selective reporting and response reduces the amount of effective service the organization can obtain. He did say, however, that the level of support his organization receives has improved since DEC established a training center nearby.

The fourth user, who represented an engineering concern on the Pacific Coast, was completely pleased with his system. He said that his VAX-11 system was reliable, and he registered particular approval of the VAX/VMS operat-

nous Interfaces, and the DMP11, DMR11 and DUP11 Communications Interfaces.

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, high-precision programmable realtime clock, and time-of-year clock with battery backup. Also included in the standard System Building Block configuration is the console subsystem made up of two integral TU58 tape cartridge units and an LA100 or LA12 terminal.

Expansion space for 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: additional 64K chip MS730 memory modules up to a total of 3MB, FP730 Floating Point Accelerator, H7750 Memory Battery Backup, TU80 Magnetic Tape Controller, LP11 Printer Controller, and LP32 Printer via the DMF32 port.

VAX-11/730 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, the DR11-W general-purpose interface, the DEUNA Ethernet communications controller, and the DMP11, DMR11 and DUP11 Communications Interfaces.

DEC's entry-level VAX-11/725 is a packaged product that contains a VAX-11/730 CPU, up to 3M bytes of advanced 64K-chip main memory, a built-in VAX Unibus adapter, two TU58 tape cartridge drives, and the RC25 52M-byte fixed and removable 8-inch Winchester drive. The 11/725 is available with the FP730 floating point accelerator, DMF32 controller, DMR11 high-speed DECnet card, DEUNA Ethernet communications interface, VAXstation 100 hardware and software, and choice of hard copy (LA100) or soft copy (VT100/VT200 series) console.

The MicroVAX I CPU supports Q-Bus options and interfaces including: a 256K-byte dual-size board and a 512K-byte quad-size board main memory module; 800K-byte RX50 5.25-inch dual diskette drive, 10M-byte RD51 5.25-inch Winchester drive, and 28M-byte 5.25-inch Winchester drive mass storage devices; hardcopy, alphanumeric, and graphic video terminal peripheral interfaces; analog/digital converter, analog multiplexer, and digital input realtime laboratory interfaces; and the Ethernet local area network interface. Maximum Q-Bus I/O throughput is 2.5M bytes per second.

On VAX systems, the DMR11 series synchronous communications line provides high performance point-to-point interprocessor connection using the Digital Data Communications Message Protocol (DDCMP). For very high performance interprocessor communications, the 11/780 and 11/785 offer both multipoint memory (MA780) and a high-speed channel interface (DR780). The DR11-W is a general-purpose interface that performs high-speed block data transfers between the VAX memory and user peripheral devices.

WORKSTATIONS: Up to 384 terminals may be configured with the 11/782, 11/780, and 11/785 (96 per each Unibus adapter); up to 128 terminals may be configured with the 11/750 (64 per each Unibus adapter); and up to 8 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 8 terminals.

DISK STORAGE: Each Massbus adapter can support up to eight disk drives. Up to eight disk drives may be configured

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ing system. He remarked that VAX/VMS provides good tools for system monitoring and management, makes the system easy to configure, and is easy to keep up-to-date. He also said he felt that DEC's VAX Information Architecture tools are particularly strong for software development and information management. He indicated that his VAX-11 system provides a solid base for expansion, and said that plans are already under way to add another mid-range VAX-11 system and to bring 11 of the firm's 15 branch offices on-line to the corporate system through 9600-baud communications facilities. (Four offices are already tied in.) He also said that the company plans to install a MicroVAX I in one of its western offices and connect it to the corporate system through DECnet for completely distributed processing.

The fourth user also praised the service he receives from DEC. Although he remarked that DEC software support personnel sometimes assume too much knowledge on the user's part and thus place too much of the burden of service on the recipient, he had unqualified praise for DEC's hardware support. He stated that service personnel usually arrive within two or three hours after a hardware problem has been reported, and always seem to have the appropriate technical knowledge to address the problem. He characterized the service he gets from DEC as far superior to that which he had previously received from third-party maintenance organizations. □

per Unibus. The 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. The 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: Maximum of two TS11 subsystems on the 11/750 and one TS11 subsystem on the 11/730. Each Massbus adapter can support up to eight tape formatters.

PRINTERS: One LP11 lineprinter is required on the 11/730 (a maximum of one per system). Up to 4 lineprinters 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

For information on available terminals please refer to Chart C, Terminals. For information on available printers please refer to Chart D, Printers. For information on available magnetic tape equipment please refer to Chart E, Magnetic Tape Equipment.

OTHER PERIPHERALS: VAX-11 systems also support dot-matrix printers, printing terminals, a pen plotter, and a voice synthesis module.

The LA50 Personal Printer is a tabletop dot-matrix printer for use with video terminals and small systems. It prints at speeds up to 100 cps in text mode and 50 cps in memo mode; it also has a graphics capability. 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 LA100 is available in two versions: the receive-only Letterprinter 100 and the keyboard send/receive Letterwriter 100. The LA120 is a 180 cps printing terminal. Like the LA100, the LA120 is available in two versions: the receive-only DECprinter III and the keyboard send/receive DECwriter III.

The LVP16, a six-color graphics pen plotter with print speeds up to 15 ips, is supported by all VAX-11 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 Xon/Xoff 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 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.

Six variations of the *DZ11 Asynchronous Multiplexer* are available with VAX systems. Three variations are designed for EIA/CCITT terminals or lines, and the other three are for 20 ma current loop terminals or lines. The DZ11 provides control for up to 16 asynchronous terminal devices or 16 full-duplex lines. Each line can be individually programmed for one of 15 line speeds up to 9600 bps. The DZ11 includes modem controls to operate a Bell 103, 113, or equivalent 300 bps data set.

The DZ11 optionally generates parity on output and checks parity on input. Input characters are buffered with identification hardware in a first-in/first-out (FIFO) buffer, or "SILO" (in DEC terms). Up to 8 or 16 asynchronous serial lines per Unibus can be used in a system.

The *DZ 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 *DMF32 Multipurpose Communications Controller* is an intelligent, high-performance communications controller which enables a combination of modems and terminals to communicate with the VAX system. This upgrade option

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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 lineprinter (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-11 PSI, VAX-11 2780/3780, and 3271 Protocol Emulators. Only the asynchronous lines of the DMF32 are supported under Ultrix-32.

The *DMP11 Multipoint Synchronous Interfaces* permit high-speed Direct Memory Access (DMA) data transfers between computer systems in distributed networks. Parallel data is converted to serial data for line transmission and vice-versa for the Unibus via the controller. The microcode, which is stored in ROM and executed by the microprocessor, implements the Digital Data Communications Message Protocol (DDCMP) protocol. 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. An integral modem is included for connection to shielded cables. 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 Bell 200 series modems or equivalent at speeds up to 9600 bps and includes modem cable and data set control.

The *DMR11 Network Links* are single-line synchronous interfaces for local and remote support, operating in full- or half-duplex. The Network Link for local support provides high-speed connection to another DMR11 or DMC11 using twinaxial, coaxial, or triaxial cable up to 18,000 feet, and includes an integral modem. Switch-selectable speeds are 56,000 bps, 250,000 bps, 500,000 bps, and one million bps.

The remote DMR11 has speeds up to 19,200 bps, includes data set control for switched network operations, and can be used to communicate over common carrier facilities to another DMR11, DMC11, or to a synchronous interface with software implementation of DDCMP version 3.1 or 4.0. The remote Network Link interfaces to EIA RS-232-C/CCITT V.10 synchronous modems (Bell series 200-compatible) and to EIA RS-423/CCITT V.10 synchronous modems.

The *DUP11 Single-Line Synchronous Interface* is full/half-duplex and can be programmed to handle 8-bit character-oriented protocols such as DDPMP and BISYNC, and bit-oriented protocols such as SDLC and HDLC. 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 equivalent at speeds up to 9600 bps.

The *KMS11 Auxiliary Communications Microprocessor* is an intelligent, full-duplex, eight-line synchronous communications front-end for the VAX-11/780 and 11/785 only. The KMS11 supports concurrent data transfers over eight lines with full synchronous modem control, at speeds up to 56K bps. Maximum throughput is achieved by DMA from the multiplexer to the processor under control of the microprogram loaded into the WCS of the device. The KMS11 multiplexer is microprogrammed to off-load link and packet-level functions from the host for ADCCP, HDLC, and 3271 Bisynchronous Communications protocols. 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, MIL-188-114 (unbalanced), and V.24.

The *KCT32 Communications Controller* is an intelligent front-end communications processor for VAX-11/730, 11/750, 11/780, and 11/785 computers in networking and custom communications applications. The KCT32 can be used in computer-to-computer and computer-to-terminal networks, and can be employed to develop VAX-based network applications that require unique protocols. The KCT32 permits users to develop networks that, while not based on Digital's Decnet, are centered around DEC products.

The KCT32 features 56KB of user-programmable memory and employs the PDP-11 instruction set. The unit consists of a single hex-width board; 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 also has supporting software that permits it to run under the VAX/VMS operating system. This software includes on-line and standalone diagnostics and a user-environment test program. Firmware consists of an executive debugging tool based on ODT, as well as software interface modules for modem control, baud rate, direct memory access (DMA) functions between on-board processors and the host, and timers.

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 *PCL11 Parallel Communications Link* is a multidrop computer link used to connect up to 16 processors to form a local distributed network. Full duplex interfaces, residing in each CPU, are interconnected by a single high-speed bus which can operate at speeds up to 1M bits per second depending on the bus length. The maximum bus length is 300 ft. (91 m). CRC and word parity error detection are supported by the hardware.

DECnet is a family of network products that add networking capability to all of DEC's computer families, including the VAX systems. Using DECnet, various kinds of computer system networks can be constructed to facilitate remote communications, resource sharing, and distributed computation. DECnet is highly modular and flexible, and enables the user to select the appropriate hardware and software to build a network that satisfies a particular application's requirements.

Ethernet Communications Servers are small, dedicated computer systems which enable cost-effective resource sharing in a network. They provide specific communications functions for all hosts attached to the Ethernet, freeing individual hosts from performing those functions themselves.

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 the VAX/VMS, RSX-11M, or RSX-11M-Plus operating systems. Both server hardware and software are customer installed.

A Communications Server requires an Ethernet LAN including all the physical channel hardware, Phase IV DEC-

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net 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 standalone LAN configuration supports up to eight systems or system-based devices (not terminals) using standard Ethernet transceiver cables up to 50 meters away. The hierarchical standalone LNI LAN configuration supports a combination of LNIs and devices using standard Ethernet transceiver cables up to 50 meters away. Hierarchical LNI LANs are not connected to the Ethernet coaxial cable. The connected LNI LAN configuration supports up to eight devices using the standard Ethernet transceiver cable up to 50 meters away. 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 1000 meters per repeater. The repeater times, amplifies, and repeats all signals it receives from one segment to the other segment. Both local and remote repeater are connected to the Ethernet via the H4000 transceivers and two transceiver cables. The remote repeater consists of two local repeaters each with a fiber-optic interface board.

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 on an Ethernet LAN; users can acess multiple hosts from the same terminal. This device allows multiple terminals to be connected in configurations independent of specific host or nodal processing units. Users at terminals connected to the Terminal Server can establish virtual circuits to one or more hosts, permitting input and output from the terminals to appear identical to those from directly connected terminal and host nodes.

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.

Because it offloads virtual terminal processing from host nodes, the Terminal Server, according to DEC, enables hosts in a LAN to dedicate more CPU cycles to processing user applications. 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. (A version of LAT software, called LAT–11, is available to enable PDP–11 computers to function as terminal servers.) The Terminal Server is available in two versions, supporting a maximum of 16 or 32 terminals.

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. Unlike most other layers, it has interfaces defined not only for adjacent layers, but also for every other layer in the architecture. The multiple interfaces meet the special requirements of network system management.
- The Network Application Layer, which defines network functions used by the two higher layers. The most important DECnet functions currently operating within this layer are remote file access, file transfer, and the 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. Modules in the User Layer, Network Management Layer, and the Network Application Layer can use all the mechanisms provided by the Session Control and Network Service Layer.
- The Transport Layer, which defines an adaptive-path-routing mechanism for transporting data from one node to a specific node elsewhere in the network over the least costly path, as defined by the user.
- 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. The hardware includes interface devices, modems, and communications lines.

DNA specifies the interface by which DECnet software modules in the same system interact with one another. Reflecting the structure of DNA, DECnet modules are like building blocks. 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 as follows:

- Network Information and Control Exchange protocol (NICE) defines mechanisms for exchanging network,

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node, and configuration data and for servicing requests from modules residing in the Network Management Layer.

- The Data Access Protocol (DAP) 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) 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) defines a mechanism for dispatching data to any node in the network via the best possible route.
- The Maintenance Operation Protocol (MOP) defines mechanisms for transmitting data over a communications channel for down-line loading of a remote node, up-line dumping from a remote node, testing a node and network connections, and starting up an unattended remote node.
- The Digital Data Communications Message Protocol (DDCMP) defines a mechanism for ensuring the integrity and sequentiality of data transmitted over a communications channel.

DNA does not define protocols for all functional layers. For example, User Layer programs communicate over the network according to the rules defined by the programmer. More than one protocol can be defined for the same layer because some layers support more than one function. For instance, the Network Applications Layer can include modules that use the Data Access Protocol (DAP) as well as modules that use a protocol defined by users for a specific application.

SOFTWARE

OPERATING SYSTEMS: Operating systems for the VAX systems include the general-purpose VAX/VMS; MicroVMS, a specially packaged version of the VMS system that supports the less-expensive, Q-Bus-based MicroVAX I configurations; 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.

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 operating system provides a dynamic virtual memory programming environment. Large programs can be executed in a portion of physical memory that is considerably smaller than the program's memory requirements, without requiring the programmer to define overlays. The operating system optimizes its virtual memory system for program locality and provides tools that support optimization. It makes program performance predictable and controllable by restricting paging to the process program, and by allowing the user to cause large amounts of a program to be brought in at one time.

The operating system provides sophisticated peripheral device management for sharing, protection, and throughput. Devices can be shared among all jobs or reserved for exclusive use by particular jobs. Input and output for low-speed devices is spooled to high-speed devices to increase throughput. Files on mass storage devices can be protected from unauthorized access on an individual, group, or volume basis.

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.

VAX/VMS provides the programming tools, scheduling services, and protection mechanisms for multiuser program development. Programmers can write, execute, and debug programs interactively, and can also create batch command files that perform repetitive program development operations without requiring their attention.

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 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 scheduler always ensures that the ready-to-execute time-critical job of highest priority receives control of the processor until it relinquishes it. When no time-critical jobs are ready to execute, the scheduler dynamically allocates processor time to all other jobs according to their resource requirements. The swapper works in conjunction with the scheduler to move entire jobs into and out of memory when memory requirements exceed memory re-

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sources. The swapper ensures that the jobs most likely to execute are kept in memory.

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. The I/O system ensures rapid interrupt response and processing throughput, and provides programming interfaces for both special-purpose and general-purpose I/O processing.

For system and data security, VAX/VMS provides the following features:

- Password and login limits to control, manage, restrict, and monitor access to the system.
- Control lists that define methods of data access.
- Operator interface facilities that allow different classes of operators to be defined.
- Security auditing capabilities for monitoring unusual or suspicious system activities.

VAX/VMS provides features for friendly and flexible system use. The operating system's user interface, the Digital Command Language, allows special prompts and command recall and editing, among other features. The system's operator interface allows flexibility in management of batch and print queues.

VAX/VMS also 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.

MicroVMS is a specially packaged version of the VMS system that supports the less-expensive, Q-Bus-based MicroVAX I configurations, yet provides the same runtime environment as that on larger VAX computers. Because both MicroVMS and VAX/VMS are based on the same architecture, native, user-mode application programs written for VAX systems can run under MicroVMS without change, although they are subject to support on the peripherals available for the MicroVAX I. User-written system services and drivers for VAX/VMS may require alterations to accommodate MicroVAX I hardware.

MicroVMS requires a minimum of one megabyte of physical memory. It includes the same routines found in VAX/VMS for backup, copy, rename, delete, and edit functions. Programming aids include VMS macro and object libraries, assembler, debugger, and system programming utilities.

MicroVMS is available in four basic software kits: extended base system, full MicroVMS, program development upgrade, and DECnet networking. The extended base system kit provides a runtime environment, common utilities, and basic system management facilities. The full MicroVMS kit includes both the extended base system kit and program development upgrades. The program development upgrade kit includes programming language support and extended system programming facilities; depending upon their application needs, customers can install either the entire kit or selected subcomponents. The Phase IV DECnet networking kit is available in two versions: an end node kit and a routing node kit. The end node kit provides full access to a Phase IV DECnet network; the routing node enables the MicroVAX I to pass communications between other DECnet networking nodes.

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). Ultrix-32 can be used on VAX-11/730, 11/750, 11/780, and 11/785 systems. On the MicroVAX I, Ultrix-32 can be used for general-purpose multiuser support, while a special version, Ultrix-32M, can be used for Unix program development. 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, and 11/785 systems.

Ultrix-32 is an interactive, timesharing system. It employs a demand-paging scheme to take advantage of the virtual memory architecture of VAX-11 systems. It features a hierarchical file system with demountable volumes, sharing of input/output resources among processes, and asynchronous process execution. The system also provides settable disk and job quotas for users, as well as over 200 subsystems for program development and execution. Also included are facilities for localizing disk indices and data, increasing block sizes, and controlling fragmentation of data on disk volumes.

Ultrix-32 supports Unix Version VII 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. The UUCP (Unix-to-Unix Communication Protocol) interface allows point-to-point file transfer between an Ultrix-32 system and other Unix systems that use the "g" protocol. Ultrix-32 also permits Ethernet connection between homogenous systems that use DEC's DEUNA Ethernet adapter. Moreover, Ultrix-32 software uses Ethernet facilities to support Arpanet, Milnet, and packet switched networks based on TCP/IP protocols. In addition, an Ultrix-32 mail utility allows transmission of text and data among users in single-user or multinode environments.

Ultrix-32 has limited compatibility with V7M-11, the Unix Version VII-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 V7M-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.

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On the top layer, the VAX languages and VAX-11 FMS (Forms Management System) provide a user interface for interactive and language-callable video forms. VAX-11 Datatrieve supports English-like queries, hardcopy reports, and graphics.

On the next level, the VAX-11 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-11 Datatrieve high-level and distributed data access facilities. High-level access provides the capability to access data without having to specify the means to access it, without specifying the file type, keys, etc. Datatrieve handles this by using definitions in the CDD that contain information about the 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. Users do not have to determine in advance the records they want to link. Using a relational join, the high-level access facility is capable of making these associations dynamically.

The distributed data access facility retrieves data from remote VAX-11 nodes running VAX-11 Datatrieve. The process is totally transparent to the user. A remote query looks just like a local query as far as the results of a Datatrieve request are concerned.

The lowest-level consists of five on-line multiuser data management facilities: VAX-11 RMS (Record Management Services), VAX-11 DBMS (Database Management System), VAX Rdb (comprising two relational database management systems, Rdb/VMS and Rdb/ELN), and VAX-11 ACMS (Application Control and Management System).

The VAX programming languages which are a basic part of the VAX system architecture, are integrated into the information architecture. Language support for high-level access and direct access to VAX-11 RMS files and VAX-11 DBMS databases is provided through the VAX standard calling interface to VAX-11 Datatrieve. Programmers can concentrate on coding the procedural part of the application and call Datatrieve to supply a high-level conditional value-based data access.

VAX-11 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. VAX-11 RMS also supports transparent file access to and from remote DECnet systems.

VAX-11 DATATRIEVE is a complete 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 comprehensive query and report writer with full update capabilities. It also includes an integrated graphics capability and forms support through FMS.

VAX-11 ACMS is a transaction processing software product set for developing and controlling complex, interactive commercial and industrial applications. The VAX-11 ACMS product set comprises two components: VAX-11 ACMS/AD, for developing and maintaining applications; and VAX-11 ACMS, for monitoring and controlling execution of applications developed with VAX-11 ACMS/AD as well as those developed with existing VMS tools. VAX-11 ACMS also provides facilities for creation of operator control menus and for authorization of terminals and users.

VAX-11 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 high-level office functionality and transaction processing capabilities. For users who require an integrated office automation/data processing solution accessible to all end-users, ALL-IN-1 software can be modified to run ACMS under the ALL-IN-1 menu. This avoids the need for an ACMS menu and presents a consistent user interface for both office and data processing tasks. ALL-IN-1 and VAX-11 ACMS software can also be installed without modification and run separately where common access to office and data processing functions is not required.

The *VAX-11 Common Data Dictionary* is the keystone of the architecture. The CDD is prerequisite to the operation of VAX-11 Datatrieve and VAX-11 DBMS. VAX-11 Datatrieve statements refer to data definitions in the Common Data Dictionary. The CDD is also used to store sequences of VAX-11 Datatrieve statements as procedures that can be invoked interactively or from application programs, as well as to store database definitions that VAX-11 DBMS needs to create, access, and maintain databases.

VAX-11 DBMS is a multiuser, general-purpose, full-scale Codasyl-compliant database management system based on the March 1981 Working Document of the ANSI Data Definition Committee. It integrates special ease-of-use and performance features. VAX-11 DBMS is used to administer databases ranging from simple hierarchies to complex, multisystem networks with multilevel relationships. It supports full concurrent access and update activities for large numbers of users while maintaining the integrity and consistency of the database. The VAX information architecture allows DBMS data to be accessed directly from programming languages, through VAX-11 Datatrieve, or through special DBMS utilities. Version 2 of VAX-11 DBMS provides: a new security schema; improved system performance through a page feature for managing free space in storage locations, a Boolean record selection expression on FIND and FETCH data manipulation language statements, and batch retrieval; and control utilities.

The *VAX Rdb* products are relational database management systems. VAX Rdb/ELN runs on the MicroVAX I, VAX-11/725, VAX-11/730, and VAX-11/750 in dedicated or distributed VAXELN environments. VAX Rdb/VMS runs on systems using VMS or MicroVMS.

Unlike VAX-11 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 organize data into tabular relations of rows and columns, constructing dynamic relationships among records. The two products 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. With these two systems, 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 and remote databases. Databases on remote systems can be accessed through DECnet communications links; the database can reside on one system in a network and be accessed transparently by all other systems.

The two VAX Rdb systems employ a data definition language to describe and centrally store data descriptions. Both products also use an interactive query language to manipulate data and to debug application program logic. Transac-

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tion management facilities in both systems treat a series of data manipulation steps as a single, atomic operation. In addition, the two systems employ data validation functions to ensure that data values conform to predefined parameters, while transaction recovery features protect data from program and system failures; VAX Rdb/VMS features long-term journaling for additional protection. Security constraints prevent unauthorized personnel from accessing and altering data. The two systems also feature contention arbitration facilities that handle simultaneous attempts to access the same information.

VAX Rdb/VMS can also work with the VAX–11 Datatrieve query and report facility to access the VAX Rdb/VMS database interactively; VAX–11 Datatrieve can also be used to access VAX Rdb/ELN databases on the same Ethernet as a VAX/VMS system. In addition, VAX Rdb/VMS can work in conjunction with other VAX information management tools, including VAX–11 TDMS, VAX–11 ACMS, and VAX–11 DECgraph.

VAX–11 FMS provides a forms management capability for programming languages and VAX–11 Datatrieve. It provides video form support for applications on VT200, VT100, VT125, and VT52 video terminals. FMS forms are defined interactively and then stored in a FMS forms library. At runtime, VAX–11 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 exactly the same way when FMS forms are used with VAX–11 Datatrieve. If a form name is used as part of a Datatrieve definition, the VAX–11 Datatrieve facility will automatically use the form to collect, display, or modify the associated data.

LANGUAGES: VAX/VMS provides a native programming environment. The native programming environment consists of the language processors that produce native object code and the program development tools that support native program development. VAX Fortran, RPG II, and Lisp and VAX–11 Cobol, Basic, PL/1, Pascal, Coral 66, Bliss–32, DSM, and C 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 optimizing Fortran compiler designed to achieve high execution speed. It 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. It includes switch-selectable support for programs conforming to the previous standard, ANSI X3.9–1966.

VAX Fortran includes language elements for keyed and sequential access to VAX–11 RMS multikey ISAM files, a set of data types beyond those specified for full-language Fortran 77, and a multiphase optimizer that performs optimizations across entire program units. VAX Fortran also allows users to declare composite data structures and to access data in a common data dictionary with one declaration.

VAX RPG II is DEC's native-mode implementation of the RPG II programming language, enhancing industry-standard specifications common to RPG II implementations. In the file specification, for example, VAX RPG II supports sequential, relative, and indexed file organizations through the VAX–11 RMS facility; it does not require a primary file in every program. The calculation specification supports most standard operating codes and provides additional codes for calling both routines written in other VAX languages and services provided by the VMS operating system or the Runtime Procedure Library. According to DEC, VAX RPG II also permits a number of non-architecturally dependent programs written in other versions of RPG II to compile and execute unaltered on VAX/VMS systems.

VAX RPG II 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. An overstrike mode allows code entry or correction in proper columns without affecting the remainder of a program line. The screen displays an 80-column ruler with tab stops to match the current specification type; tab and backspace keys move the cursor among consecutive tab stops. An on-line help facility, featuring a two-window screen format, displays the locations of editing function keys, gives information about each editing key, and displays column headings for the current specification. Also, users can compile programs while still in editing mode. If errors are present, the programmer can step through the program, reviewing and correcting each successive error, and recompile the program without leaving the editor.

VAX RPG II is integrated into the VAX Common Language Environment, enabling VAX RPG II programs to call modules written in other VAX-supported languages, VMS Runtime Procedure Library routines, and VMS system services. VAX RPG II also uses VAX–11 RMS file management services, which provide mutual shared access to files by programs written in VAX RPG II and other VAX languages.

VAX Lisp is a language for development of artificial intelligence (AI) programs that simulate human behavior and thought through representation of real-world properties and objects and the relationships among objects. Developed to manipulate symbolic values and perform numerical computations, VAX Lisp is an implementation of Common Lisp, the most widely used AI language. VAX Lisp incorporates the following features:

- Interpreter and compiler modes available to the user.
- Dynamic linking of compiled and interpreted code.
- Lexically scooped variables.
- A user-extensible editor, written in VAX Lisp, with the ability to display multiple windows.
- Integrated debugging facilities.
- A facility for calling routines written in any other language in the VAX/VMS environment.
- A user-controllable printer utility for enhancing readability of printed output.

The VAX Lisp programming package runs on appropriately configured VAX and VAXcluster systems; it requires a minimum half-megabyte of physical memory per simultaneous user.

VAX–11 Cobol is a high performance, interactive language processor based on the ANSI X3.S3–1974 standard. VAX–11 Cobol also incorporates many features planned for the upcoming ANSI standard, including more structured programming to allow simplification of complex coding procedures.

VAX–11 Cobol takes full advantage of the VAX hardware, generating in-line instructions for high-speed compilation and program execution and support of larger programs. It includes full implementations of nine ANSI modules, in-

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cluding SORT/MERGE. Utilities are included to aid users in migrating other Cobol programs to VAX-11 Cobol.

VAX-11 Basic is a native-mode language processing system. It is an excellent instructional language as well as a general-purpose programming language with a variety of industrial, technical, and commercial applications. VAX-11 Basic is a superset of PDP-11 Basic-PLUS-2/VAX, which is itself a highly extended superset of standard Basic language developed at Dartmouth College. VAX-11 Basic produces shareable native objective code, makes full use of the VAX floating point and character-string instructions, and is itself shareable.

VAX-11 Pascal is a reentrant, native-mode compiler particularly suited to instructional use. Pascal is a structured, high-level programming language that provides a modular systematic approach to computerized problem solving. VAX-11 Pascal takes full advantage of the VAX hardware floating point and character instruction sets and the virtual memory capabilities of the VAX/VMS operating system.

VAX-11 Coral 66 is a high-level block-structured programming language. It is the standard, general-purpose language prescribed by the British government for realtime applications and system implementation. VAX-11 Coral 66 is designed to replace assembly-level programming in a number of commercial, process control, research, and military applications. It is designed for long-life products requiring flexibility and ease of maintenance.

VAX-11 PL/1 is a comprehensive language that supports scientific computation, commercial data handling and data organization, and extensive string manipulation capabilities. Block structuring is employed to develop programs which are easier to understand and less error prone.

VAX-11 PL/1 is an extended implementation of the proposed ANSI X3.74 PL/1 General Purpose Subset. Extensions to the subset language are either full language PL/1 features, or system-specific features that provide more complete access to VAX/VMS features. The VAX-11 PL/1 compiler generates optimized, shareable, native object code.

VAX-11 Bliss-32 is a high-level systems implementation language for VAX systems. Bliss-32 supports development of modular software according to structured programming concepts by providing an advanced set of language features for VAX systems to facilitate programming of realtime and/or hardware-independent applications. VAX-11 Bliss-32 is especially intended for the development of operating systems, compilers, runtime system components, database file systems, communications software, and utilities.

VAX-11 DSM is a multiuser data management system and a high-level interpretive language. The Digital Standard Mumps (DSM) language 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-11 DSM provides a language precompiler to optimize routine execution in an application environment.

VAX-11 C is a general-purpose programming language featuring control and data structures with concise operations. Based on the C programming language, VAX-11 C is an integrated VAX/VMS layered language product, allowing programmers to use all of the services and program development aids that the VAX/VMS system provides. Also featured with VAX-11 C is runtime support to aid Unix-to-VAX/VMS migration; it includes emulation of many Unix-specific routines.

Fortran IV/VAX-to-RSX Cross Compiler is a software tool for development and execution of RSX-11M or RSX-11S Fortran programs. Based on ANSI Fortran X3.9-1966, the compiler operates under the RSX-11M application migration executive. Programs compiled and tasks built through the compiler can be transported to remote RSX-11M or RSX-11S target systems or executed on VAX systems with VAX-11 RSX facilities.

The *VAX-11 Macro* assembler accepts one or more source modules written in Macro assembly language and produces a relocatable object module and optional assembly listing. VAX-11 Macro is similar to PDP-11 Macro, but its instruction mnemonics correspond to the VAX native instructions.

COMMUNICATIONS: *DECnet-VAX* permits suitably configured VAX/VMS- and MicroVMS-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; adjacent nodes control opposite ends of a point-to-point communications line.

Among its features, DECnet-VAX permits area routing for development of networks containing several thousand processors. On the MicroVAX I, DECnet-VAX supports the DEQNA Ethernet controller and the DHV-11 and DZV11 Q-Bus communications interfaces. For VAX/VMS-based systems, DECnet-VAX supports DZ11, DMF32, and DZ32 asynchronous Unibus communications interfaces, as well as a number of other synchronous Unibus interfaces.

DECnet-VAX interfaces are standard with VAX/VMS and MicroVMS. To program task-to-task communication or file access, programmers use identical calls whether or not the tasks or data are on the same or different systems. The logical link between two programs is like an I/O channel over which programs can send and receive data. Using DECnet for task-to-task communication is like doing I/O with an existing driver.

Task-to-Task Communication—DECnet-VAX provides task-to-task communication, enabling cooperating programs to exchange data. 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. Any VAX language programmer can write programs that perform task-to-task communication.

Intertask communication routines can be coded using one of two methods: transparent calls or nontransparent calls. The process can send optional data along with the connect request. The receiving process or task can accept or reject the connect initiate. A process can access multiple connect requests and can send or receive mailbox messages to or from another process or task.

In a DECnet-VAX network, a program using nontransparent access normally opens a control path directly to the Network Ancillary Control Process (NETACP) and designates one or more mailboxes for receiving information from the NETACP about the logical or physical links over which the process is communicating.

Access Control—Access control is the method by which network users are screened before gaining access to network facilities. With the appropriate access control information, a

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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. DECnet–VAX also incorporates a proxy login feature that allows a network user at one host to sign into another host on the same network without sending passwords in clear text.

Remote File Access—All DECnet systems support exchange of sequential ASCII or binary files. The DECnet software handles compatibility issues among operating systems by translating the file syntax of the sending node into a common network syntax and then retranslating at the receiving end appropriately for that node. The transfer of file types other than ASCII can also be supported between particular operating systems.

DECnet–VAX supports file transfers between locally supported File Control Services (FCS) devices and the file system of other DECnet nodes. Wildcards can be used for the user identification code, file name, file type, and version number for local-to-remote file transfers. Directory listings are also a supported feature.

Additional facilities available on DECnet/VAX software allow system command files to be submitted to a remote node. The list of commands must be in a format acceptable to the node responsible for the execution. Similarly, command files can be received from other systems and then executed.

Down-line loading of tasks (programs) and systems is another tool provided by DECnet products. Down-line system loading and its converse, up-line system dumping, can be used for small memory-based RSX–11S systems or for systems in hostile environments.

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. The messages can be exchanged in a dialog.

Network Command Terminals—With the Network Command Terminal facility, local users can log onto and use remote VAX systems as though they were local. Network Command Terminals, which are a software capability, require no special hardware. They provide virtual terminal communication between VAX/VMS systems. Intermediate nodes can be running DECnet–VAX or other DECnet Phase III or Phase IV software.

Network Management—The Network Control Program (NCP) performs three primary functions: displaying statistical and error information, controlling network components, and testing network operation. These functions can be performed locally or executed at remote Phase III or Phase IV nodes that support these functions.

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. This type of multipoint topology can reduce line costs. Multipoint configurations include a control station and tributaries. The control station controls network traffic by polling; it queries the tributary computer stations to determine if they have messages to send.

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. If either a line or a node in this preferred path goes down, the network will automatically reroute over the next least-cost path.

Digital's Internet family of products supports the interconnection of Digital computers and Digital networks to systems built by other manufacturers. Members of the Internet family are the VAX–11 2780/3780 Protocol Emulator, VAX–11 3271 Protocol Emulator, and MUX200/VAX.

The *VAX–11 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–11 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 communication interface.

The *VAX–11 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–11 3271 package makes it possible for VAX users to have on-line access to IBM databases for the purpose of information entry, retrieval, and update. The communications discipline used by the VAX–11 3271 Protocol Emulator is the 3271 subset of IBM's binary synchronous communications (BSC) protocol using EBCDIC code. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communications interface.

Mux200/VAX is a VAX-based software package that allows communication with a CDC 6000, Cyber series, or other host computer systems capable of using 200UT mode 4A communication protocol. It can be configured to support either the ASCII or the extended BCD versions of the protocol. Mux200/VAX provides for one synchronous communication circuit to a host computer system and allows several users to communicate simultaneously with the host computer over a single line. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communication interface.

VAX–11 PSI (Packetnet System Interface) allows a suitably configured VAX–11 system to connect to Public Packet Switched Networks (PPSNs) conforming to the CCITT recommendation X.25. Access to VAX–11 PSI is supported for VAX/VMS user programs written in VAX–11 Macro and native-mode high-level languages—for example, VAX Fortran. VAX–11 PSI supports process-to-process and remote terminal communications via the network. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communication interface. (VAX–11 PSI is the prerequisite software to operate the KMS11 multiple-line communication interface.)

UTILITIES: Available for VAX–11 systems are two environmental aids for program development and execution, VAX–11 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

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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-11 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. In effect, VAX-11 RSX makes optionally available compatibility features that were intrinsic to the VAX/VMS operating system prior to June 1984.

VAX-11 RSX incorporates an application migration executive, a user interface, and utilities. Among the features of the system are backup/restore and indirect command file execution functions. VAX-11 RSX supports DEC's MicroPower Pascal and Professional Developer's Toolkit, allowing creation and modification on VAX systems of programs that can run on the company's Professional 300 series personal computers LSI-11 microcomputers.

VAXELN (formerly called VAXElan) software 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 the MicroVAX system is the principal target system for VAXELN applications, VAX-11/750 and 11/730 systems are also supported as target systems.

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. The user can insert, delete, and replace lines, find and substitute strings, or modify the text a character at a time. Lines can be identified by line number, by relative position, or by content. An adjacent group of lines can be copied or transferred from one place to another. Editing can be done in any order in the file. Editor parameters can be set to user-specified values, and the current values can be shown. User-specific parameters can be set automatically at editor start-up.

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. The command file provides a reliable way to duplicate the changes made to a file at a later time or on another system. SLP provides a formal record of changes made to files, both in the source file and in an audit-trail listing.

The *EDT* editor lets users enter and manipulate text and programs. EDT, with its extensive HELP facility, is designed to be learned easily by novices. EDT features line and character editing facilities, screen editing and keypad editing on VT200, VT100, and VT52 video terminals, a start-up command file, a journaling facility, and the ability to work on multiple files simultaneously. It is shipped as part of VAX/VMS.

VAX-11 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. The input to Runoff is a file containing the text of the document and the Runoff instructions. 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 symbols and procedure references between them, and produces an executable program image. The linker also enables a programmer to create shareable images that can be linked subsequently with other modules to produce an executable image. Furthermore, the linker not only accepts object modules to produce executable or shareable images, but can also accept object module libraries, shareable images, and shareable image libraries.

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. A programmer can request the linker to use one or more library files from which the linker can obtain modules to resolve references during linking.

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 to control program execution during development. The debugger can be used interactively or controlled from a command procedure file. The debugging language is similar to the VAX/VMS command language. Expressions and data references are similar to those of the source language used to create the image being debugged. Debugging commands include the ability to start and interrupt program execution, to step through instruction sequences, to call routines, to set break or trace points, to set default modes, to define symbols, and to 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)* software package is designed for the nonprogrammer who develops small, simple applications such as personnel records, order processing, department budgets, financial/forecasting models, and mail/telephone lists. ADE provides easy-to-use facilities and functions for users to create their own databases, add, change or delete data, produce simple bar graphs and write reports—without waiting for formal programming and report generation. In addition, ADE uses full-screen handling, prompts the user after each input, offers extensive "HELP" messages, provides user protection of data, and automatic sorting alphabetically, numerically, or in date order.

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VAX-11 DECalc is an interactive applications package for creating, editing, and manipulating the electronic equivalent of an accountant's spreadsheet. VAX-11 DECalc executes in native mode under VAX/VMS and drives a VT100 or VT200 series terminal. Since DECalc is self-teaching, users require little previous computer experience. This package was designed for the following applications categories: loans and investments, advertising and sales, general business, and engineering.

The *VAX-11 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.

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.

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.

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

OFFICE AUTOMATION: *DX/VMS* is a VAX Fortran software package that executes on a VAX/VMS operating system. It enables a WPS-8 word processing system running WPS-8, WPS8/78, or WPS-8/MTS software to communicate with the VAX/VMS host over an asynchronous terminal interface. DX/VMS enables distributed standalone WPS-8 systems and the host VAX system to be linked together for better system utilization and data sharing.

VAX-11 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. DECmail has the ability to store, search, and retrieve messages held in system-provided or user-created folders. DECmail can also be used to store documents created on Digital's word processing systems which use the CX (Character Transmission) option that allows document transfer (text only) to and from VAX-11 DECmail.

VAX-11 ALL-IN-1 *Office Menu* provides office applications such as electronic mail, document processing, desk management, and forms development on VAX/VMS-based systems. A flow-control facility allows a user at a VT100 family terminal to select from an option menu, moving from one application to another. The VAX-11 ALL-IN-1 software requires a VAX/VMS system with at least 2M bytes of dedicated main memory.

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

APPLICATIONS: Digital'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.

One significant application avialable through this service is *OPS5*, designed for use by software engineers trained in artificial intelligence methodology and technology in developing expert systems that encode production rules. Expert systems are applications that work out complex problems containing ambiguities in definition or boundaries; an expert system mimics the way a human expert performs a task that requires decision-making based on varying data or knowledge about the task.

OPS5 is a high-performance version of a language originally developed at Carnegie-Mellon University. It is a forward-chaining, rule-based language that can handle large production systems. OPS5 provides two different conflict resolution strategies so that users can choose the one that best addresses their application requirements. Applications developed in OPS5 can call and be called by software written in any language supporting the VAX calling standard; for example, it can call VAX-11 Datatrieve and DBMS to manage activities involving large amounts of data.

VAX VTX is a videotex system that runs under the VMS operating system on all VAX-11 computers. It 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.

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. The terminal control and concentrator functions are independent of access and update functions; consequently, the system can be modified to support Prestel, NAPLPS, and other display protocols, as well as additional video display terminals.

The database access software controls all requests for information and provides a menu-based interface for users. This component provides such security features as closed user groups, which limit the ability to access or modify information to authorized individuals. The database access component also provides account control information and a facility that permits billing programs to track videotex system usage.

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. For extra security, pages of information created or modified through IPAT are not actually entered into the database until a privileged user or manager has given the proper command.

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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; pages of videotex information can thus be captured, edited, and integrated into reports, memoranda, and letters.

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.

In addition, 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 Servicenters, 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 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.

All warranted VAX-11 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-11 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

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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 nonproduct-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-11 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, VAX/VMS license only	$21,500
RUA80-AA(AD)	RA80 121MB fixed disk	19,000
TU80-AA(AB)	TU80 magnetic tape	9,900
DMF32-LP	Multipurpose communications interface	3,500
LA100-BA	1 Hardcopy Terminal	2,195
VT220-A	10 Video Terminals	10,800
VT22K-AA	10 VT220 data entry keyboards	2,150
LP11-AA	Two 300 lpm printers	16,700
TOTAL		85,745

VAX-11/750 System Building Block Configuration

750XA-AE(AJ)	VAX-11/750 CPU, 2MB ECC MOS memory, VAX/VMS license only	$ 47,000
MS750-CA	1MB ECC MOS expansion memory	4,900
RUA80-AA(AD)	RA80 121MB fixed disk	19,000
REM05-FA(FB)	RM05 256MB removable disk	46,000
TU80-AA(AB)	Two TU80 magnetic tapes	19,800
DZ11-HP	8-line 20 ma async serial communications interface	2,500
LA100-BA	1 Hardcopy Terminal	2,195
VT220-A	20 Video Terminals	21,600
VT22K-AA	20 VT220 data entry keyboards	4,300
LP11-EA	Two 600 lpm printers	27,200
TOTAL		194,495

VAX-11/785 System Building Block Configuration

785XA-AE(AJ)	VAX-11/780 CPU, 2MB ECC MOS memory, VAX/VMS license only	$195,000
MS780-FA	2MB ECC MOS expansion memory	9,000
RUA81-AA(AD)	RA81 456MB fixed disk and UDA50 controller	24,000
RA81-EA(ED)	Three RA81 456MB fixed disks and cabinet	50,000
TU80-AA(AB)	Four TU80 magnetic tapes	39,600
DZ11-HP	8-line 20 ma async serial communications interface	2,500
LA120-DA	1 Hardcopy Terminal	2,800
VT220-A	40 Video Terminals	43,200
VT22K-AA	40 VT220 data entry keyboards	8,600
LP27-UA(UB)	1200/800 lpm printer	28,990
LN01-CA(CB)	12 pg./min. laser printer	19,995
TOTAL		423,685

EQUIPMENT PRICES

		Purchase Price ($)	Monthly Maint. ($)
VAX PACKAGED SYSTEMS			
SV-CXMMA-GK(GN)	VAX-11/730 System Package; includes 1MB main memory, integrated disk controller, DMF32 communications controller, dual TU58 tape cartridge drives, LA100 console terminal, two RL02 cartridge disk drives, VAX/VMS operating system	29,500	343
SV-CXMMA-HK(HN)	Same as SV-CXMMA-GK(GN), but with LA12 console terminal	29,500	337
SV-CXWMA-GK(GN)	VAX-11/730 System Package; includes 1MB main memory, integrated disk controller, DMF32 communications controller, dual TU58 tape cartridge drives, LA100 console terminal, R80 fixed disk drive and RL02 cartridge disk drive, VAX/VMS operating system	40,000	361
SV-CXWMA-HK(HN)	Same as SV-CXWMA-GK(GN), but with LA12 console terminal	40,000	355
SU-CXWMA-GK(GN)	VAX-11/730 System Package; includes 1MB main memory, integrated disk controller, DMF32 communications controller, dual TU58 cartridge tape drives, LA100 console terminal, R80 fixed disk drive and RL02 cartridge disk drive, Ultrix-32 operating system	42,000	361
SU-CXWMA-HK(HN)	Same as SU-CXWMA-GK(GN), but with LA12 console terminal	42,000	355
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	134
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	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	287

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		Purchase Price ($)	Monthly Maint. ($)
610QA–DE	Micro VAX I; rack-mounted unit, includes CPU, 512KB main memory, and VAXELN license	10,095	90
610QA–XZ	Same as 610QA–DE, but without software license	9,995	90
610QN–DE	MicroVAX I; floor-standing/tabletop unit with same components as 610QA–DE	10,245	90
610QH–XZ	Same as 610QH–DE, but without software license	10,145	90
610QB–DE	MicroVAX I; rack-mountable unit, includes CPU, 512KB main memory, 800KB diskette, 10MB Winchester disk, and VAXELN license	13,830	110
610QB–XZ	Same as 610QB–DE, but without software license	13,730	110
610QJ–DE	MicroVAX I; floor-standing/tabletop unit with same components as 610QB–DE	13,980	110
610QJ–XZ	Same as 610QJ–DE, but without software license	13,880	110
610QC–DE	MicroVAX I; rack-mounted unit, includes CPU, 1MB main memory, 800KB diskette, 28MB Winchester disk, and VAXELN software license	16,935	140
610QC–XZ	Same as 610QC–DE, but without software license	16,835	140
610QK–DE	MicroVAX I; floor-standing/tabletop unit with same components as 610QC–DE	17,085	140

VAX SYSTEM BUILDING BLOCKS

Vax System Building Blocks (SBBs) begin with a core of components: CPU, 2MB or 4MB of ECC MOS 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. SBBs are available for the VAX–11/730, 11/750, 11/780, 11/782, and 11/785.

785XA–AE(AJ)	VAX–11/785 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet, and VAX/VMS license	195,000	506
785XA–BE(BJ)	Same hardware as 785XA–AE(AJ), but with Ultrix–32 license	200,500	*TBA
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 only	320,000	1,816
780XA–AE(AJ)	VAX–11/780 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet, and VAX/VMS license only	145,000	407
780XA–BE(BJ)	Same components as 780XA–AE(AJ), but with Ultrix–32 license	150,500	407
750XA–AE(AJ)	VAX–11/750 CPU, 2MB ECC MOS memory, and VAX/VMS license only	47,000	226
750XA–BE(BJ)	Same hardware as 750XA–AE(AJ), but with Ultrix–32 license	52,500	226
730XA–AE(AJ)	VAX–11/730 System Building Block; includes VAX–11/730 CPU, 2MB ECC MOS memory, and VAX/VMS license only	21,500	124
730XA–BE(BJ)	Same hardware as 730XA–AE(AJ), but with Ultrix–32 license	23,500	124

VAXCLUSTER BUILDING BLOCKS

A VAXcluster is composed of one or more VAX–11/750, 11/780, 11/785, or 11/782 processors running on VAX/VMS connected by a high-speed bus, one or more mass storage servers, and communication links to the user community. VAXcluster systems are configured by starting with a standard Building Block system and adding a CI750 or CI780 Computer Interconnect. There are two types of System Building Blocks. The first type is a basic system element, which, for the 11/78X, consists of a VAX–11/780 or 11/785 CPU with 2MB of memory, or a VAX–11/782 with 4MB of memory, CI780 computer interconnect, HSC50 intelligent controller, and two disk interfaces (each with four ports), plus a VAX/VMS operating system license. The second type of Cluster System Building Block is an upgrade to an existing VAXcluster. The 11/78X upgrade consists of a VAX–11/780 or 11/785 CPU with 2MB of memory or a VAX–11/782 with 4MB of memory, CI780 computer interconnect, and VAX/VMS operating system license. To this must be added an LA120 console terminal, and an optional system disk such as the RA60, RA80, or RA81 disk drives.

785CA–AE(AJ)	VAX–11/785 VAXcluster Building Block; includes VAX–11/785 CPU, 2MB ECC MOS memory, CI780 Computer Interconnect, SC008–AC star coupler, HSC50 intelligent disk controller, two disk interfaces (four RA ports each), VAX/VMS operating system license, and Unibus expansion cabinet with expander box and backplane	257,000	846
785CA–AP(AT)	VAX–11/785 VAXcluster upgrade; includes VAX–11/785 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet with BA11–K expander box and DD11–DK backplane, computer interconnect, and VAX/VMS license	223,000	671
782CA–AE(AJ)	VAX–11/782 VAXcluster Building Block; includes VAX–11/782 dual CPU, 4MB shared ECC MOS memory, C1780 Computer Interconnect, SC008–AC Star Coupler, intelligent disk/tape server, interfaces for eight RA disks, VAX/VMS license, and Unibus expansion cabinet with BA11–K expander box and DD11–DK backplane	370,000	2,133
782CA–AP(AT)	VAX–11/782 VAXcluster Upgrade; includes VAX–11/782 dual CPU, 4MB shared ECC MOS memory, H9652 cabinet, computer interconnect, and VAX/VMS license	320,000	1,966
780CA–AE(AJ)	VAX–11/780 VAXcluster Building Block; includes VAX–11/780 CPU, 2MB ECC MOS memory, computer interconnect, star coupler, intelligent disk controller, interfaces to eight RA disks, VAX/VMS license, and Unibus expansion cabinet with BA11–K expander box and DD11–DK backplane	217,000	744
780CA–AP(AT)	VAX–11/780 VAXcluster Upgrade; includes VAX–11/780 CPU, 2MB ECC MOS memory, Unibus expansion cabinet, computer interconnect, and VAX/VMS license	173,000	577

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
PROCESSOR AND MEMORY OPTIONS			
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	96
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	50
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	45
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	25
E75VC–AG	One FP750 high performance floating-point accelerator, 1MB of ECC MOS memory, and VAX–11 Fortran with support; for VAX–11/750	15,000	74
E75VC–DZ	Same as E75VC–AG, except VAX–11 Fortran license only	12,000	74
E75VD–AG	One FP750 high performance floating-point accelerator, 2MB of ECC MOS memory, and VAX–11 Fortran with support; for VAX–11/750	18,500	103
E75VD–DZ	Same as E75VD–AG, except VAX–11 Fortran license only	15,500	103
E782A–AY	Two FP780 high performance floating-point accelerators, 1MB of ECC MOS memory, and VAX–11 Fortran with support; for VAX–11/782	36,700	266
E782A–DZ	Same as E782A–AY, except VAX–11 Fortran license only	32,700	266
E782B–AY	Same as E782A–AY, except uses FP782–AB and requires 240 V/50 Hz power	36,700	266
E782B–DZ	Same as E782B–AY, except VAX–11 Fortran license only	32,700	266
E782C–AY	Two FP780 high performance floating-point accelerators, 2M–bytes of ECC MOS memory, and VAX–11 Fortran with support; for VAX–11/782	41,700	376
E782C–DZ	Same as E782C–AY, except VAX–11 Fortran license only	37,700	376
E782D–AY	Same as E782C–AY, except uses FP782–AB and requires 240 V/50 Hz power	41,700	376
E782D–DZ	Same as E782D–AY, except VAX–11 Fortran license only	37,700	376
CI780–AA (AB)	Optional microcoded intelligent adapter to the dual path computer interconnect; supported by DECnet–VAX and VAX/VMS; for VAX–11/780 and 11/785	19,500	150
CI780–SA (SB)	CI780 Starter Kit; includes two C1780–ABs, cables, and one star coupler	40,000	322
CI750–AA(AD)	An expansion CI750 adapter for mounting into the cabinet supplied with the CI750–AA(AB); for VAX–11/750	17,500	150
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 inch) 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 inch) 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	18,500	150
CI750–SA(SD)	Two node starter kit containing two CI750–BA(BB), SC008 Star Coupler, and cables; for VAX–11/750	39,000	322
SC008–AC	Star coupler; 8-mode with cabinet	7,500	22
SC008–AD	Upgrade to Star Coupler; for 9 to 16 nodes	5,500	22
BNCIA–10	CI cable set; 32 feet (10 meters)	600	**N/C
BNCIA–20	CI cable set; 65 feet (20 meters)	830	N/C
BNCIA–45	CI cable set; 145 feet (45 meters)	1,460	N/C
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	55
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 feet of cable	18,700	88
DW750	VAX–11/750 second Unibus adapter	7,000	20
DW780–AA (AB)	Unibus adapter; for the VAX–11/780 and 11/785	12,900	39

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
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	N/C
KU780–A	2K words (99-bit words) User Control Store; for VAX–11/780 and 11/785	11,000	53
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	47
MA780–BA(BB)	Additional MA780 Multiport Memory subsystem	34,600	188
MA780–D	VAX–11/780 and 11/785 Multiport Memory Selective Cache Invalidate option	9,900	61
MA780–EA(EB)	MA780 Multiport memory port interface	10,600	26
MA780–JA(JB)	256KB ECC MOS Multiport Memory subsystem, which can be shared by up to four VAX–11/780 and 11/785 systems; for VAX–11/780 and 11/785 systems	39,500	188
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	N/C
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	594
MS730–CA	1MB ECC MOS expansion memory (one 64K chip array); for VAX–11/730	4,900	29
MS730–CB	2MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/730	9,000	58
MS730–CC	3MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/730	13,000	87
MS730–CD	4MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/730	17,000	116
MS730–CF	10MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX–11/730	34,000	***N/A
MS730–CH	25MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX–11/730	75,000	725
MS730–CJ	50MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX–11/730	137,500	1,450
MS750–CA	1MB ECC 64K MOS expansion memory; for VAX–11/750	4,900	29
MS750–CB	2MB ECC 64K MOS expansion memory; for VAX–11/750	9,000	58
MS750–CC	3MB ECC 64K MOS expansion memory; for VAX–11/750	13,000	87
MS750–CD	4MB ECC 64K MOS expansion memory; for VAX–11/750	17,000	116
MS750–CF	10MB ECC 64K MOS expansion memory (single system maximum is 8MB); for VAX–11/750	34,000	290
MS750–CH	25MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX–11/750	75,000	725
MS750–CJ	50MB ECC MOS memory Multiple System Memory Expansion Package; for VAX–11/ 750	137,500	1,450
MS750–DA	11/750 64K upgrade, 1MB, no BP (battery pack); prerequisite; VAX–11/750–BA CPU-serial # less than BTO3096	10,000	29
MS750–DC	11/750 64K upgrade, 1MB, with BP (battery pack); prerequisite; VAX–11/750–BA CPU-serial # less than BTO3096	10,000	29
MS780–CH(CJ)	1MB ECC MOS, 16K chip memory with MS780–C controller; for VAX–11/780	23,400	242
MS780–DA	256KB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	2,400	61
MS780–DB	512KB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	4,000	103
MS780–DC	1MB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	7,000	179
MS780–DD	2MB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	13,000	294
MS780–DE	3MB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	18,000	380
MS780–DF	4MB ECC MOS expansion memory (in 16K chip arrays); for VAX–11/780	22,000	460
MS780–EA(EB)	4MB ECC MOS, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX–11/780	36,000	184
MS780–EC(ED)	2MB ECC MOS memory, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX–11/780	28,900	126
MS780–FA	2MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/780 and 11/785	9,000	58
MS780–FB	4MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/780 and 11/785	17,000	116
MS780–FC	6MB ECC MOS expansion memory (in 64K chip arrays); for VAX–11/780 and 11/785	24,000	174
MS780–FF	10MB ECC MOS memory (in 64K arrays); for VAX–11/780 and 11/785	34,000	290
MS780–FH	25MB ECC MOS expansion memory (in 64K arrays); for VAX–11/780 and 11/785	75,000	725
MS780–FJ	50MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX–11/780 and 11/785	137,500	1,450
H7112–A (B)	MOS memory battery backup; for VAX–11/780 and 11/785	1,800	12
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	1,029
11780–VA(VB)	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 with software support	155,000	439
11780–VC(VD)	Same as 11780–VA(VB) except without software support	145,600	439
11750–VH(VJ)	VAX–11/750 Upgrade Package; includes VAX–11/750–CA CPU with 1MB memory, LA120 console terminal, TU58 magnetic tape cartridge, and VAX/VMS license	46,200	243

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
MASS STORAGE			
HSC50–AA(AB)	HSC50 intelligent I/O server with space for six HSC5X–BA; cables not included	32,500	95
HSC5X–BA(BB)	Data channel interface for interfacing up to four disk drives	7,100	25
HSC5X–EA(EB)	Second power supply for over three HSC5X–BA on the HSC50	2,600	25
RA60–AA	205MB rack-mounted RA60 drive (no cabinet)	15,000	80
RA60–CA(CD)	205MB cabinet-mounted RA60–AA add-on drive	17,000	80
RUA60–AA	205MB RA60 drive and UDA50 controller without cabinet	20,000	110
RUA60–CA(CD)	205MB RA60–AA cabinet-mounted drive and UDA50 controller	22,000	110
RUA60–JA(JD)	205MB RA60 drive mounted in an H9642–AP(AR) cabinet and two UDA50 controllers	27,000	140
RA80–AA(AD)	121MB rack-mounted RA80 drive (no cabinet)	14,000	81
RA80–CA(CD)	121MB cabinet-mounted RA80 add-on drive	16,000	81
RUA80–AA(AD)	121MB RA80 rack-mounted drive (no cabinet) and UDA50 controller	19,000	111
RUA80–CA(CD)	121MB RA80 cabinet-mounted drive and UDA50 controller	21,000	111
RA81–AA(AD)	456MB RA81 drive (no cabinet)	19,000	90
RA81–CA(CD)	456MB cabinet-mounted RA81 drive	21,000	90
RA81–EA(ED)	Three 456MB RA81 drives mounted in an H9642–AP(AR) deep cabinet. Requires a UDA50 or an HSC50	50,000	270
RUA81–AA(AD)	456MB RA81 rack-mounted drive and UDA50 controller	24,000	120
RUA81–CA(CD)	456MB RA81 cabinet-mounted drive and UDA50 controller	26,000	120
RL02–AK	10.4MB RL02 add-on cartridge drive	3,000	63
RL02K–DC	10.4MB cartridge for the RL02	210	N/A
RL211–AK	10.4MB RL02 top-loading, rack-mounting, removable cartridge drive and controller with interconnect cabling	6,900	71
REM05–FA(FB)	Single-ported, 256MB removable disk pack drive and VAX–11/780 Massbus adapter (MBA)	46,000	326
REM05–FC(FD)	Dual-ported, 256MB removable disk pack drive and two VAX–11/780 Massbus adapters	60,600	415
REM05–FE(FF)	Dual-port conversion kit with RM05 dual-port kit, power supply, and VAX–11/780 Massbus adapter	16,700	89
REP07–FA(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	240
REP07–FC(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	320
REP07–FE(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	80
RGP07–FA(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	240
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 Massbus adapter	34,000	252
RM05–FC(FD)	Single-ported, 256MB removable disk pack drive and drive adapter packaged in freestanding disk drive cabinet only; requires VAX–11/750 or 11/780 Massbus adapter	34,000	252
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 Massbus adapter	39,140	268
RM05–FH(FJ)	Dual-ported, 256MB removable disk pack drive packaged in freestanding disk drive cabinet only; requires VAX–11/750 or 11/780 Massbus adapter	39,140	268
RM05–ZC(ZD)	RM05–FA plus RM05–FC	49,900	480
RGM05–FA(FB)	Single-ported 256MB RM05 drive and one VAX–11/750 Massbus adapter; the drive is contained in a separate utility cabinet	46,000	310
RM05–P	256KB removable disk pack for RM05	1,215	N/A
RM05–PX	RM05 disk pack, hard error (flag) free	1,435	N/A
RP07–AA (AB)	Single-access, freestanding 516MB fixed Winchester disk drive, requires RP07–D for 2.2MB transfer rate with interleaved memory, VAX–11/780 MBA	38,000	180
RP07–BA (BB)	Dual-access, freestanding 516MB fixed Winchester disk drive, requires RP07–D for 2.2MB transfer rate with interleaved memory, VAX–11/780 MBA	43,140	200
RP07–C	RP07 dual-access kit containing drive logic and cables to convert RP07–A to RP07–B	5,150	20
RP07–D	1.3 to 2.2MB transfer rate upgrade kit, requires interleaved memory	N/A	N/A

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
MAGNETIC TAPE EQUIPMENT			
TE16–AE(AJ)	Program-selectable 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport and VAX–11/780 Massbus adapter; prerequisite: VAX–11/780, 11/785, or 11/782 and TGE16 or TEE16	15,900	97
TEE16–FA(FD)	TE16 magnetic tape transport, formatter, and VAX–11/780 MBA	27,000	163
TEU77–FB(FD)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips magnetic tape transport and VAX–11/780 Massbus adapter; prerequisite: VAX–11/780, 11/785, or 11/782	36,800	259
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; prerequisite: VAX–11/780, 11/785, or 11/782	54,000	340
TEU78–FF(FJ)	Dual-ported TU78 magnetic tape transport, formatter, and two VAX–11/780 MBAs	68,600	420
TGE16–FA(FD)	TE16 magnetic tape transport, formatter, H9604–AC standalone option expansion kit, and VAX–11/750 MBA	27,000	155
TGU77–FB(FD)	TU77 magnetic tape transport and VAX–11/750 MBA	36,800	259
TGU78–FB(FD)	TU78 magnetic tape transport and VAX–11/750 MBA	54,000	340
TM78–C	TU78 dual-port kit containing drive logic and cables to provide dual-porting capability to TEU78–AB(AD) or TU78–AB(AD); prerequisite: TEU78–FB(FD) or TU78–AB(AD)	5,150	20
TU77–AF(AJ)	TU77 magnetic tape transport; prerequisite: TGU77 or TEU77	23,800	193
TU78–AB(AD)	TU78 magnetic tape transport and formatter (master); requires an MBA and a TM78–C for dual-porting capability	48,000	280
TU78–AF(AJ)	TU78 magnetic tape transport (without formatter); prerequisite: TGU78, TEU78, or TU78 Master	25,500	170
TU80–AA(AB)	1600 bpi; 9-track, 25 ips (100 ips streaming) magnetic tape subsystem, Unibus adapter and power controller in a dedicated 40-inch H9643 cabinet	9,900	63
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-inch (26.6 cm) disk; I/O connection panel space to mount three groups of four panels each and one group of one panel unit; for VAX–11/750 and VAX–11/730	2,200	N/C
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 group of one panel unit; for VAX–11/750 and VAX–11/730	2,050	N/C
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	N/C
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	N/C
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	20
DD11–CK	Expansion backplane mounting for BA11–K box; provides for two hex- and two quad-slot modules	470	N/C
DD11–DK	Same as DD11–CK except for providing seven hex- and two quad-slot modules	940	N/C
MULTIPURPOSE COMMUNICATIONS CONTROLLERS			
DMF32–LP	Direct Memory Access Unibus communications controller; system option, supported by VAX/VMS, DECnet/VAX, VAX–11 PSI, VAX–11 2780/3780, and 3271 Protocol Emulators; external cables for terminals not included	3,500	55
DMF32–M	DMF32 upgrade option; base module only; requires selection of appropriate external cables and cabinet kit	2,225	55

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
UNIBUS ASYNCHRONOUS OPTIONS			
Multiplexers			
DZ11-DP	System option; eight-line multiplexer with distribution panel for EIA/CCITT terminals; with modem control for use with DF01, DF02, DF03, and Bell 103, 113, or 212 modems or equivalent; external cables not included	2,175	33
DZ11-HP	System option; eight-line multiplexer for use with 20 ma current loop terminals; terminal cables not included	2,500	33
DZ11-M	Upgrade option; RS-232 interface; includes base module only	1,560	33
DZ11-N	Upgrade option; 20 ma interface; base module only	1,635	33
DZ32-AP	System option; eight-line EIA/CCITT multiplexer comprised of a single Unibus Hex module and a panel insert; external cables not included	2,988	36
DZ32-M	Upgrade option; EIA/CCITT interface; includes base module only	2,055	36
UNIBUS SYNCHRONOUS OPTIONS			
Point-to-Point Interfaces			
DUP11-AP	System option; interfaces to Bell 200 series modems or equivalent at speeds up to 9600 bits/second; includes data set control and BC22f-25 cable	1,575	12
DUP11-M	Upgrade option; includes only the base module	1,230	12
DMR11-AP	System option; interfaces to EIA RS-232/CCITT synchronous modems at speeds up to 19.2K bits/second	4,400	39
DMR11-FP	System option; interfaces to EIA RS-423/RS-429 V.24 synchronous modems at speeds up to 56K bits/second	4,400	39
DMR11-BP	System option; interfaces to CCITT V.35/DDS synchronous modems at speeds up to 1M bits/second	4,400	39
DMR11-CP	System option; includes integral modem for local interconnection	4,400	39
DMR11-EP	System option; interfaces to EIA RS-422/RS-429 V.24 synchronous modems, supports speeds up to 1M bits/second (FDX)	4,400	39
DMR11-M	Upgrade option; includes base module only	4,110	39
Multipoint Interfaces			
DMP11-AP	System option; interfaces to EIA RS-232/CCITT synchronous modems at speeds up to 19.2K bits/second	6,900	74
DMP11-FP	System option; interfaces to EIA RS-423/RS-449 V.24 synchronous modems at speeds up to 56K bits/second	6,900	74
DMP11-BP	System option; interfaces to CCITT V.35/DDS synchronous modems at speeds up to 56K bits/second	6,900	74
DMP11-CP	System option; includes integral modem for local interconnection	6,900	74
DMP11-EP	System option; interfaces to EIA RS-422/RS-449 V.24 synchronous modems; supports speeds up to 1M bits/second (HDX) or 500K bits/second (FDX)	6,900	74
DMP11-M	Upgrade option; includes base module only	6,450	74
DEUNA-AA	Ethernet communications controller; connects Unibus system to an Ethernet local area network	3,500	44
Auxiliary Communications Microprocessors			
KMS11-BD/KMS11-BE	Intelligent, full-duplex, eight-line, synchronous, communications, front-end interface with concurrent data transfers over eight lines	12,500 12,200	97
KMS11-PX	High performance network link for interconnection of VAX-11 and PDP-11 computers; includes EIA RS-232-C interface operating at speeds up to 19.2K bit/second and EIA RS-423-A/CCITT V.10 interface operating at speeds up to 56K bits/second	6,000	76
KMS11-PY	High performance network link for interconnection of VAX-11 and PDP-11 computers; includes ISO 2593/CCITT V.35 interface operating at speeds up to 56K bits/second	6,000	76
KMS11-PZ	High performance network link for interconnection of VAX-11 and PDP-11 computers; includes CCITT V.11 interface operating at speeds up to 56K bits/second	6,000	76
STATISTICAL MULTIPLEXERS			
DZS11-EA	Single module containing a DZ11-A asynchronous multiplexer emulator and a VT1XX-EB statistical multiplexer	4,050	38
VT1XX-EB	Eight-channel statistical multiplexer	3,250	28
MULTIPOINT PARALLEL INTERFACE			
PCL11-B	Multidrop computer link used to connect up to 16 processors to form a local distributed network; full duplex interfaces, residing in each CPU, are interconnected by a single high speed bus which can operate at speeds up to 1M bits/second depending on bus length	7,750	66

DEC VAX-11 Systems

		Purchase Price ($)	Monthly Maint. ($)
GENERAL-PURPOSE UNIBUS INTERFACES			
DR11-W	General-purpose DMA controller, interfaces to VAX Unibus	1,650	11
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	199
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	233
FEPCM-NA	PDP-11/23-PLUS-based front-end processor; includes H9642 cabinet, FEPCM, RSX-11S license only, and cable kit	21,490	199
FEPCM-PA	PDP-11/24-based front-end processor; includes H9642 cabinet, FEPCM, RSX-11S license only, and cable kit	23,490	233
KCT32 DUAL-LINE COMMUNICATIONS CONTROLLER			
KCT32-AB	Dual-line communications controller for bit/byte synchronous or asynchronous data transmission and reception; includes 56KB of user programmable memory, on-board diagnostic testing, and VMS-supported software	7,400	76
DECnet COMMUNICATIONS			
DECSA-AH	DECnet/SNA Gateway (RL02) including server unit, gateway software, and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA)	26,995	135
DECSA-AM	DECnet/SNA Gateway (9-track 1600 bpi magtape) including server unit, gateway software, and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA)	26,995	135
DECSA-DZ	DECnet/SNA Gateway including server unit, one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA), and a right-to-copy, no support license for software	25,795	135
DECSA-EA	DECnet Router Server and DECnet Router/X.25 Gateway unit, including server unit and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA). Note: configuration to either Router Server or Router/X.25 Gateway unit requires purchase of Router Server or Router/X.25 Gateway software	25,795	135
ETHERNET COMMUNICATIONS			
H4000	Digital Ethernet transceiver; provides functional interface between the Ethernet coaxial cable and an Ethernet station	300	N/A
DELNI-AA	Local Network Interconnect; allows Ethernet-compatible devices to be grouped up to 50 meters away from the LNI; can be configured three ways; supports up to eight systems	985	N/A
DEREP-AA	Ethernet Repeater; tabletop device with its own power supply; allows for connection of multiple segments of Ethernet coaxial cable for expansion of the network	1,500	N/A
DEREP-RA	Same as DEREP-AA, but remote	4,400	N/A
DECSA-CA	Terminal server; supports up to 16 lines	14,000	****
DECSA-DA	Terminal server; supports up to 32 lines	20,000	****
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	1,950	22
DRS11-B	Digital output device with open collector drivers; same components as DRS11-A	2,150	22
DRS11-MP	Optically isolated DC drivers with open collectors; requires DRS11-B	1,000	17
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	2,425	17
DSS11-B	Digital input device; same components as DSS11-A	2,625	17
DSS11-MP	Contact sense input; requires DSS11-A	1,400	12
DRE11-CC	General-purpose interface for moving 16-bit data directly to or from memory; compatible for interface to local connections at up to 49 feet (15 meters)	2,495	25
DRE11-CD	Same as DRE11-CC, but incorporates a signal conditioning module with differential line drivers and receivers for operation at up to 984 feet (300 meters)	3,495	39
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	40
CMR21-BA(BB)	Same as CMR21-AA(AB), plus library of software utilities	4,050	40
CMR21-AC(AD)	Same as CMR21-AA(AB), but can also operate at 12 VDC	4,300	40
CMR21-BC(BD)	Same as CMR21-BA(BB), but can also operate at 12 VDC	4,450	40

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		Purchase Price ($)	Monthly Maint. ($)
LINE PRINTERS			
LP11–AA	132-column, 64-character band printer and control unit; 300 lpm	8,350	100
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	100
LP11–EA	Freestanding lineprinter operating at a speed of 600 lines/min. for 64-character set	13,600	143
LP11–EB	Same as LP11–EA; also operates at 445 lines/min. for 96-character set	13,600	143
LP27–UA(UB)	132-column fully formed character impact lineprinter with 30-ft. (9.5-m) data cable and controller	28,990	247
LP27–DA(DB)	Lineprinter with 50-ft. (15.2-m) data cable and long-line controller	32,990	295
LP27–VA(VB)	Lineprinter with BC27A data cable and controller; requires DMF32	27,990	240
LSP25–CA	300/215 lpm, 64- and 96-character long-line band printer	9,990	113
LSP26–CA	300/215 lpm, 64- and 96-character long-line Unibus lineprinter; includes US prom set, US/UK bands, universal power supply, and 50-ft. (15.2-m) cable	15,600	164
LP32–AA	132-column, 64-character printer and universal power supply, 300 lpm; prerequisite, DMF32 Unibus controller	8,350	93
LP32–BA	Same as LP32–AA, but can also operate at 215 lpm with a 96-character set	8,950	93
LP32–EA	132-column, 64-character printer and universal power supply, 600 lpm; prerequisite, DMF32 Unibus controller	13,600	136
LP32–EB	132-column, 64- and 96-character printer and universal power supply, 600/445 lpm; prerequisite, DMF32 Unibus controller	14,400	136
LASER PRINTERS			
LN01–CA (CB)	Nonimpact laser-quality page printer; prints 12 pages per minute, 13.6 cps, 188-character fixed-space font plus a variety of application-oriented font kits, up to 132 print columns, 300 x 300 dots per square inch, compatible with standard line printer interface (LP11)	19,995	320
LN01–DA (DB)	Same as LN01–CA (CB), but includes DMF32-compatible cable	19,995	320
LETTER-QUALITY PRINTER			
LQP02–AA/AD	132 columns at 10 cpi, 158 columns at 12 cpi, over 100 different character sets, 10/12 cpi variable, 6/8 lines per inch variable, 32 cps, 110 to 9600 bps	2,800	29
LQPX2–AA	Bidirectional forms tractor for fanfold paper	250	N/C
LQPX2–SF	Dual-tray cut sheet feeder with envelope tray	1,800	17
LQPXX–AC	Dual-tray cut sheet feeder for use with regular office stationery	1,800	17
WORKSTATION PRINTER			
LA50–RA	Tabletop 100 cps/50 cps dual-mode printer with graphics capability; for use with video terminals, small systems, and personal computers; 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; 96 characters, 170, 240, or 300 lpm print speed, 16.7 inches per minute plot speed; with Unibus interface	11,250	99
LXY12–DA(DB)	Same as LXY12–CA (CB); with RS–232–C interface	11,250	99
LXY12–EA (EB)	Same as LXY12–CA (CB); with DMF32 interface	11,250	99
LXY22–CA (CB)	Freestanding line printer/plotter; 96 characters, 320, 465, or 600 lpm print speed, 33.3 inches per minute plot speed; with Unibus interface	15,800	129
LXY22–DA (DB)	Same as LXY22–CA (CB); with RS–232–C interface	15,800	129
LXY22–EA (EB)	Same as LXY22–CA (CB); with DMF32 interface	15,800	129
COLOR GRAPHICS PEN PLOTTER			
LVP16–AA(BA)	Six-color color graphics pen plotter; print speeds up to 15 ips; includes RS–232–C interface, documentation, and initial supplies. Requires interface cable	1,995	N/A
TERMINALS			
LA12–D	Portable correspondent hardcopy terminal with EIA interface and accessories; 150 cps, 96 characters, 40 to 72 print columns, 9 x 9 dot matrix, 50 to 9600 bps	1,445	21
LA12–C	Includes LA12–D plus 300 baud acoustic coupler, carry case, shoulder strap	1,545	21
LA12–B	Includes LA12–D plus 300/1200 baud modem, carry case, shoulder strap	1,995	21
LA12–A	Includes LA12–D plus 300/1200 baud modem, 300 baud acoustic coupler, carry case, shoulder strap	2,095	21

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		Purchase Price ($)	Monthly Maint. ($)
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
LAX12–U2	Dial-through keyboard 1200 baud integral modem upgrade for LA12–A/–C/–D	600	N/C
LAX12–U4	300 baud acoustic coupler upgrade for LA12–B/–D	100	N/C
LAX12–U5	Microcode upgrade for LA12–A/–C/–D	75	N/C
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
LA100–ZA	Receive-only version of LA100–BA	1,595	28
LA100–ZB	Receive-only version of LA100–BB	1,595	28
LA120–DA	Freestanding DECwriter III high-speed interactive KSR hardcopy terminal; 180 cps bidirectional printing with baud rates up to 9600 bps	2,800	32
LA120–RA	DECprinter III RO hardcopy terminal; for use with 1- to 6-part forms	2,420	37
LA120–RB	DECprinter III RO hardcopy terminal; for use with 4- to 9-part forms	2,600	37
VT220–A	VT220 terminal with white phosphor nonglare screen	1,080	6
VT220–B	VT220 terminal with green phosphor nonglare screen	1,080	6
VT220–C	VT220 terminal with amber phosphor nonglare screen	1,080	6
VT22K–AA	Data entry keyboard for VT220	215	3
VT22K–BA	Word processing keyboard for VT220	215	3
VT240–A	VT240 text/graphics terminal; includes monochrome monitor, system box with logic and power supply, and keyboard; white phosphor nonglare screen	1,980	16
VT240–B	VT240 terminal with green phosphor nonglare screen	1,980	16
VT240–C	VT240 terminal with amber phosphor nonglare screen	1,980	16
VT241–AA	VT241 color text/graphics terminal; includes monitor, system box with logic and power supply, and keyboard	2,980	23
VT24K–AA	Data entry keyboard for VT240/VT241 terminals	215	3
VT24K–BA	Word processing keyboard for VT240/VT241 terminals	215	3
VT24X–AA	Optional 300/1200 baud auto answer/auto dial integral modem	495	6
VT100–AA (AB)	High performance, tabletop, hardcopy, receive-only terminal; includes double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard	1,945	18
VT100–WA (WB)	Video display terminal for DECmail applications; includes word processing features, double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard; operates on full-duplex asynchronous communications lines, with a standard interface	2,140	22
VT101–AA (AB)	Video display terminal, totally self-contained with no functional upgrade options, offers basic VT100 functions and full VAX/VMS support plus local echo (which allows connection to non-Digital computer systems); features double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard; operates on full-duplex asynchronous communications lines with a standard EIA interface; same software support as VT100	1,350	15
VT102–AA (AB)	Video display terminal of the VT100 family, fully optioned and functional; communicates with both Digital and non-Digital systems, for data processing or word processing on models with DECWORD word processing keycaps; features advanced video and built-in printer port characteristics, and the U.S. and European half- and full-duplex communications and modem controls, plus local echo; same software support as VT100	1,595	22
VT102–WA (WB)	Video terminal with advanced features and word processing keyboard	1,710	22
VT125–AA (AB)	An enhanced VT100 alphanumeric video terminal with data plotting extensions, automatic vector and curve generation	3,800	29
VT125–WA (WB)	Video terminal with graphics, advanced video features, word processing keyboard, and printer port	3,995	32
VT131–AA(AB)	Video display terminal with conversational block-mode transmission capability	1,695	23
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–CA	20 ma current loop adapter for VT125	140	4
VT1XX–CB	Upgrade/conversion kit to convert VT100 to VT125	1,800	11

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		Purchase Price ($)	Monthly Maint. ($)
VT1XX–AC	Printer port option for connection of a VT100 to a hardcopy printer	350	7
VT1XX–CE	Word processing upgrade kit to convert VT100 and VT125 to word processing functionality	395	N/A
VT1XX–SA	Tilt/swivel base assembly for VT100	89	N/A
VT1XX–ST	Terminal stand with casters for VT100	159	N/A
RT137–AA	RT100 console, bar code reader and keyboard, VT100 keyboard, light pen; 120 V; RS–232	5,625	45
RT137–BA	20 ma version of RT137–AA	5,625	45
RT137–AE	RT100 console, bar code reader and keyboard, light pen; 120 V; RS–232	5,250	45
RT137–BE	20 ma version of RT137–AE	5,250	45
RT137–AM	RT100 console, bar code reader; 120 V; RS–232	4,775	45
RT137–BM	20 ma version of RT137–AM	4,775	45
RT137–AK	RT100 console, bar code reader, light pen, bar code, and RT100 keyboard; 120 V; RS–232	6,215	57
RT137–BK	20 ma version of RT137–AK	6,215	57
RT137–AC	Bar code keyboard	320	N/A
RT137–AD	Light pen	320	N/A
RT137–SR	Slot reader	565	9
RT037–AA	Bar code reader and decoder	2,050	30
RT037–BA	Bar code reader, decoder, and keypad	2,295	30
RT100–AA (AB)	Industrial VT100 with membrane keyboard; EIA interface	4,300	30
RT100–BA(BB)	Industrial VT100 with membrane keyboard; 20 ma interface	4,300	35
RT102–AA (AB)	Industrial VT102 with membrane keyboard; EIA interface	4,300	30
RT102–BA(BB)	Industrial VT102 with membrane keyboard, 20 ma interface	4,300	35
RT102–EA	Completely sealed version of RT102–AA(AB) with tactile feedback keyboard	4,500	30
RT102–FA	Completely sealed version of RT102–BA(BB) with tactile feedback keyboard	4,500	35
RT1XX–AE	Plastic and Mylar membrane keyboard compatible with VT100	1,100	10
COLOR GRAPHICS SYSTEM			
VS11–AA (AB)	High performance, 16 color and monochrome raster graphics system; features graphics instruction set, bit-slice architecture, switch-selectable resolution and intensity for interlaced (512 x 512 x 2 bits) or noninterlaced (512 x 256 x 4 bits) image memory operation; prerequisite, VAX/VMS system configuration and VAX/VMS driver	4,725	62
VAX STATION 100 GRAPHICS WORKSTATION			
VS100–AA	VAX station 100 primary (VR100–AA) monochrome 19-inch (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	9,805	85
VS10X–BA	One 11 x 11-inch graphics tablet and one 5-button puck	1,700	23
VS10X–EA	Three-button mouse and cable	500	10
LK201–CA	Keyboard with 12-ft. cord	245	3
BN25B–15	15-meter optical cable with terminators	200	N/A
BN25B–30	30-meter optical cable with terminators	350	N/A
BN25B–60	60-meter optical cable with terminators	650	N/A
VOICE SYNTHESIS MODULE			
DTC01–AA	DECtalk voice synthesis module; translates ASCII text into speech output	4,000	22

**TBA = To be announced.*
***N/C = No charge.*
****N/A = Not applicable.*
*****Contact Digital's Field Service Organization.*

DEC VAX-11 Systems

SOFTWARE PRICES

		License Fee* ($)
OPERATING SYSTEMS AND ENVIRONMENTS		
QX001	VAX/VMS operating system (11/725, 11/730, 11/750, 11/780, and 11/782)	10,000
QN001	MicroVMS (Extended base system kit)	500
QN002	MicroVMS (Extended base system kit and program development upgrades)	1,500
QN003	MicroVMS (Program development upgrade kit)	1,500
QC821	Ultrix–32 maximum 16-user binary license only; for VAX–11/730	12,000
QD821	Ultrix–32 maximum 32-user license only; for VAX–11/750	15,500
QE821	Same as QD821, but for VAX–11/780, 11/785, and 11/782	15,500
QD822	32-user to 64-user Ultrix–32 upgrade; for VAX–11/750	4,000
QE822	Same as QD822, but for VAX–11/780, 11/785, and 11/782	4,000
QE823	64-user to 65+-user Ultrix–32 upgrade; for VAX–11/780, 11/785, and 11/782	5,000
QE824	32-user to 65+-user Ultrix–32 upgrade; for VAX–11/780, 11/785, and 11/782	7,500
QX825	Ultrix–32 encryption license	200
QX375	VAXELN	6,700
LANGUAGES		
QX100	VAX Fortran	4,700
QX099	VAX–11 Cobol	7,590
QX095	VAX–11 Basic	5,060
QX126	VAX–11 Pascal	4,500
QX067	VAX–11 Coral 66	7,500
QX114	VAX–11 PL/1	7,590
QX106	VAX–11 Bliss–32	5,500
QX107	Fortran IV/VAX-to-RSX Cross Compiler	700
QX014	VAX–11 Bliss–16	5,500
QX015	VAX–11 C	4,500
QX018	VAX–11 Dibol	3,950
QX020	VAX–11 APL	7,590
QX075	Coral 66/VAX-to-RSX Cross Compiler	4,050
QX917	VAX Lisp	8,000
COMMUNICATIONS		
QXD03	DECnet–VAX	3,500
QX111	VAX–11 2780/3780 Protocol Emulator	4,200
QX070	MUX200/VAX	5,800
QX071	VAX–11 PSI	3,000
QX112	VAX–11 3271 Protocol Emulator	5,000
QX725	DECnet Router Server	2,420
QX727	DECnet Router/X.25 Gateway	2,420
QX762	LAT (Local Area Transport) software	500
DATA MANAGEMENT		
QX898	VAX–11 DATATRIEVE	6,000
QX800	VAX–11 FMS Forms Management System	3,120
QX897	VAX–11 Data Dictionary	1,200
QX899	VAX–11 DBMS	12,000
QX130	VAX–11 DSM	9,000
QX079	VAX–11 ACMS	9,000
QX706	VAX–11 TDMS	2,500
QX354	VAX Rdb/MVS	9,000
QXD07	VAX Rdb/ELN	7,500
APPLICATIONS AND UTILITIES		
QX400	VAX–11 DECmail	12,000
QX007	DEC/CMS Code Management System	8,260
QX118	VAX–11 ReGIS Graphics Library (RGL)	3,500
QX425	VAX–11 ADE	2,700
QX902	VAX–11 ALL–IN–1 office menu	15,000
QX310	VAX–11 DECalc	3,400
QX109	VAX–11/780 Microprogramming Tools	**1,210
QX500	VAX–11 Module Management System	2,000
QX650	DECspell Verifier/Corrector	3,200
QX652	DECspell Verifier	2,000
QX654	DECspell Correction Option	1,700
QX360	VAX–11 DECgraph	2,500
QX361	VAX–11 DECslide	2,500
QX382	VAX–11 RSX	2,000
QX810	VAX GKS/0b	2,000

**Non-hardware-dependent single-use license and warranty.*
***Warranty excluded.*