DEC PDP-11 Family Communications Capabilities

Digital's PDP 11/23, shown above, represents the versatility of the entire product line. It can be implemented for use as a communications processor, local network node, or other dedicated communications application.

A family of minicomputers which can be used as distributed processing systems, local or remote network nodes, or communication processors.

Seven models are currently being marketed, with user memory capacities ranging from 64K bytes to four megabytes. These seven models are supported by four operating systems which offer a wide range of communications support. All models now support DECnet, which allows PDP-11s to share resources with other DEC computers, such as VAX, using public facilities. Depending upon model and configuration, PDP-11s can communicate with an IBM host in batch or interactive modes and can participate in an SNA environment. They can also communicate with CDC and Univac hosts.

A typical PDP-11/44 processor running under the RSTS/E operating system with 512K bytes of memory, two asynchronous line interfaces, disk and tape drives with controllers, printer, Cobol, and DECnet costs $106,500. Monthly maintenance for this configuration is $508.

MANAGEMENT SUMMARY

Digital Equipment Corporation's all time leader in both longevity and revenues generated is the PDP-11 minicomputer family. Initially introduced in 1970 as a minicomputer for OEM use, DEC has now installed over 320,000 units making it by far the DEC earnings champion. Continued DEC communications enhancements have permitted the PDP-11 to evolve from a slab of "iron" for OEMs it was a decade ago to a system on which many users now depend to perform dedicated communications functions. Its versatility is demonstrated by its ability to act as a front-end or communications processor, local or remote network node, or distributed processor.

The PDP-11 family employs various internal architectures. The 11/03L and the 11/23 both use an LSI-11 bus architecture. The 11/23 Plus uses an Extended LSI-11 bus structure and the 11/24, 11/34A, 11/44, and 11/70 all utilize the Unibus architecture. Our feeling is that the newer Extended LSI-11 bus will eventually be used for future small PDP-11 systems and replace the LSI-11 bus.

These busses include expansion slots which are extensions of the PDP-11's bus and electrical connections. When a compatible interface card is plugged into one of these slots, it acts as part of the computer system. OEMs and independents especially appreciate this capability and many offer their own PDP-11 add-ons.

DEC provides a wide variety of synchronous and asynchronous communications interfaces to accommo- ➢

CHARACTERISTICS

VENDOR: Digital Equipment Corporation, 129 Parker Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

DATE OF FIRST ANNOUNCEMENT: March 1970.

DATE OF FIRST DELIVERY: August 1970.

NUMBER DELIVERED TO DATE: Over 320,000 PDP-11 processors (estimate for all models).

SERVICED BY: Digital Equipment Corporation.

MODELS AND CONFIGURATION

The original PDP-11 family of 16-bit minicomputers began in 1970 with the 11/20 model, and its closely related but stripped-down version, the 11/15. Both of these contained about 19 boards and some 600 integrated circuits. In 1971, the 11/05 and 11/45 were introduced, and marketed as more cost effective replacements to the 11/15 and 11/20. These processors consisted of two boards and about 200 integrated circuits. The 11/45, like the other PDP-11s, was a core-only machine, but included memory management circuitry that raised the maximum memory capacity from 56K bytes to 248K bytes.

Although these models all contained a Unibus-type of I/O channel, it was not until MOS memory was introduced that the high-speed Unibus architecture that is prevalent today was introduced. Subsequent models used both core and ➢

DEC PDP-11 Family Communications Capabilities

date and execute most communications applications. Communications interfaces are placed in slots on the PDP-11 bus. Some of these interfaces include enough built-in, microprocessor-supplied intelligence to help with processing burdens from the PDP-11 when acting as a front-end or communications processor. Others can be used to support and multiplex up to 16 asynchronous communications lines. Tables 1, 2, and 3 provide a complete description of all DEC supplied communications interfaces.

The PDP-11 communications capabilities may be divided into two distinct categories: DEC-to-DEC communications and DEC-to-non-DEC communications.

Digital Equipment Corporation uses its Digital Network Architecture (DNA) to interconnect dissimilar DEC computer products. DECnet is the software which implements DNA on all current PDP-11 family computers. It allows users file access and transfer through non-adjacent nodes, downline loading, upline dumping, task-to-task communications, and other resource sharing procedures.

DECnet Phase III is available for all systems now. In the Spring of 1984, DECnet Phase IV will link Unibus-based PDP-11s running under RSX-11M and RSX-11M-Plus with Professional 300 Series personal computers, DECSYSTEM-20 mainframes, and VAX superminis. Digital Data Communications Message Protocol (DDCMP) will be supported. Phase III users will also be able to communicate with Phase IV users and vice versa. Phase IV implementation will allow 1000 supporting nodes while Phase III currently only supports 250.

In addition to remote communications of DEC-to-DEC products, several interfaces allow the PDP-11 family to participate in a cable connected local network. The most interesting of these interfaces is not yet available. DEC has promised that by early 1984, Ethernet local network interfaces will be available for PDP-11s using a Unibus or Extended LSI-11 bus running under RSX family operating systems. Ethernet under DECnet control will allow a local network participant to access any of the long haul network gateways of DECnet Phase IV. Tables 1, 2, and 3 supply complete characteristics of currently available Local Network Link Modules.

DEC also supports a large number of DEC-to-non-DEC communications packages for PDP-11 processors. With appropriate operating system support, PDP-11 processors can be made to appear as an IBM RJE/HASP workstation, 2780/3780 batch processor, or 3271 interactive terminal to an IBM System/370 or other compatible host. Univac 1004 and CDC Cyber 6000 emulation programs are also offered.

One of the most significant aspects of DECnet Phase IV is its ability to provide a gateway into IBM's Systems Network Architecture (SNA), which will enable all DECnet users to participate in an SNA environment. This should be available in early 1983.

MOS memory, until the transition from core to MOS was completed.

Models 11/40, 11/35, and 11/04 were subsequently introduced that offered increasing price performance until 1975, when DEC announced the low-end, OEM-oriented LSI-11 microcomputer, and the high-end 11/70. The 11/70 was said to deliver 75 percent of the throughput of an IBM 370/158. It contained cache memory and memory management which permitted addressing of up to 4 million bytes.

The LSI-11 was subsequently marketed in a packaged version as the 11/03. In order to keep prices low, DEC left out the Unibus structure from this model.

In 1976, the 11/34 was announced, 50 percent faster than its predecessor model, the 11/04. Along with its cache memory brother, the 11/34A, main memory was supported to 248K bytes.

In 1977, the mid-range 11/60 was announced, with performance levels between the 11/34 and 11/70. It included cache memory, main memory to 256K bytes, and user-accessible microprogramming.

In March of 1979, the PDP-11/23 was announced. It featured low-end price/performance improvements over previous models and included the by-then established LSI-11 bus. Later in the year, the 11/44 was introduced. It uses improved MOS memory over previous models, and features built-in ECC logic and cache memory.

In March of 1981, DEC introduced the 11/24, the lowest priced PDP-11 model with Unibus architecture. In November of 1981, the 11/23 Plus was introduced. The 11/23 Plus is similar to the existing 11/23, but extends memory up to one megabyte and has an Extended LSI-11 Bus.

Each new announcement has contributed attributes to the entire product line. The current PDP-11 processor family consists of the 11/03L, 11/23, 11/23 Plus, 11/24, 11/34A, 11/44, and 11/70.

The foundation of the PDP-11/24, 11/34A, 11/44, and 11/70 hardware architecture is a standard I/O bus that DEC calls the Unibus. All elements of the system are connected to the Unibus, including the central processor, main memory, I/O hardware interfaces, and communications interfaces. With certain exceptions, data is transferred between the elements of the system only by passing through the Unibus. I/O interfaces normally transfer data to and from memory via central processor interrupts, but several communications interfaces do have direct memory access without processor intervention. Central processors with cache memory (PDP 11/44, 11/70) have direct access to all types of memory without having to go through the Unibus. Additionally, high-speed mass storage units have direct access to cache memory and thus can bypass the Unibus when transferring data to and from memory.

Connections to the Unibus are via the backplane, printed circuit board with sockets. The backplane that is provided with the central processor consists of nine rows of sockets. Each row, called a slot, has six records. Two slots have two sockets reserved. This results in seven slots of six sockets per slot (Hex slot) and two slots of four sockets (Quad slot) per slot. To connect most I/O interfaces require six sockets, four sockets, or multiples thereof. The combination of devices is limited to the mix of sockets and slots required. Slots as well as sockets must be taken into consideration. A Hex or six-socket interface requirement could not use two Quad slots even though eight sockets are available.

DEC PDP-11 Family Communications Capabilities

Ethernet and CCITT X.25 protocols have been incorporated into DECnet Phase IV. This will allow Extended LSI-11 and Unibus based PDP-11 processors running an RSX family operating system to distribute communications activity either locally or via long haul networks to other similarly supported non-DEC devices.

DEC's X.25 has been certified by GTE Telenet for domestic use. In addition to providing an international gateway with higher level functions, Ethernet PDP-11 processor users can also access X.25 and SNA networks from *local* origins.

In an age when technology brings new advancements daily, the PDP-11 family has demonstrated unparalleled staying power. DECnet Phase IV guarantees its life at least into the mid or late 1980s when it can proudly be replaced by the VAX. From humble beginnings, the PDP-11 has graduated into perhaps the most sophisticated communicating minicomputer in the industry.

USER REACTION

Datapro's first Network Users Survey was conducted in November and December of 1981 in conjunction with *Data Communications* magazine. The survey yielded 12 PDP-11 users representing a total of 36 systems being used as *dedicated* communications devices. The ratings of the PDP-11 users are shown as follows:

	Excellent	Good	Fair	Poor	WA*
Overall satisfaction	7	4	1	0	3.5
Ease of installation	5	4	3	0	3.2
Throughput	2	5	5	0	2.8
Hardware reliability	6	3	3	0	3.3
Promptness of manufacturer's maintenance	2	5	4	0	2.6
Quality of manufacturer's maintenance	2	5	4	0	2.6
Manufacturer's software	1	5	2	2	2.1
Manufacturer's technical support	0	4	5	1	1.9

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

As these responses reflect, DEC PDP-11 users are generally very satisfied with their equipment despite subaverage hardware and software support. This serves as testimonial to the performance and reliability of the PDP-11 family, but confirms that the PDP-11 remains oriented towards users who have the sophistication to be able to perform at least some trouble-shooting, maintenance service, and software development in-house, or who deal through an OEM or system builder who can perform these functions for them.□

Two expansion panels are available. One expansion panel provides four slots (two Hex and two Quad) and another expansion panel provides nine slots (seven Hex and two Quad).

Memory cycle time for PDP-11 processors is 0.45 or 0.3 microseconds for MOS memory, and 0.3 microseconds for bipolar memory. The top of the PDP-11 line can support up to 3.5M bytes of memory plus an 8K bipolar cache memory with a cycle time of 0.24 microseconds. The PDP-11 word consists of 16 bits. However, the PDP-11/70 utilizes an extended Unibus that transfers data in 32-bit words.

All four Unibus-based models have four automatic hardware priority level interrupts. They can also use any of seven programmable software-supported additional interrupt levels; these have an automatic vectoring instruction held in a reserved main storage location. Each of the interrupt levels can accommodate independently prioritized peripheral devices.

The priority of any device connected to the Unibus is determined by its physical position; hence, the processor is normally attached so as to give it the highest priority. There is no logical limit to the number of devices that can be attached to the Unibus, with bus access and control handled by the interrupt system.

The theoretical maximum Unibus data transfer rate is five million bytes per second, and attached components communicate in a master/slave manner. The typical transfer rate, however, including average bus delays, is two million bytes per second. On the 11/70, the 32-bit bus is fast enough to permit overlapped use by the CPU, Unibus, and/or several mass storage units, the fastest of which can presently operate at 1 million bytes per second.

The LSI-11 bus used on the PDP-11/03L and 11/23, and the Extended LSI/11 bus used on the 11/23 Plus each have a maximum data transfer rate of two million bytes per second.

DEC offers a vast array of PDP-11 family equipment, and it is beyond the scope of this report to present more than generalized information regarding the physical specifications of the processors. Please note that all cabinet-mounting components fit in standard (19-inch) cabinet interiors, and that the cabinets generally measure 21 inches wide, 30 inches deep, and 72 or 50 inches high. A 19-inch rack-mounted version is available for OEMs.

TRANSMISSION SPECIFICATIONS

Communications lines are attached directly to DEC communications interfaces. Single-line, 4-line, 8-line, and 16-line interfaces are available with asynchronous speeds up to 9600 bps and synchronous speeds up to 1M bps. EIA, CCITT, and 20mA interfaces are supported. Some of the interfaces include microprocessors with direct memory access for outgoing and incoming data. Processing throughput, rather than physical restrictions (backplane socket availability) usually limits the number of lines that can be supported. For instance, a maximum of 32 asynchronous lines can operate simultaneously at a 9600 bps rate. However if the data rate is lower, a proportionate number of additional lines can be added to the system.

Data communications control for all PDP-11s is supplied on the interface board. A number of variants and options are available, so that PDP-11s can be connected to almost any type of communication channel (private phone, dial-up phone, 20-mA line, telegraph line), almost any type of terminal, or almost any type of modem. Supplementing these interfaces is additional data communications hardware to provide flexibility in unique situations.

DEC PDP-11 Family Communications Capabilities

TABLE 1. PDP-11 COMMUNICATIONS INTERFACE CHARACTERISTICS

Synchronous Transmission Mode Single Line Options

Model	Multi-Drop Master	Half-Full Duplex Mode	Max. Line Speed (bps)	Line Interface	Bus Support	Slot Requirements	CRC Error Correction	Direct Memory Access
DUP11-DA	No	H/F	9,600	RS-232-C/V.24	Unibus	1 Hex Slot	Yes	No
DMC11-AR/DA	No	H/F	19,200	RS-232-C/V.24	Unibus	1 Hex Slot	Yes	Yes
DMC11-AR/FA	No	H/F	250,000	V.35/DDS	Unibus	1 Hex Slot	Yes	Yes
DMR11-AA	No	H/F	9,600	ISO 4902	Unibus	2 Hex Slots	Yes	Yes
			19,200	RS-232-C/V.24	Unibus		Yes	Yes
			20,000	RS-449	Unibus		Yes	Yes
			56,000	RS-423-A	Unibus		Yes	Yes
DMR11-AB	No	H/F	1,000,000*	ISO 2593/V.35	Unibus	2 Hex Slots	Yes	Yes
DMR11-AC	No	H/F	1,000,000*	Integral Modem	Unibus	2 Hex Slots	Yes	Yes
DMR11-AE	No	H/F	1,000,000*	RS-422-A	Unibus	2 Hex Slots	Yes	Yes
DPV11-DB	No	H/F	56,000	RS-232-C	LSI-11 bus	1 Double Slot	Yes	No
DMP11-AA	Yes	H/F	19,200	RS-232-C/V.24/V.28	Unibus	1 Hex Slot	Yes	Yes
			56,000	RS-423-A				
DMP11-AB	Yes	H/F	56,000	CCITT V.35	Unibus	1 Hex Slot	Yes	Yes
DMP11-AC	Yes	Full	500,000	Integral Modem	Unibus	1 Hex Slot	Yes	Yes
		Half	1,000,000	Integral Modem	Unibus		Yes	Yes
DMP11-AE	Yes	Full	500,000	RS-422-A	Unibus	1 Hex Slot	Yes	Yes
		Half	1,000,000	RS-422-A	Unibus	1 Hex Slot	Yes	Yes
DMV11-AA	Yes	H/F	19,200	RS-232-C	**	1 Quad Slot	Yes	Yes
			19,200	V.24/V.28				
			56,000	RS-423-A				
DMV11-AB	Yes	H/F	56,000	V.35/DDS	**	1 Quad Slot	Yes	Yes
DMV11-AC	Yes	H/F	56,000	Integral Modem	**	1 Quad Slot	Yes	Yes
PCL11-B	Yes	Full	1,000,000	Local cable connect	Unibus	2 Expansion Slots	Yes	Yes

*Speed is dependent upon modem.
**LSI-11 bus or Extended LSI-11 bus.

The characteristics of the available interfaces are summarized in the Communications Interface Characteristics Tables 1, 2, and 3.

Unibus Communications Interfaces (for PDP-11/24, 11/34A, 11/44, and 11/70)

The *DL11-WB Asynchronous Serial Line Interface* provides full- or half-duplex EIA/CITT line control, changeable under program control. Mode changing, however, is the only programmed change that can be made to this unit. All other characteristics are set when the device is ordered, usually by straps on the board. Those features include a choice of 13 standard data rates between 50 and 9600 bits per second, choice of character size (5, 6, 7, or 8 bits) and stop element size (1, 1.5, or 2 bits), and selection of parity (odd, even, or none). Appropriate parity is appended to outgoing characters, and parity is checked on incoming characters. The unit contains independent two-character buffers (one to transmit data and one to receive data), permitting longer delays between interrupt servicing without annoying rate errors. The DL11-WB can operate with different input and output line speeds. The DL11-WB is contained on one board.

The *DL11-WC Asynchronous Serial Line Interface* is the same as the DL11-WB except that it includes 10-foot cable for connection to a modem instead of a 25-foot cable.

The *DL11-WA Asynchronous Serial Line Interface* is the same as the DL11-WB, except that it is intended for 20mA use and does not have a modem cable.

The *DL11-E Asynchronous Serial Line Interface* is the same as the DL11-WB, except data rate is not switch-selectable.

The *DZ11-A Asynchronous Eight-Line Multiplexer* allows each of up to eight lines or terminals to be individually programmed through software control at speeds up to 9600 bps. The DZ11-A is a lower-cost, reduced-performance multiplexer and does not have DMA facilities. However, the DZ11-A includes enough modem controls to operate a 300-bps data set. Interrupts can be programmed to occur for each character or after 16 characters. The DZ11-A supports asynchronous EIA or CCITT lines and is generally transparent to data, but can report parity errors and framing errors. Input characters are buffered with identification hardware in a first-in/first-out (FIFO) buffer or "silo" (in DEC terms).

The *DZ11-B Eight-Line Expansion Multiplexer* is an eight-line expansion for the DZ11-A which extends line capabilities to 16.

The *DZ11-C Asynchronous Eight-Line Multiplexer* is the same as the DZ11-A, except it is intended for 20mA current loop use only.

The *DZ11-D Eight-Line Expansion Multiplexer* is an eight-line expansion for the DZ11-C.

The *DZ11-E Asynchronous Multiplexer* can support up to 16 EIA/CCITT terminals or lines. It features programmable speeds up to 9600 bps and formats on a per-line basis. It operates at full- or half-duplex and is compatible with Bell Series 100 modems or equivalents.

The *DZ11-F Asynchronous Multiplexer* is the same as the DZ11-E, except it is intended for 20mA current loop use only.

DEC PDP-11 Family Communications Capabilities

TABLE 2. PDP-11 COMMUNICATIONS INTERFACE CHARACTERISTICS:

Asynchronous Transmission Mode/Single Line Options

Model	Modem Control	Max. Line Speed (bps)	Line Interface	Bus Support	Slot Requirements	Error Correction	Direct Memory Access
DL11-E	Yes	9,600	RS-232-C/V.24	Unibus	1 Quad Slot	No	No
DL11-WA	No	9,600	20 mA Loop	Unibus	1 Quad Slot	No	No
DL11-WB	Yes	9,600	RS-232-C/V.24	Unibus	1 Quad Slot	No	No
DL11-WC	Yes	9,600	RS-232-C/V.24	Unibus	1 Quad Slot	No	No
DLV11	No	9,600	20 mA Loop RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No
DLV11-E	Yes	19,200	RS-232-C	LSI-11 bus	1 Double Slot	No	No
DLV11-EB	Yes	19,200	RS-232-C	LSI-11 bus	1 Double Slot	No	No
DLV11-ED	Yes	19,200	RS-232-C	Extended LSI-11 bus	1 Double Slot	No	No
DLV11-F	No	19,200	20 mA Loop RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No
DLV11-FA	No	19,200	20 mA Loop RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No
DLV11-FB	No	19,200	RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No

The *DH11-AD Programmable 16-Line Asynchronous Multiplexer* provides programmed selection of nearly all parameters that are switch-selectable on the DL11—data rate, character and stop element size, and parity check/generation on receive and transmit lines. The DH11-AD offers a choice of 14 data rates plus 2 special rates of the user's choice. Each of the 16 lines can operate independently at any speed. Receive characters for each line are buffered in a 128-byte buffer to reduce CPU loads. Transmit characters can be sent directly in blocks from memory (DMA). The DH11-AD has 16 separate DMA transmitters, each with its own hardware byte count and address registers. Also, special hardware to detect data breaks and to generate program-controlled breaks is provided. The DH11-AD supports EIA RS-232-C connections.

The *DH11-AE Programmable 16-Line Asynchronous Multiplexer* provides the same capabilities as the DH11-AD, except it does not support modems. It is for local connection only.

The *DUP-11—DA Synchronous Line Interface* is a single-line, program-controlled, double-buffered controller capable of handling both byte-oriented protocols, such as binary synchronous and DEC's DDCMP, and bit-oriented protocols, such as SDLC and HDLC. The DUP-11-DA is restricted to 8-bit characters. Bit- or byte-oriented operations are software-selectable. Modem controls are provided, permitting operation with Bell 200 Series or equivalent synchronous data sets at speeds up to 9600 bps.

Additional features of the DUP-11-DA include calculating and checking of CRC-16 block check characters and bit stuffing. The latter is engaged when using DDCMP and CRC/CCITT bit-oriented protocols to preclude data characters from being confused with control characters. Specifically, the DUP-11-DA inserts "0" bits in bit streams containing five or more consecutive "1" bits so that the receiving device will not interpret this stream as a FLAG control character.

The *DMC11 Network Link Modules* interconnect PDP-11 computers similarly equipped in a remote network. They operate in full or half duplex. They interface to Bell 200 Series or equivalent modems at speeds up to 19.2K bps or Bell 500 Series or equivalents at 250K bps. The DMC11s can be used to communicate over common carrier facilities to other DMC11s or to a synchronous interface with software implementation of DDCMP Version 3.2.

The DMC11 Network Link Modules include:

- The DMC11-AR, which is designed to be used for DDCMP operations with a DMC11-DA or DMC11-FA line unit.
- The DMC11-DA, a network line unit designed for remote use with RS-232-C and CCITT devices at up to 19.2K bps.
- The DMC11-FA, which interfaces to CCITT modems (Bell 500 Series or equivalent) at speeds up to 250K bps.

The *DMP11 Multipoint Network Link Modules* provide multipoint or point-to-point connections. They operate at full or half-duplex. The DMP11s can be used over common carrier facilities to other DMP11s or equivalent synchronous interface with software implementation of DDCMP Version 3.1 or 4.0. Depending upon the operating system, the DMP11s will support up to 32 tributaries. RS-232-C data rates of up to 19.2K bps are supported.

The DMP11 Multipoint Modules include:

- The DMP11-AA, which supports up to 32 tributaries at full or half-duplex. Data rate is 56K bps for RS-423-A and 19.2K bps for RS-232-C. In multipoint operation, the complementary device must be either a DMP11 or DMV11 operating in the same mode.
- The DMP11-AB, which is the same as DMP11-AA, except it supports a CCITT V.35 interface only at a data of 56K bps, and it includes a 25 foot modem cable.
- The DMP11-AC, which supports up to 32 tributaries in a local network. Maximum speeds are 1M bps for half-duplex and 500K bps for full-duplex. An integral modem is included. Complementary devices must be DMP11s or DMV11s.
- The DMP11-AE, which is the same as the DMP11-AC, except that instead of having an integral modem, it provides an RS-422-A interface.

The *DMR11-AA Network Link Module* supports speeds up to 56K bps in a full or half-duplex mode. The DMR11-AA includes a built-in modem, provides ISO 4902, RS-232-C, RS-449, RS-423-A, or CCITT V.24 interfaces, and requires a DMR11 or DMC11 as a complementary device.

The *DMR11-AB Network Link Module* is the same as the DMR11-AA but can also communicate locally at speeds up to 1M bps. Interfaces can be ISO 2593 or CCITT V.35.

The *DMR11-AE Network Link Module* is the same as the DMR11-AB, except that it supports an RS-422-A interface.

The *DMR11-AC Network Link Module* interconnects PDP-11 computers in local network applications and provide a

DEC PDP-11 Family Communications Capabilities

TABLE 3. PDP-11 COMMUNICATIONS INTERFACE CHARACTERISTICS

Asynchronous Transmission Mode Multi-Line Options

Model	Number of Lines	Mode	Modem Control	Max. Line Speed (bps)	Line Interface	Bus Support	Slot Requirements	Error Correction	Direct Memory Access
DH11-AD	16	H/F	Yes	9,600	RS-232-C/V.24	Unibus	2 Expansion Slots	No	No
DH11-AE	16	H/F	Yes	9,600	RS-232-C/V.24	Unibus	2 Expansion Slots	No	No
DZ11-A	8	Full	Yes	9,600	RS-232-C/V.24	Unibus	1 Hex Slot	No	No
DZ11-A/B	16	Full	Yes	9,600	RS-232-C/V.24	Unibus	1 Hex Slot	No	No
DZ11-C	8	Full	No	9,600	20 mA Loop	Unibus	1 Hex Slot	No	No
DZ11-C/D	16	Full	No	9,600	20 mA Loop	Unibus	1 Hex Slot	No	No
DZ11-E	16	Full	Yes	9,600	RS-232-C/V.24	Unibus	2 Hex Slots	No	No
DZ11-F	16	Full	No	9,600	20 mA Loop	Unibus	2 Hex Slots	No	No
DZV11-B	4	H/F	Yes	9,600	RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No
DZV11-C	4	H/F	Yes	9,600	RS-232-C/V.24	Extended LSI-11 bus	1 Double Slot	No	No
DLV11-J	4	H/F	No	38,400	RS-232-C/V.24	LSI-11 bus	1 Double Slot	No	No
DLV11-JA	4	H/F	No	38,400	RS-232-C/V.24	Extended LSI-11 bus	1 Double Slot	No	No
DLV11-KA	4	H/F	No	38,400	20 mA Loop	LSI-11 bus	1 Double Slot	No	No

connection to other DMR11-AC modules using twin-axial, co-axial, or tri-axial cables up to 18,000 feet long. It operates at full-duplex with two cable and half-duplex with a single cable. Switch-selectable speeds range from 56K bps to 1M bps.

The *PCL11-B Multidrop DDP Network Link* is used to connect up to 16 processors in a local distributed processing network. It transmits data in a block mode via a time division multiplexed bus. Total bus bandwidth ranges up to 1M bps. The total bandwidth between any transmitter and receiver is 500K bps or less depending upon the percentage of bandwidth that is allocated to the transmitter. Data is transmitted at full-duplex with CRC error detection support.

The *KG11-A Communications Arithmetic Error Connector* computes cyclic redundancy check (CRC), longitudinal redundancy check (LRC), and block check characters (BCC).

LSI-11 Bus Communications Interfaces (for PDP-11/03L and 11/23)

The *DLV11 Serial Interface Unit* operates at full or half-duplex for 20mA connections at data rates up to 9600 bps. This unit does not provide modem control. Support is provided for a single line only.

The *DLV11-E Asynchronous Line Interface Module* operates at full or half-duplex with data rates of up to 19,200 bps. It provides modem control for Bell 100 and 200 Series or compatible modems.

The *DLV11-EB Asynchronous Line Interface Module* is the same as the DLV11-E, but includes a modem cable.

The *DLV11-F Asynchronous Line Interface Module* operates at full or half-duplex with data rates from 50 to 19.2K bps. This unit supports a 20mA current loop and does not provide modem control.

The *DLV11-FA Asynchronous Line Interface Module* is the same as the DLV11-F but includes a cable.

The *DLV11-FB EIA/CCITT Asynchronous Line Interface Module* operates at full or half-duplex at data rates up to 19.2K bps but does not provide modem control. It supports EIA/CCITT interface levels.

The *DLV11-J Four-Line Asynchronous Line Unit* operates at full or half-duplex at data rates up to 38.4K bps. Character formats are seven or eight data bits with one or two stop bits. Parity is even, odd, or none. This unit does not provide modem control.

The *DLV11-KA Four-Line Asynchronous Line Unit* converts the DLV11-J to 20mA current loop use.

The *DZV11-B Four-Line Asynchronous Multiplexer* provides per line speed programmability for data rates between 50 and 9600 bps. The DZV11-B supports Bell 103 or compatible modems.

The *DPV11-DB Single-Line Synchronous Interface* is used to connect the LSI-11 bus to Bell 201 or compatible modems. It supports data rates up to 56K bps for full or half-duplex operation.

The *DMV11-AA Intelligent Synchronous Line Controller* is a microprocessor based device that supports multipoint or point-to-point DMA data transfers for a maximum of 12 tributaries. It handles all DDCMP protocol processing. In a point-to-point operation, the DMV11-AA can communicate with a DMC11, DMR11, DMP11, or DMV11. For multipoint communication, the complementary device must be either a DMP11 or DMV11. Maximum data rate is 56K bps for RS-423-A interface and 19.2K bps for RS-232-C interface.

The *DMV11-AB Synchronous Line Controller* is the same as the DMV11-AA, except it only supports CCITT V.35 operation at 56K bps.

The *DMV11-AC Intelligent Synchronous Line Controller* has the same capabilities as the DMV11-AA above, but includes a built-in modem.

Extended LSI-11 Bus Communications Interfaces (for PDP-11/23 Plus)

The *DLV11-ED Single Line Asynchronous Interface* operates at full or half-duplex with data rates from 50 to 19.2K bps. It supports Bell 100 or 200 Series or compatible modems.

The *DLV11-JA Four-Line Asynchronous Interface* operates at full or half-duplex with data rates from 150 to 38.4K bps. Character formats of seven or eight bits with even, odd, or no parity. This unit does not include modem control.

The *DMV11-AA Intelligent Synchronous Line Controller* supports point-to-point or multipoint DMA data transfers

DEC PDP-11 Family Communications Capabilities

TABLE 4. PDP-11 OPERATING SYSTEM SUPPORT

	RT-11	RSX-11M	RSTS/E	RSX-11M-Plus
Minimum Memory (K bytes)	64	128	256	256
Currently Marketed Machines:				
PDP-11/03L	Yes	No	No	No
PDP-11/23	Yes	Yes	No	No
PDP-11/23 Plus	No	Yes	Yes	Yes
PDP-11/24	Yes	Yes	Yes	Yes
PDP-11/34A	Yes	Yes	Yes	No
PDP-11/44	No	Yes	Yes	Yes
PDP-11/70	No	Yes	Yes	Yes

for up to 12 multipoint tributaries. It handles all DDCMP protocol processing. In point-to-point operation, the DMV11-AA can communicate with a DMC11, DMR11, DMP11, or DMV11. In multipoint communications, the complementary device must be either a DMP11 or a DMV11. The maximum data rate is 56K bps for RS-423-A and 19.2K bps for RS-2332-C interface.

The DMV11-AB Synchronous Line Controller is the same as the DMV11-AA, except it only supports CCITT V.35 operation at 56K bps.

The *DMV11-AC Intelligent Synchronous Line Controller* provides the same capabilities as the DMV11-AA, but includes a built-in modem.

The *DZV11-C Asynchronous Four-Line Multiplexer* provides programmable line speed on a per-line basis for speeds up to 9600 bps. It supports Bell 103 or compatible modems.

SOFTWARE

Four functionally different operating systems are available from DEC for the PDP-11 family. Not all of these operating systems are capable of running on all of the PDP-11 models. Table 4 provides a comparison of these operating systems and the machine models on which they run.

The operating systems differ not only in function, but also in the degree and type of data communications supported. Table 5 depicts these operating systems and the communications support each provide.

All of the current operating systems support DECnet Phase III. In the not too distant past, this was not the case. Now any PDP-11 family processor can be linked to the entire DEC communications network.

All DEC networks will typically use DECnet, but DECnet is not a turnkey solution. At the very least, customers must purchase communications links such as a telephone line or private wire, one or more of DEC's communications interfaces for each computer in the network, and often a modem for each end of every link. Some of the more complicated applications will require considerable programming, as well.

DECnet allows customers to:

- Transmit data files across a room or around the world, with less expense and greater speed than is generally possible through other media.
- Share expensive peripherals among several CPUs, some of which may be remote.
- Use another tool in the creation of high-availability (super-reliable) systems, adding to the Unibus links and multi-port options that Digital already supplies.

The Digital Data Communications Message Protocol (DDCMP), the link protocol for DNA/DECnet, performs the physical line control for most of the synchronous communications hardware interfaces noted in Tables 1, 2, and 3.

DDCMP performs line scanning, error detection and error recovery. On half-duplex lines, DDCMP controls the direction of traffic, while on full-duplex lines, DDCMP controls bidirectional traffic; on multi-point lines DDCMP performs the polling function. Outgoing transmissions are enveloped with control characters mainly to enable the receiving device to perform error detection. The CRC-16 polynomial checking technique is employed in creating an error detection code. Incoming transmissions are stripped of control characters after passing error detection checks. To accommodate for the relatively long transit time for satellite destined messages, DDCMP can support the transmitting up to 255 messages before halting transmissions to await acknowledgements for the previously transmitted messages.

DECnet software to handle the DDCMP protocol line handling is intended for use with medium speed communications systems. The software will perform the function for both the program-interrupt and the DMA types of communications hardware interfaces. When volume increases substantially and begins to consume too much central processor overhead or when high-speed communications lines are used, the DMC11 interface can be employed. Containing a dedicated microprocessor, the DMC11 will perform, via firmware, the line handling function, thus relieving the central processor's DECnet software of this time-costly burden. With the DMC11, a user could employ DDCMP protocol without using the other functions of DECnet.

See Report #C11-384-101 in Section C11 for more details on DECnet.

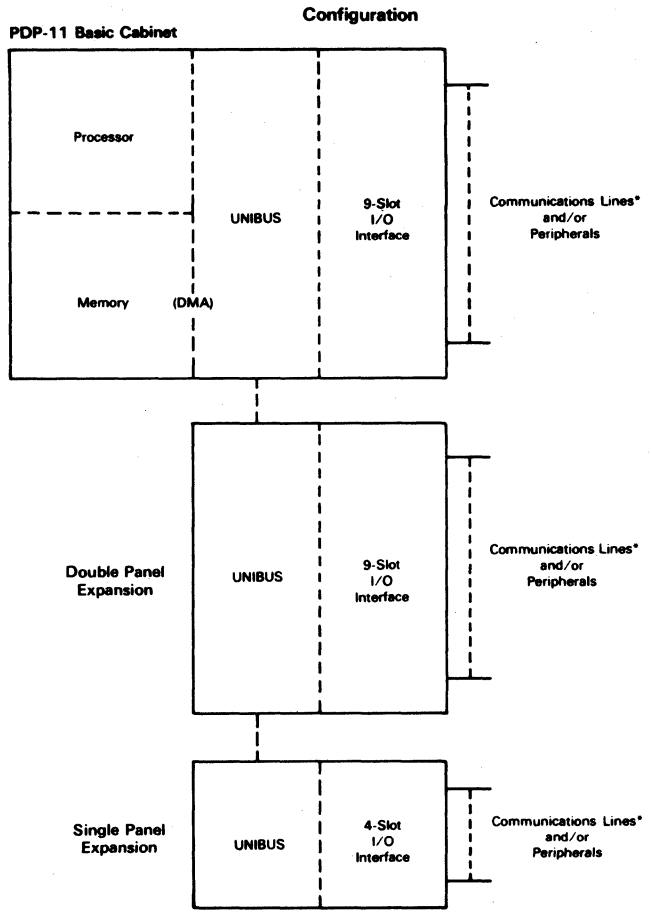
The *RT-11 Operating System* is a disk-based, real-time operating system typically designed for a smaller and even single user. It may be implemented on Models 11/03L, 11/23, 11/24, and 11/34A.

Special communications software programs supported by RT-11 are listed below:

- DECnet-RT (QJ687) is a Phase III network product that allows an RT-11 based system to participate as a non-routing node in a DEC computer network.
- RT-11 2780/3780 Protocol Emulator (QJD59) permits an RT-11 system to emulate an IBM 2780 or 3780 remote batch terminal. A DUV11 or DUP11 Synchronous Interface is required.

RSTS/E (Resource Sharing Timesharing System/Extended) is a timesharing system designed to accommodate large numbers of interactive users. RSTS/E can run on a PDP 11/23 Plus, 11/24, 11/34A, 11/44, or 11/70 and supports a

DEC PDP-11 Family Communications Capabilities



*Throughput considerations determine line configuration alternatives; see Tables 1, 2, and 3 for specifications.

wide range of communications interfaces for local and remote terminals with varying characteristics.

Special communications software programs supported by RSTS/E are as follows:

- RSTS/E-2780 (QPD10) is a software package which permits RSTS/E systems to act as an IBM 2780 device.
- DECnet/E (QP692) allows a RSTS/E system to participate as a routing or non-routing node in a DEC computer network.
- RSTS/E High Performance 2780/3780 Emulator (QRD06) is a program which permits an RSTS/E system to appear as an IBM 2780 or 3780 to an IBM System 370, 303X, or other mainframe processor. It requires a DUP11-KA and a compatible communications processor.
- RSTS/E 3271 Protocol Emulator (QRD05) permits RSTS/E system jobs to communicate interactively with tasks running on an IBM 370, 303X or other host supporting the 3271 protocol. The IBM program must run under IMS/VS or CICS/VS systems. It requires a DUP11-DA and a compatible communications processor.
- DX/RSTS (QJ703) is a software package that makes asynchronous communications possible between RSTS/E systems and DEC word processors and personal computers.

The *RSX-11M Operating System* is realtime programming system designed for a wide range of applications. Consequently, it supports all current PDP-11 family processors except the 11/03L. Communications software support is just as broad and includes the following packages:

- DECnet-11M (QJ684) allows RSX-11M systems to participate as a routing or non-routing node in a DEC computer network.
- MUX200/RSX-IAS Multiterminal Emulator (QJ070) is a software program that provides communications with a CDC 6000 Cyber Series computer or other system using the 200 UT-mode 4A protocol.
- RSX-11M/IAS RJE/HASP (QJS60) is a software package for performing the standard functions of an IBM HASP remote job entry workstation.
- RSX-11M/SNA Protocol Emulator (QJD69) provides an RSX-11M system the ability to participate in an IBM Systems Network Architecture network. It supports half- or full-duplex transmissions at speeds up to 9600 bps when used with the prerequisite DUP11.
- RSX-11 2780/3780 Emulator (QJD82) emulates the communications protocol of an IBM 2780/3780 device while running a job under RSX-11M or RSX-11M-Plus systems.
- RSX-11/3271 Protocol Emulator (QJD76) permits jobs running under RSX-11M or RSX-11M-Plus systems to

DEC PDP-11 Family Communications Capabilities

TABLE 5. PDP-11 OPERATING SYSTEM COMMUNICATIONS SUPPORT**

Feature	RT-11	RSX-11M	RSX-11M-Plus	RSTS/E
DECnet Phase III	Yes	Yes	Yes	Yes
DECnet Phase IV	No	Yes***	Yes***	No
**Emulation Supported:				
IBM RJE/HASP	No	Yes	Yes	No
IBM 2780 Batch	Yes	Yes	Yes	Yes
IBM 3780 Batch	Yes	Yes	Yes	Yes
IBM 3271 Interactive	No	Yes	Yes	Yes
IBM SNA	No	Yes	No	No
CDC 6000 Cyber	No	Yes	No	No
Univac 1004	No	Yes	No	No
TTY	No	Yes	No	Yes
Communications Interfaces Supported:				
DL11-WA/WB/WC	Yes	Yes	Yes	Yes
DL11-E	Yes	Yes	Yes	Yes
DZ11-A/B/C/D/E/F	Yes	Yes	Yes	Yes
DH11-AD/AE	Yes	No	Yes	Yes
DUP11-DA	No*	Yes	Yes	No
DMR11-AC	No*	Yes	Yes	No*
DMC11-AR/DA/FA	No*	Yes	Yes	No*
DMP11-AA/AB/AC/AE	No*	Yes	Yes	No*
DMR11-AA/AB/AE	No*	Yes	Yes	No*
PLC11-B	No	Yes	Yes	No
DLV11	Yes	Yes	Yes	No
DLV11-E/EB/F/FA/FB/J	Yes	Yes	Yes	No
DZV11-B	Yes	Yes	Yes	No
DPV11-DB	No	Yes	Yes	No
DMV11-AA/AB/AC	Yes	Yes	No	No
DLV11-ED	Yes	Yes	Yes	Yes
DLV11-JA	Yes	Yes	Yes	No
DZV11-C	Yes	Yes	Yes	Yes

* Operating System supports interface for DECnet use only.
** This Table shows software offered by DEC only. Independent vendors may offer additional emulation software support.
*** Not yet available. Delivery is promised for early 1984.

communicate interactively with jobs running on an IBM 370, 303X, or other compatible host.

- **UN1004/RSX/Univac 1004 Terminal Emulator (QJ170) provides communications between an RSX-11M system and a Univac 1100 series or other system using the Univac 1004 RMS-1 protocol.**
- **DX/11M (QJ704) is a software program that allows asynchronous communications between an RSX-11M and a DEC word processor or personal computer.**

RSX-11M-Plus **is the fourth current operating system in the PDP-11 family. RSX-11M-Plus is a higher performance superset of the RSX-11M. It is a disk-based system and supports the larger PDP-11s: 11/23 Plus, 11/24, 11/44, and 11/70.**

Special communications software support for RSX-11M-Plus is provided by the following software:

- **DECnet-11M-Plus (QR580) allows an RSX-11M-Plus system to participate as a routing or non-routing node in DEC computer networks using Digital Network Architecture (DNA) protocols.**
- **RSX-11 2780/3780 Emulator (QJD82) emulates the communications protocol of an IBM 2780/3780 device while running a job under RSX-11M or RSX-11M-Plus systems.**
- **RSX-11/3271 Protocol Emulator (QJD76) permits jobs running under RSX-11M or RSX-11M-Plus systems to communicate interactively with jobs running on an IBM 370, 303X, or other compatible host.**
- **RSX-11M/IAS RJE/HASP (QJS62) is a software program that allows an RSX-11M-Plus system to perform functions of an IBM HASP remote job entry workstation.**

PRICING

DEC generally provides the PDP-11 minicomputers on a purchase basis, with separately priced maintenance agreements. Leases are also available from DEC. Lease rates vary with the prime interest rate, the customer's volume of business with DEC, and the value of the equipment being leased.

Software maintenance is offered through several levels of optional service, ranging from a periodic software newsletter to automatic updates of software and manuals (software subscription service). In addition, software components, including documents and updates, can be purchased separately from Digital's Software Distribution Center.

The Digital Equipment Computer Users Society (DECUS) is a voluntary, non-profit users'group supported by DEC. DECUS provides an extensive program library, users' groups, special interest groups, and workshops/symposia.

Field maintenance services are offered on several levels which vary depending on specific customer needs. The monthly charges shown are for the 8 hour/5 day on-site Basic Service Agreement, and include all parts and labor required for system maintenance. Software license fees are for single system use, include basic support, and may vary slightly depending on medium.

DEC PDP-11 Family Communications Capabilities

	Typical Processor Configurations	Purchase Price	Monthly Maintenance
SR-VXSSB-BA	PDP-11/03L CPU with 64K bytes of memory, RT-11 operating system, four line asynchronous interface, two 500K byte diskette drives and controller, and a video display	$ 14,700	$141
SM-WXMMA-BA	PDP-11/23 CPU with 128K bytes of memory, RSX-11M operating system, four line asynchronous interface, two 10.4M byte cartridge disk drives and controller, and a video display	26,100	247
SE-RXMMB-CA	PDP-11/23 Plus CPU with 256K bytes of memory, RSTS/E operating system, two 10.4M byte disk drives and controller, and a 180 cps printer	32,900	247
SE-FXHHA-CA	PDP-11/24 CPU with 256K bytes of memory, RSTS/E operating system, two line asynchronous interface, two 2817 byte disk drives and controller, and a 180 cps printer	62,700	447
SM-30MMB-BA	PDP-11/34A CPU with 128K bytes of memory, RSX-11M operating system, single line asynchronous interface, two 10.4M byte disk drives and controller, and a video display terminal	37,100	250
SE-40UAC-CA	PDP-11/44 CPU with 512K bytes of memory, RSTS/E operating system, Cobol programming language, two single line asynchronous interfaces, two 256K byte cartridge tape drives, one 67M byte disk drive and controller, one mag tape drive, and a 180 cps printer	102,200	508
SE-70DBA-CA	PDP-11/70 CPU with 512K bytes of memory, RSTS/E operating system, single line asynchronous interface, one 256M byte disk drive and controller, 800/1600 bpi tape drive, and a 180 cps printer	178,300	932
	PDP-11/24, 11/34A, 11/44, and 11/70 Communications Options		
DL11-WB	EIA/CCITT Single Line Asynchronous Interface	950	7
DL11-WC	Asynchronous Serial Interface	950	7
DL11-WA	Asynchronous 20mA Serial Interface	990	7
DL11-E	Single Drive Asynchronous Interface	1,170	8
DZ11-A	EIA/CCITT Eight-Line Asynchronous Multiplexer	2,700	33
DZ11-B	EIA/CCITT Eight-Line Asynchronous Expansion Multiplexer	2,150	28
DZ11-C	Eight Line Asynchronous Multiplexer	3,000	33
DZ11-D	Eight Line Asynchronous Expansion Multiplexer	2,310	28
DZ11-E	EIA/CCITT Asynchronous 16-Line Multiplexer	4,350	56
DZ11-F	Asynchronous 16-Line Multiplexer	5,000	56
DH11-AD	Programmable EIA/CCITT 16-Line Multiplexer	8,950	68
DH11-AE	Programmable 16-Line Multiplexer	7,950	57
DUP11-DA	Single Line Synchronous Interface	1,575	12
DMR11-AC	Local Network Link Line Unit	6,900	74
DMC11-AR	DDCMP Network Link Module	2,130	21
DMC11-DA	Remote Network Link Module	1,500	7
DMC11-FA	Remote Network Link Module	1,880	7
DMP11-AA	Multipoint Network Link Module	6,900	74
DMP11-AB	Multipoint Network Link Module	6,900	74
DMP11-AC	Local Network Link Module	6,900	74
DMR11-AA	Network Link Module with Modem	4,400	39
DMR11-AB	Local Network Link Module	4,400	39
DMR11-AE	Network Link Module	4,400	39
DMP11-AE	Remote Network Link Line Unit	6,900	74
PLC11-B	Multidrop DDP Network Link	7,750	66
KG11-A	Communications Arithmetic Error Correction Option	1,350	7
	PDP-11/03L and PDP-11/23 Communications Options		
DLV11	Serial Interface Unit	525	6
DLV11-E	Asynchronous Line Interface Module	440	8
DLV11-EB	Asynchronous Line Interface Module	550	8
DLV11-F	Asynchronous Line Interface Module	440	8
DLV11-FA	Asynchronous Line Interface Module	550	8
DLV11-FB	EIA/CCITT Asynchronous Line Interface Module	670	8
DLV11-J	Four Line Asynchronous Line Unit	580	11
DLV11-KA	20mA Current Loop Converter	190	7
DZV11-B	Four Line Asynchronous Multiplexer	1,100	11
DPV11-DB	Single Line Synchronous Interface	770	13
DMV11-AA	Intelligent Synchronous Line Controller	2,200	39
DMV11-AB	Intelligent Synchronous Line Controller	2,300	39
DMV11-AC	Intelligent Synchronous Line Controller With Integral Modem	2,000	39
	PDP-11/23 Plus Communications Options		
DLV11-ED	Single Line Asynchronous Interface	490	8
DLV11-JA	Four Line Asynchronous Interface	650	10
DZV11-C	Asynchronous Four Line Multiplexer	1,100	10

DEC PDP-11 Family Communications Capabilities

SOFTWARE

		License Fee*
QJ687	DECnet-RT	$ 2,000
QJD59	RT-11 2780/3780	3,500
QPD10	RSTS/E-2780	7,000
QP692	DECnet/E	4,300
QRD06	RSTS/E High Performance 2780/3780 Emulator	7,400
QRD05	RSTS/E 3271 Protocol Emulator	8,000
QJ703	DX/RSTS	2,900
QJ684	DECnet-11M	4,000
QJ070	MUX200/RSX-IAS Multiterminal Emulator	7,600
QJS60	RSX-11M/IAS RJE/HASP	9,900
QJD69	RSX-11M/SNA Protocol Emulator	10,000
QJD82	RSX-11 2780/3780	6,400
QJD76	RSX-11/3271 Protocol Emulator	6,700
QJ170	UN1004/RSX/Univac 1004 Terminal Emulator	7,200
QJ704	DX/11M	2,900
QR580	DECnet-11M-Plus	5,000
QJS62	RSX-11M/IAS RJE/HASP	9,900

*Includes software support.■

DEC PDP-11 Family Communications Capabilities

MANAGEMENT SUMMARY

Datapro estimates that something on the order of 60,000 PDP-11 processors have been delivered by DEC, and many are involved in communications applications to some extent.

The extremely versatile PDP-11 line of minicomputers has been continually enhanced throughout its ten-year history. (A thumbnail sketch of the past and present models is provided in Table 1.) As of this publication, there are five model groups actively marketed by DEC and, with the exception of the low-end PDP-11/03, all share a common internal design called the UNIBUS. The UNIBUS design permits the user to connect any DEC I/O devices to any of the PDP-11 models.

Over twenty different line controller and interface sets are available from DEC which effectively handle local, remote and interprocessor communications. Virtually all modes and types of data communications, protocols and facilities, are supported. Seven functionally different operating systems are available from DEC, along with numerous emulation software packages which permit PDP-11 interconnection with IBM, Univac and CDC mainframes.

There are basically two groups of communications interfaces available from DEC, differentiated primarily in their effect on processor utilization. The DMC11, for example, contains communications processing microcode which greatly reduces the amount of communications processing that the host processor must perform. These "controllers" generally feature Direct Memory Access

A family of minicomputers which may be effectively implemented as front-end communications processors, as remote processors in a distributed network, as remote network nodes/controllers, or in a combination of these functions.

A user may choose from among five currently-marketed PDP-11 models with memory ranging from 16K bytes to four megabytes. Seven operating systems are available from DEC which offer extensive and widely varying communications capabilities. In addition, DEC offers dozens of communications options including DECnet and emulation software for use with IBM, Univac and CDC mainframes.

A typical PDP-11/34 processor running the RSX-11M operating system with DECnet, 64K bytes of memory, disk storage, and interfaces for eight asynchronous and two synchronous lines can be purchased for $39,500. Monthly maintenance for this configuration is $298.

CHARACTERISTICS

VENDOR: Digital Equipment Corporation, 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

DATE OF FIRST ANNOUNCEMENT: March 1970.

DATE OF FIRST DELIVERY: August 1970.

The largest member of the PDP-11 line, the 11/70, features memory management hardware capable of addressing up to four million bytes of memory, and 0.24-microsecond cache memory. The 11/70 configuration shown in the photo contains 512K bytes of memory, two magnetic tape transports, two 1-megabyte fixed-head disk drives (right of magnetic tape units), two 88-megabyte disk pack drives (right rear), five user terminals (foreground), a 300-lpm line printer (left), and two communications subsystems (stand-alone center and rear), which contain communications controllers and interfaces.

DEC PDP-11 Family Communications Capabilities

TABLE 1. PDP-11 MODEL SUMMARY

	LSI-11/2	LSI-11	11/03	11/04	11/05*	11/10*	11/15*	11/20*	11/34, 11/34A	11/35*	11/40*	11/45*	11/55	11/60	11/70
Date Announced	1/78	2/75	12/75	11/74	10/71	1/73	4/71	3/70	2/76	10/73	8/72	10/71	12/75	3/77	2/75
First Delivery	3/78	5/75	—	7/75	2/72	2/73	6/71	8/70	3/76	1/74	1/73	4/72	3/76	5/77	5/75
Typical Purchase**	$1.1K	$1.6K	$10K	$17.3K	—	—	—	—	$20.9K	$29.9K	—	$41.8K	$66.2K	$40K	$100K
Number Installed***	—	29,000		9,100	11,000		4,250		750	8,000		3,000		400	1100

* System is no longer actively marketed.

**Includes memory and I/O configurations; quantity prices are shown for the LSI-11 and LSI-11/2.

***Estimated, as of 1978.

(DMA) for the messages and data they handle. The others operate on a character-interrupt basis (including, for example, the DUP11), and require substantial processor involvement in communications handling (i.e., protocol and code conversion, error handling, and so on).

Many independent vendors have jumped on the bandwagon in the manufacture of communications interfaces for the popular PDP-11 family. Among the most notable is Digital Communications Associates, Inc. (DCA), of Norcross, Georgia. DCA markets turnkey network systems, and specializes in PDP-11 UNIBUS-compatible controllers. The DCA System 205/11, for example, is a UNIBUS adapter capable of supporting up to 128 asynchronous terminals. It is essentially a statistical multiplexer that can reportedly replace up to 16 DEC DZ11 interfaces at a considerable cost saving. Another DZ11 replacement is offered by COMDESIGN, Inc., of Goleta, California. Its TC-3 plugs into a UNIBUS and works with similar remote devices. In addition to other functions, it off-loads error detection and correction from the host, thereby increasing throughput.

As a front-end, DEC markets several specially-modified PDP-11's to front end DEC mainframes, specifically the DECsystems-10 and -20. The DN87, for example, is a specialized PDP-11/40 which front ends most of the DECsystem-10 models. It may contain up to 64K bytes of memory and handle up to 128 communications lines. The DN20 front end is actually a newer PDP-11/34A which performs front-end communications processing for the later DECsystem-10 models, and the DECsystem-20. When front-ending DEC mainframes, the PDP-11 is loaded with a portion of the host's operating system dedicated to communications handling; TOPS-10 or TOPS-20, depending on the host.

DEC also markets a specialized PDP-11 to perform as a remote node in large DEC mainframe networks. The DN200 is a PDP-11/34A which supports up to two synchronous or 32 asynchronous communications lines. Functioning as a remote concentrator, the DN200 optionally supports a character printer and card reader. Software for this remote node is likewise included with the mainframe package.

Some of DEC's communications features for the PDP-11 are available on a specialty basis only, and

NUMBER DELIVERED TO DATE: Over 60,000 PDP-11 processors (all models—1978 estimate).

SERVICED BY: Digital Equipment Corporation.

CONFIGURATION

The original PDP-11 family of 16-bit minicomputers began in 1970 with the 11/20 model, and its closely related but stripped-down version, the 11/15. Both of these contained about 19 boards and some 600 integrated circuits. In 1971, the 11/05 and 11/45 were introduced, and marketed as more cost effective replacements to the 11/15 and 11/20. These processors consisted of two boards and about 200 integrated circuits. The 11/45, like the other PDP-11's, was a core-only machine, but included memory management circuitry that raised the maximum memory capacity from 56K bytes to 248K bytes.

Although these models all contained a UNIBUS-type of I/O channel, it was not until MOS memory was introduced (with the 11/50) that the high-speed UNIBUS that is prevalent today was introduced. Subsequent models used both core and MOS memory, and DEC turned its attention to packaged systems and software support.

Subsequent models (the 11/40, 11/35 and 11/04) were introduced that offered increasing price performance until 1975, when DEC announced the low-end, OEM-oriented LSI-11 microcomputer, and the high-end 11/70. The 11/70 was said to deliver 75 percent of the throughput of an IBM 370/158. It contained cache memory and memory management which permitted addressing of up to 4 million bytes.

The LSI-11 was subsequently marketed in a packaged version as the 11/03. In order to keep prices low, DEC left out the UNIBUS structure from these models.

In 1976, the 11/34 was announced, 50 percent faster than its predecessor model, the 11/04. Along with its cache memory brother, the 11/34A, main memory (either core or MOS) is supported to 248K bytes.

In 1977, the mid-range 11/60 was announced, with performance levels between the 11/34 and 11/70. It includes cache memory, main memory to 256K bytes, and user-accessible microprogramming.

The foundation of the PDP-11 hardware architecture is a standard I/O bus that DEC calls the UNIBUS. All elements of the system are connected to the UNIBUS, including the central processor, main memory, I/O hardware interfaces, and communications interfaces. With certain exceptions, data is transferred between the elements of the system only by passing through the UNIBUS. One exception is memory. Central processors without cache memory have access to core memory through the UNIBUS, but semiconductor memory can be attached so that the central processor also has direct access. I/O interfaces normally transfer data to and from memory via central processor interrupts, but several

DEC PDP-11 Family Communications Capabilities

TABLE 2. COMMUNICATIONS FUNCTIONS SUPPORTED BY PDP-11 DECNET PRODUCTS

	DECnet-11M	DECnet-11S	DECnet-IAS	DECnet/E	DECnet-RT
Current Version	2.0	2.0	2.0	1.0	1.0
Functions Supported:					
Program-to-Program Communication	Yes	Yes	Yes	Yes	Yes
Intersystem File Transfer	Yes	No	Yes	Yes	Yes
Command/Batch File Submission	Yes	No	Yes	Yes	Yes
Command/Batch File Receipt and Execution	Yes	No	Yes	Yes	No
Remote File Access	Yes	Yes*	Yes	No	Yes
Downline System Loading	Yes	No	Yes	No	No
Downline Program Loading	Yes	No	Yes	No	No

*DECnet-11S node may access files of remote DECnet nodes, but may not itself be accessed.

are not considered standard features or options. These include, for example, channel adapters for IBM 360/370 or Univac 1100 mainframes, which permit the PDP-11 to front end these non-DEC hosts. Other special packages include PDP-11's in packet-switching, message-routing, or network-controlling applications. Still others include PDP-11's as RJE terminals to IBM, CDC, Univac and other non-DEC computers.

Numerous OEM's, such as ASI Teleprocessing, Inc., of Watertown, Massachusetts, and Racal-Milgo, of Miami, Florida, specialize in PDP-11-based communications systems, and market configurations which include many of these special features.

ASI markets three PDP-11 based communications systems; the Nucleus 4000, 4010, and 4100. These are a family of front-end and network node processors which are compatible with IBM, NCR, Data General and Burroughs computers and terminals. Turnkey systems are offered which feature PDP-11's with up to 256K bytes of memory, and proprietary, bundled ASI software. Numerous options, including packet-switching software, are available.

Racal-Milgo markets the PDP-11 in its Communications Management Series; the System 200 Network Management System, and its recently-announced CMS System 2000. The System 200 includes a PDP-11/04 or 11/05 with up to 64K bytes of memory, and provides for the control and monitoring of up to 64 communications lines, with up to 255 terminal devices per line. The CMS System 2000 can reportedly manage up to 256 lines and up to 65,280 terminal devices. It includes a PDP-11 running under the RSX-11M operating system.

DNA AND DECNET

No discussion of the PDP-11's communications capabilities would be complete without mentioning

communications interfaces do have direct memory access without processor intervention. Central processors with cache memory (PDP-11/60, 70) have direct access to all types of memory without having to go through the UNIBUS. Additionally, high-speed mass storage units have direct access to cache memory and thus can bypass the UNIBUS when transferring data to and from memory.

Connections to the UNIBUS are via the backplane, a printed circuit board with sockets. The backplane that is provided with the central processor consists of nine rows of sockets. Each row, called a slot, has six records. Two slots have two sockets reserved. This results in seven slots of six sockets per slot (Hex slot) and two slots of four sockets (Quad slot) per slot. To connect most I/O interfaces require six sockets, four sockets, or multiples thereof. The combination of devices is limited to the mix of sockets and slots required. Slots as well as sockets must be taken into consideration. A Hex or six-socket interface requirement could not use two Quad slots even though eight sockets are available.

Two expansion panels are available. One expansion panel provides four slots (two Hex and two Quad) and another expansion panel provides nine slots (seven Hex and two Quad).

Memory cycle time for PDP-11 processors is 1.2 microseconds for core memory, 0.45 or 0.3 microseconds for MOS memory, and 0.3 microseconds for bipolar memory. The top of the PDP-11 line can support up to 1.024K words of memory plus a 1K bipolar cache memory with a cycle time of 0.24 microseconds. The PDP-11 word consists of 16 bits.

All models except the LSI-11 and 11/03 have four automatic hardware priority level interrupts. The 11/45, 11/55, 11/60, and 11/70 can also use any of seven programmable software-supported additional interrupt levels; these have an automatic vectoring instruction held in a reserved main storage location. Each of the interrupt levels can accommodate independently prioritized peripheral devices.

The priority of any device connected to the Unibus is determined by its physical position; hence, the processor is normally attached so as to give it the highest priority. There is no logical limit to the number of devices that can be attached to the Unibus, with bus access and control handled by the interrupt system.

The theoretical maximum Unibus data transfer rate is 5 million bytes per second, and attached components

DEC PDP-11 Family Communications Capabilities

DEC's Digital Network Architecture (DNA) and the DECnet software products which implement it.

Announced in 1975, DNA was devised to permit generalized interconnection between DEC processors. Unlike other major vendors' architectures (such as IBM's SNA, for example), DNA promotes peer-to-peer interprocessor communications rather than a hierarchical structure with a single network-controlling host (or front end). DECnet software modules are loaded in each of the network nodes (PDP-11 or VAX minicomputers which are connected by point-to-point synchronous lines). Each runs under its own operating system with its own applications, but may freely access another's resources. Essentially, any DECnet node may access the I/O devices (mass storage, printers, etc.), transfer files to or from, or engage in program-to-program communications with any other node.

DNA and DECnet were not unveiled by DEC all at one time. In 1976, DEC announced the availability of Phase I DECnet products, which offered connectability between "like" processors (similar machines with similar operating systems and applications). In the fall of 1978, Phase II products were delivered which offered interconnection between the PDP-11, VAX-11/780, and DECsystems-10 and -20; an unlikely combination of 16-bit, 32-bit and 36-bit processors, respectively. DEC has alluded to a projected Phase III and IV of DNA and DECnet, which will reportedly offer interconnection between DEC mini-networks and the networks of other major vendors, including the packet-switched carriers. No scheduled delivery dates have yet been announced by DEC for Phase III or IV products, however.

Phase II networking is most highly developed between PDP-11 and VAX processors. Products now exist which permit a user to create an impressive network of PDP-11's, all capable of accessing and sharing each other's programs, files and I/O devices. As of this publication, five PDP-11 operating systems may be supported with DECnet modules.

They are:

- RT-11, release 3B and later (DECnet-RT),
- RSX-11S, release 2.1 and later (DECnet-11S),
- RSX-11M, release 3.1 and later (DECnet-11M),
- RSTS/E, release 6C and later (DECnet/E), and
- IAS, release 3.0 and later (DECnet-IAS).

The DECnet modules added to the operating systems contain similar sub-modules, or protocols, which provide the common ground through which the different operating systems communicate. These range from the byte-synchronous line protocol DDCMP, communicate in a master/slave manner. The maximum data rate of the 11/45 and 11/55 sold-state bus is 6 million bytes per second, without affecting the Unibus's capability. On the 11/70, the 32-bit bus is fast enough (i.e., 2 million 8-bit bytes per second) to permit overlapped use by the CPU, Unibus, and/or several mass storage units, the fastest of which presently operates at 1 million bytes per second. DEC also states that interleaved core memory raises this 32-bit bus bandwidth to 5.8 million bytes per second. Interleaving is done whenever more than minimum memory is purchased.

The LSI-11 and PDP-11/03 bus has a maximum data transfer rate of 1666K bytes per second.

DEC offers a vast array of PDP-11 family equipment, and it is beyond the scope of this report to present more than generalized information regarding the physical specifications of the processors. Please note that all cabinet-mounting components except the 11/60 processor fit in standard (19-inch) cabinet interiors, and that the cabinets generally measure 21 inches wide, 30 inches deep, and 72 or 50 inches high. The standard cabinet for the 11/60 is 27.5 or 46.5 inches wide, 30 inches deep, and 50.5 or 60.5 inches high. A 19-inch rack-mounted version is available for OEM's.

TRANSMISSION SPECIFICATIONS

Communications lines are attached directly to DEC communications interfaces or to line adapters which are themselves connected to the communications inter-faces. Single-line, 8-line, and 16-line interfaces are available with asynchronous speeds up to 9600 bps and synchronous speeds up to 1,000,000 bps. EIA, CCITT, and 20 mA interfaces are supported. Some of the interfaces include microprocessors with direct memory access for outgoing and incoming data. Processing throughput, rather than physical restrictions (backplane socket availability) usually limits the number of lines that can be supported. For instance, a maximum of 32 asynchronous lines can operate simultaneously at a 9600 bps rate. However if the rate is lower, a proportionate number of additional lines can be added to the system.

Data communications control for all PDP-11's is supplied by numerous interface controllers. However, each of these has a number of variants and options so that PDP-11's can be connected to almost any type of communication channel (private phone, dial-up phone, 20-mA line, telegraph line), almost any type of terminal, or almost any type of modem. Supplementing these interfaces is additional data communications hardware to provide flexibility in unique situations.

Communications Interface Controller	Line Adapter	Line Adapter Type
DV11-AA	DV11-BA	8-line; synchronous
	DV11-BB	8-line; asynchronous
	DV11-BC	8-line; 4 lines asynchronous, 4 lines synchronous
DMC11-AL	DMC11-MA	1-line, 1,000K bps, 6000 ft.
	DMC11-MD	1-line; 56K bps; 18,000 ft.
DMC11-AR	DMC11-DA	1-line; Bell 200 Series up to 19,200 bps
DH11-AA	DM11-BB	16-line; Bell 103/202
	DM11-DA	4-line; 20-mA
	DM11-DB	4-line; EIA
	DM11-DC	4-line; EIA/CCITT (req. DM11-BB).

The characteristics of the available interface controllers are summarized in the Communications Interface Characteristics table (Table 3). The available communications line adapters and their specifications are tabulated below.

DEC PDP-11 Family Communications Capabilities

TABLE 3. PDP-11 COMMUNICATIONS INTERFACE CHARACTERISTICS

Controller/ Interface Set	Number Lines	Timing/ Protocol	Mode	Maximum Line Speed (bps)	Interface	Modem Control/ Compatibility
DV11-AA and BA	8	Sync	F/H	9600	EIA/CCITT	Full Control
DV11-AA and BA	8	Async	F/H	9600	EIA/CCITT	Full Control
DV11-AA and BC	8	4-Sync/4-Async	F/H	9600	EIA/CCITT	Full Control
DL11-WB	1	Async	—	9600	EIA/CCITT	—
DL11-WA	1	Async	—	9600	20mA current loop	None
DL11-E	1	Async	—	9600	EIA/CCITT	Full Control
DZ11-A	8	Async	—	9600	EIA/CCITT	Bell 103, 113
DZ11-A and B	16	Async	—	9600	EIA/CCITT	Bell 103, 113
DZ11-C	8	Async	—	9600	20mA current loop	None
DZ11-C and D	16	Async	—	9600	20mA current loop	None
DZ11-E	16	Async	—	9600	EIA/CCITT	Bell 103, 113
DZ11-F	16	Async	—	9600	20mA current loop	None
DH11-AD	16	Async	—	9600	EIA/CCITT	Full Control
DH11-AE	16	Async	—	Unspecified	EIA/CCITT	None
DUP11-DA*	1	Sync-all	F/H	9600	EIA/CCITT	Bell 200 Series
DMC11-AL and MA	1	Sync-DDCMP	F/H	1,000,000	Local cable	to 6,000 ft.
DMC11-AL and MD	1	Sync-DDCMP	F/H	56,000	Local cable	to 18,000 ft.
DMC11-AR and DA	1	Sync-DDCMP	F/H	19,200	EIA/CCITT	Bell 208, 209
DMC11-AR and FA	1	Sync-DDCMP	F/H	250,000	V.35	DDS/Leased
DQ11-DA*	1	Sync-all	F/H	9,600	EIA/CCITT	Bell 201, 208, 209
DQ11-EA*	1	Sync-all	F/H	1,000,000	V.35	Bell 303
DLV11 (PDP-11/03)	1	Async	—	9,600	EIA or 20mA	None
DLV11-E (PDP-11/03)	1	Async	—	19,200	EIA/CCITT	Full Control
DLV11-F (PDP-11/03)	1	Async	—	19,200	EIA or 20mA	None
DLV11-J (PDP-11/03)	1	Async	—	38,400	EIA or 20mA	None
DZV11-B (PDP-11/03)	4	Async	—	9,600	EIA/CCITT	Bell 103, 113
DUV11-DA (PDP-11/03)	1	Sync	F/H	9,600	EIA/CCITT	Full Control
DN11-AA and DA	1-4	Autodial Interface		—	—	Bell 801 ACU
DA11-B	1	Parallel Interprocessor Link			—	Local Cable

*DUP11 includes CRC for DDCMP, HDLC, SDLC, etc., but requires KG11-A arithmetic unit for BSC block check. KG11-A also employed with DQ11 interfaces.

to the Data Access Protocol (DAP) which handles the location, addressing and retrieval of a file located on a remote system.

Due to the inherent differences in functionality between the PDP-11 operating systems, it is not surprising that the networking functions differ somewhat between the DECnet nodes. Table 2 presents a comparison of the functions offered by the different DECnet products as regards PDP-11-supported operating systems.

The PDP-11 operating systems and their DECnet functions are discussed in more detail in the Software section of this report. Also, a detailed report on the DEC Digital Network Architecture and DECnet, report C11-384-101, is located in this volume behind the C11 Networks and Architectures tab.

USER REACTION

In the fall of 1978, Datapro conducted a user survey of computer systems, and received responses and usable ratings from 84 PDP-11 users who collectively had over 200 machines in use. Of these, 30 percent (25 users) indicated that their PDP-11's were being used in data communications applications. The following user reaction summary reflects the ratings and comments of these 25 users.

The *DL11 Asynchronous Serial Line Interfaces* provide full- or half-duplex line control, changeable under program control. Mode changing, however, is the only programmed change that can be made to this unit. All other characteristics are set when the device is ordered, usually by straps on the board. Those features include a choice of 13 standard data rates between 50 and 9600 bits per second, choice of character size (5, 6, 7, or 8 bits) and stop element size (1, 1.5, or 2 bits), and selection of parity (odd, even, or none). Appropriate parity is appended to outgoing characters, and parity is checked on incoming characters. The unit contains independent two-character buffers (one to transmit data and one to receive data), permitting longer delays between interrupt servicing without annoying rate errors. The DL11 can operate with different input and output line speeds *except* when the 110 or 134.5 bps speeds have been selected. The DL11 is contained on one board.

The *DJ11 Asynchronous Multiplexer* bears some resemblance to the DL11, in that similar functions on both are hardware-selectable. As in the DL11, data rate, character size and stop element length, and parity check/generation are all set up through hardware (switches or straps). In the case of the DJ11, it's all switches, whereas in the DL11 some of the above functions are selected through straps. Unlike the DL11, this multiplexer has no provisions for data set handshaking.

Another minor difference to note: the DJ11 offers 11 different speeds compared to the 13 offered by the DL11. Character buffering in the DJ11 is also slightly different. A common 64-character buffer serves all 16 lines and can be used to reduce per-character overhead as well as to prevent rate errors if the incoming characters temporarily exceed the CPU's process-

DEC PDP-11 Family Communications Capabilities

Virtually all currently-marketed models of the PDP-11 were being employed, to some extent, in communications applications, but response was especially heavy for the 11/70 and 11/34 models, which together comprised almost half of the rated systems. The 25 communications users had a total of 74 PDP-11's in use. The average time in use was 36 months.

While these respondents do not by any means represent an accurate cross-section of the entire PDP-11 user base, it is interesting to note that the percentage of respondents using PDP-11's in communications applications increased proportionately as the machine size increased. This ranged from 20 percent for the PDP-11/03 users, to over 35 percent for the PDP-11/70 users.

As might be expected, the low-end PDP-11 communications users were running almost exclusively on the RT-11 real-time operating system. As machine size increased, so did the use of the RSX multiprogramming and RSTS/E timesharing operating systems. All of the PDP-11/70 users were running under either RSX or RSTS.

Many of the PDP-11/34 and 11/40 users did not indicate the operating system being run on their machines. This might possibly have been because some or many of these are being used as front ends for large DEC mainframes, in which case they would be running under the communications/networking partition of the mainframe's operating system. The PDP-11/34 and 11/40 respectively comprise the DN20 and DN87 front-end communications processors.

The ratings given by the PDP-11 users with communications applications (all models) are summarized below:

	Excellent	Good	Fair	Poor	W.A.*
Overall Satisfaction	10	12	3	0	3.3
Reliability of Processor	12	11	1	1	3.4
Ease of Operation	10	14	1	0	3.4
Maintenance Responsiveness	6	16	1	1	3.1
Maintenance Effectiveness	7	12	4	1	3.0
Technical Support	6	8	9	2	2.7
Ease of Programming	8	13	2	0	3.3
Manufacturer's Operating Software	13	10	2	0	3.4

*Weighted Average based on 4.0 for Excellent.

Clearly the operating quality of the DEC machines (reliability, manufacturer's operating software, and ease of operation) enjoyed the highest ratings. Almost as highly rated were the ease of programming, and the users' overall satisfaction. The users were apparently less satisfied with the manufacturer's maintenance and technical support.□

ing rate. The 16 lines are not totally independent of each other. Character formats and speeds are selectable only for four-line groups rather than on an individual-line basis.

Since the DJ11 has no capabilities for modem control signals (handshaking), it can be used only on dedicated lines. It can still be used with a modem to send and receive data between itself and remote terminals, but these have to be connected to dedicated lines. No dial-up interfacing is possible.

The *DZ11 Asynchronous Multiplexers* have characteristics similar to those of the DJ11, but each line can be individually programmed through software control for one of 15 line speeds between 50 and 9600 bps. The DZ11 is a lower-cost, reduced-performance multiplexer and does not have DMA facilities. However, the DZ11 includes enough modem controls to operate a 300-bps data set. Interrupts can be programmed to occur for each character or after 16 characters. The DZ11 is generally transparent to data, but can report parity errors and framing errors. Input characters are buffered with identification hardware in a first-in/first-out (FIFO) buffer or "silo" (in DEC terms).

The *DH11 Programmable 16-Line Asynchronous Multiplexers* have many similarities to the DJ11. The DH11 provides programmed selection of nearly all parameters that are switch-selectable on the DJ11—data rate, character and stop element size, and parity check/generation on receive and transmit lines. A few other differences can also be noted. First, the DH11 offers a choice of 14 data rates plus 2 special rates of the user's choice. Second, each of the 16 lines can operate independently at any speed. As in the DJ11, receive characters for each line are buffered in a 64-word buffer to reduce CPU loads. Transmit characters can be sent directly in blocks from memory (DMA). The DH11 has 16 separate DMA transmitters, each with its own hardware byte count and address registers. Also, special hardware to detect data breaks and to generate program-controlled breaks is provided.

The *DU11 Synchronous Line Interface* is a single-line, double-buffered controller that is fully programmable for sync character, character length (5 to 8 bits), and parity check/generation on receive and transmit (odd, even, or none). Data rates are normally controlled by an attached modem, but an optional clock (DFC11-A) can be used for local connection not requiring a modem. Auto answering can also be selected. This unit cannot be used for DMA transfers.

The *DUP-11 Synchronous Line Interface* is a single-line, program-controlled, double-buffered controller capable of handling both byte-oriented protocols, such as binary synchronous and DEC's DDCMP, and bit-oriented protocols, such as SDLC, HDLC, and ADDCP. The DUP-11 is restricted to 8-bit characters. Bit- or byte-oriented operations are software-selectable. Modem controls are provided, permitting operation with Bell 200 Series or equivalent synchronous data sets at speeds up to 9600 bps.

Additional features of the DUP-11 include calculating and checking of CRC-16 block check characters and bit stuffing. The latter is used in several of the new data communication protocols to preclude data characters from being confused with control characters. Specifically, the DUP-11 inserts "0" bits in bit streams containing five or more consecutive "1" bits so that the receiving device will not interpret this stream as a FLAG control character.

The *DQ11 Synchronous Line Interfaces* offer many of the features of the DU11 plus a number of unique qualities. The similar characteristics are modem-controlled data rates (up to 1 megabit per second in this case), optional clock (DQ11-KA) for local connection, and programmable selection of sync character and character size (to 16 bits this time). Unlike the DU11, the DQ11 makes use of DMA, through on-board word count and address registers, for data transfers, which

DEC PDP-11 Family Communications Capabilities

TABLE 4. PDP-11 OPERATING SYSTEM SUPPORT

	RT-11	RSX-11S	RSX-11M	RSTS/E	IAS	TRAX	DSM-11
Minimum Memory (K bytes)	16-32*	16-32*	32-48*	128	96	192-256*	64
Currently Marketed Machines:							
PDP-11/03	Yes	Yes	—	—	—	—	—
PDP-11/04	Yes	Yes	Yes	—	—	—	—
PDP-11/34	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PDP-11/55	Yes	Yes	Yes	Yes	Yes	—	Yes
PDP-11/60	Yes	Yes	Yes	Yes	Yes	—	Yes
PDP-11/70	—	Yes	Yes	Yes	Yes	Yes	Yes

*Varies depending on processor and degree of functionality desired.

explains the high rate that is possible. Although sync characters are program-selectable, the choice as to whether there will be one or two sync characters per frame is made through a switch on the board. Three different operating modes—auto idle, strip sync, and half-duplex—are also program-selectable. In auto idle mode, sync characters are transmitted continuously until either the CPU or terminal signals its intention to send data. In strip sync mode, only the text portions of received messages are sent to the CPU and main memory. Sync characters are discarded after detection. Straps are provided for the user to designate any three characters as control characters. When any of these characters is received, a vectored interrupt will be generated to the CPU.

Another useful feature of the DQ11 is programmable selection of parity on received data (odd, even, or none) and programmable LRC/CRC generation and checking in hardware. If desired, LRC and/or CRC characters are appended to the transmitted data stream and checked when arriving with the input data stream.

Input and output sides of the DQ11 have two sets of word count and address registers. The DQ11 can be set to automatically switch from one set to another when a buffer is exhausted. This permits longer delays between interrupt servicing without incurring annoying rate errors. This unit furnishes RS-232C/CCITT V.24-compatible control Bell 201 or 303 modems or equivalents. It occupies one slot in a DD11 peripheral mounting panel.

The *DMC11 Network Link* is a complement to the DQ11 and is designed for high-performance interconnection of PDP-11 computers in network applications. Data rates of up to 1 million bps can be obtained over coaxial cable at distances of up to 6000 feet. Lesser data rates can be realized over greater distances.

The DMC11 is a microprocessor-based unit consisting of two modules, the DMC11-AD microprocessor module and one of the DMC11-MA, DMC11-MD, or the DMC11-DA line unit modules. Even though the line units are also mounted on hex-sized modules, they only require an SPC (quad) slot having been cut away to permit mounting over the normal Unibus connector in a DD11 peripheral mounting panel.

The three line modules adapt the DMC11 to various applications. The DMC11-MA contains a built-in modem and is used for local operation at 1 million bps over coaxial cable up to 6000 feet long. The DMC11-MD also contains a built-in modem but is used to send data over distances up to 18,000 feet at rates up to 56,000 bps. The DMC11-DA does not have a built-in modem, and only includes an EIA RS-232C interface. It is intended for use with Bell 208, 209, or equivalent modems at data rates up to 19,200 bps.

The DMC11 is intended specifically for the DDCMP protocol. The microprocessor communicates with the host computer through DMA operations and is assigned a 256-byte memory block by the operating software, for use as a control and status block. Up to seven input and seven output messages can be queued in main memory by the DMC11.

The DMC11 also features a built-in bootstrap, permitting remote program loading and control transfer on CPU's that do not have bootstrap facilities.

The *DV11 Synchronous Preprocessor* is a high-performance, microprocessor-based multiplexer that features DMA data transfers and data rates of up to 9600 bits per second for each of 16 full-duplex lines. (Total throughput capacity is 38,400 characters per second). It can relieve up to 95 percent of the central processor's load in terms of interrupt handling, generating block characters, and special character handling.

A control table scheme tells the DV11 how to act on each incoming data or control character. Table entries specify a number of choices for each possible character: to store or not to store the character in the data buffer, to include or to exclude the character from the block check calculation, to cause or not to cause a vectored interrupt to the CPU. In addition, receipt of a character can designate that a different table is to be used for subsequent characters, thereby enabling the DV11 to detect sequences of control characters without CPU intervention. The DV11 consists of a double system unit and a distribution panel.

The *DR11 General Device Interfaces* are described here because of their possible use in PDP-11 to PDP-11 communications.

The DR11-B is a general-purpose DMA interface to the Unibus. This interface is bidirectional and operates between the Unibus and a user device. Transfers are made at a user-defined rate.

The DR11-C is a general-purpose interface between the PDP-11 Unibus and a user's peripheral device. The DR11-C can also be used as an interprocessor buffer to allow two PDP-11 processors to transfer data between each other. In this case, one DR11-C is connected to each processor bus, and the two DR11-C's are cabled together, thereby permitting the two processors to communicate.

The DR11-k is an integral logic module that forms a self-contained digital I/O interface between the PDP-11 Unibus and a user's peripheral. The DR11-k performs all the necessary tasks to communicate with the PDP-11. Like the DR11-C, the DR11-k may be used as an interprocessor buffer to exchange data.

DEC PDP-11 Family Communications Capabilities

TABLE 5. PDP-11 OPERATING SYSTEM/COMMUNICATIONS SUPPORT

Feature	RT-11	RSX-11S	RSX-11M	RSTS/E	IAS	TRAX	DSM-11
Current Release	3B	2.1	3.1	6C	3.0	1	1.0
DECnet Availability and Support	Yes	Yes	Yes	Yes	Yes	No**	No
Emulation Supported:							
IBM RJE/HASP	No	No	Yes***	No	Yes***	No	No
IBM 2780 Batch	Yes***	No	Yes***	Yes***	Yes***	No	No
IBM 3270 Interactive	No	No	Yes***	Yes***	No	Yes***	No
Univac 1100	No	No	Yes***	Yes***	Yes***	No	No
CDC 6000/CYBER	No	No	Yes***	No	Yes***	No	No
Communications Interfaces Supported:							
DL11 Async	Yes	Yes	Yes	Yes	Yes	No	Yes
DJ11 Async	No	Yes	Yes	Yes	Yes	No	No
DZ11 Async	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DH11 Async	No	Yes	Yes	Yes	Yes	No	Yes
DU11 Sync	Yes*	Yes	Yes	No	Yes*	No	No
DP11 Sync	No	Yes	Yes	No	Yes*	No	No
DUP11 Sync	Yes*	Yes	Yes	No	Yes*	Yes	No
DV11 Sync	No	Yes*	Yes	No	Yes	No	No
DQ11 Sync	No	Yes	Yes	No	Yes*	No	No
DMC11 Sync	Yes*	Yes	Yes	Yes*	Yes*	Yes*	Yes
DA11 Parallel	No	Yes	Yes	No	Yes*	No	No
DLV11 Async (11/03)	Yes	Yes	No	No	No	No	No
DZV11 Async (11/03)	Yes	Yes	No	No	No	No	No
DUV11 Sync (11/03)	Yes	Yes	No	No	No	No	No

*Requires appropriate DECnet software package (TRAX/TL for TRAX systems).
**With TRAX/TL. Limited networking can be achieved, but only with other TRAX systems.
***Requires specific emulation software product, in addition to operating software.

The following units provide support functions to the line interfaces previously described:

The *DN11 Automatic Call Unit Interface* provides a buffered interface for up to four Bell 801A, 801C, or equivalent automatic call units. The DN11 uses programmed I/O for data transfers and occupies one system unit.

The *KG-11A Communications Arithmetic Option* is a programmable hardware block check character generator. It computes three different cycle redundancy check (CRC) polynomials and two different longitudinal redundancy check (LRC) characters. This single-board unit replaces software routines for generating and checking the standard check characters listed above. The choice of checking polynomials is made through program control. The unit can be used with any PDP-11 synchronous interface.

The KG11-A can be shared between multiple lines by storing interim check characters in main memory and passing the interim character to the KG11-A along with each new character. The KG11-A then computes the desired polynomial, which is read back to the CPU and stored again in main memory as the updated interim check character. In this way, several lines can make use of one unit.

SOFTWARE

Seven functionally different operating systems are available from DEC for the PDP-11 family. Not all of these operating systems are capable of running on all of the currently marketed PDP-11 models. Table 4 provides a comparison of these operating systems and the machine models which support them, along with the minimum main memory requirements.

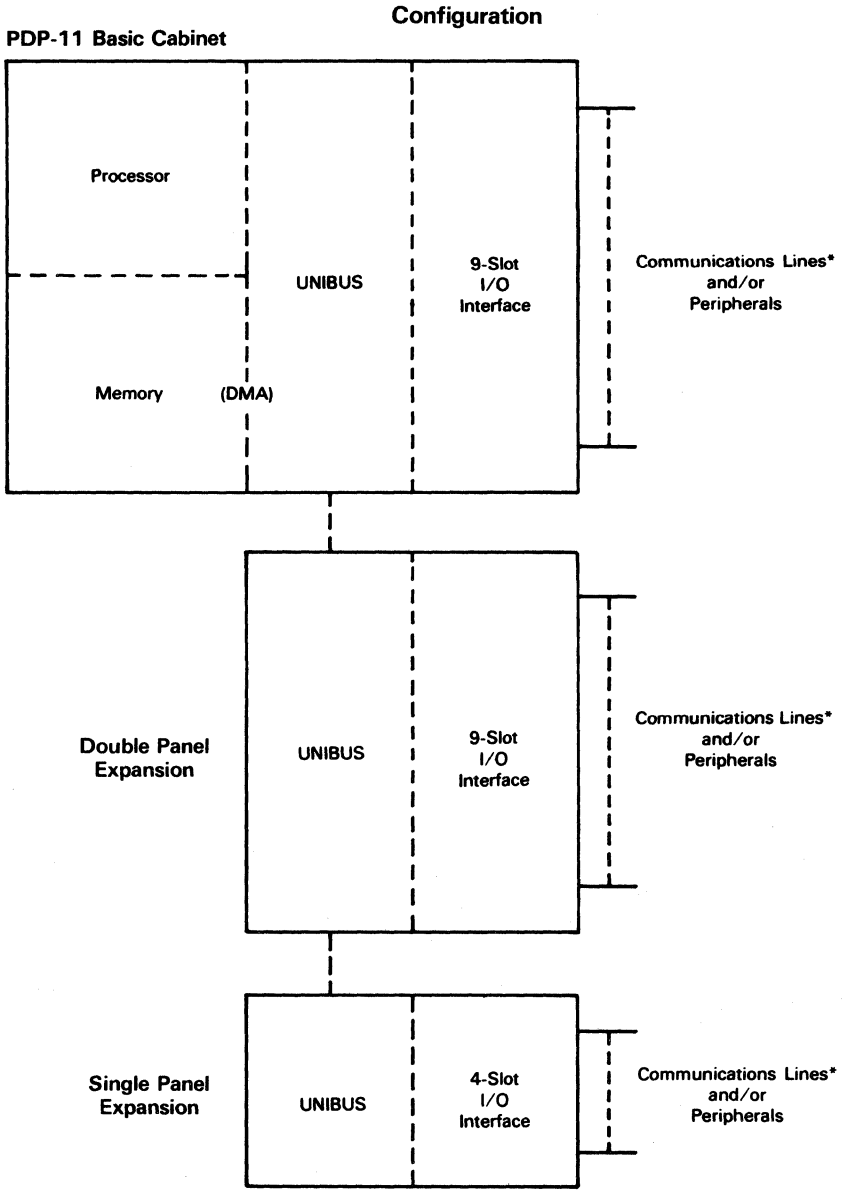
The operating systems differ not only in function, but also in the degree and type of data communications supported. Table 5 depicts these operating systems, their most current releases (as of this publication date), and the communications features they support.

RT-11 is a disk-based, real-time operating system typically designed for a single user. It may be implemented on models ranging from the 11/03 (LSI-11/2) to the 11/60 with cache memory. Special software programs include IBM 2780 batch emulation, and DECnet-RT. RT-11's support of communications controllers and interfaces is considerably enhanced through introduction of the DECnet product.

RSTS/E (Resource Sharing Timesharing System/Extended) is a timesharing system designed to accommodate large numbers of interactive users. RSTS/E may run on all PDP-11/34 and larger models, and supports a wide range of communications interfaces for local and remote terminals with varying transmission characteristics. Special software programs permit RSTS/E to support IBM 2780 and 3271, and Univac terminal emulation. RSTS/E is also supported by DECnet/E.

The RSX-11 Real-time Operating Systems consist of two compatible operating systems; RSX-11M and RSX-11S. The 11M version is disk-based, and therefore supports larger systems than the executive-only 11S, which does not support a file system. Both feature event-driven, multiprogrammed responses to real-time transactions. In regards to functional operation, 11S may be considered a subset of 11M. With its

DEC PDP-11 Family Communications Capabilities



*Throughput considerations determine line configuration alternatives; see Table 3 for specifications.

disk-based software, 11M supports more specialized communications applications than the 11S. These include IBM, CDC and Univac terminal emulations. Both operating systems are supported on all models of the PDP-11, except that 11M may not run on the low-end PDP-11/03. Both are supported by DECnet software; DECnet-11M and DECnet-11S.

From a DECnet point of view, an 11S system is ideally suited to perform as a satellite processor to a central 11M system. As the 11S will be operating on a processor with limited memory and I/O, it can use the file, program and I/O resources of the 11M system, via DECnet. Similarly, an 11M system may perform system generations and downline IPL and program load remote 11S nodes. The 11S system may typically send whole command and batch files to the 11M system for execution and I/O operations.

IAS (Interactive Application System) is a multifunction, general purpose operating system that is designed to support a mix of timesharing, batch and real-time processing activities concurrently. IAS may run on any PDP-11/34 and larger system. Special communications software is available for IAS systems to support IBM HASP/RJE, 2780, CDC and Univac terminal emulations. There also is available DECnet-IAS which affords the IAS system full interconnectability with all the preceding PDP-11 operating systems.

DSM-11 is a multi-user data base management system that is not particularly supportive of data communications. It may run on any PDP-11/34 and larger processor, and serves to provide random retrieval of data to interactive users. There is no DECnet support or product available for the DSM-11 operating system.

TRAX is a recently-announced transaction processing system that runs only on the PDP-11/34 or 11/70 models, and requires large amounts of main memory. TRAX supports up to eight communications lines, which may be a combination of multidropped asynchronous or synchronous. There is a networking software product available, TRAX/TL, which supports up to four interprocessor links with other TRAX systems only. Because of this limitation, TRAX may generally not be regarded as a DECnet-compatible operating system.

DEC PDP-11 Family Communications Capabilities

There is another special communications software product that permits a TRAX system to emulate IBM 3271 interactive terminals.

For communications with non-DEC systems, emulators provide the necessary software interfaces. DEC offers several IBM 2780 batch and 3271 interactive terminal emulators that augment the appropriate operating system and permit communications with IBM System/360 or 370 computers. All of the 2780 emulators: 1) support operations over synchronous data links, in point-to-point contention mode, at speeds up to 4800 bps; 2) can transmit data from card readers and mass storage devices; 3) can print received data on a line printer or write it on a mass storage device; 4) can support Bell 201 or 208 or equivalent modems and OS/RTE, OS/HASP, OS/ASP, and DOS/Power; and 5) can receive data in binary form or in the EBCDIC subset that is equivalent to ASCII.

IAS/2780 requires any standard configuration and a DU11 or DUP11 and KG11. Output devices supported include a line printer or any Files-11 device except DECtape and paper tape punch. Input devices supported include a card reader or any Files-11 device except DECtape. Spooling is supported on reception but not transmission. Forms control supported includes top of form; skip 1, 2, or 3 lines; skip module 8; and horizontal control.

Specifications for RSX-11M/2780 are the same as for IAS/2780 except that the RSX-11M version requires 64K bytes of memory.

RSTS-E/2780 requires a minimum system consistent with the number of users and expected application plus 16K bytes of memory and DU11 or DUP11 and KG11. Output devices supported include a line printer or any mass storage device except diskette drives. Input devices supported include a card reader, any mass storage devices, or, to a limited extent, magnetic tape units. Spooling is supported. Forms control includes top of forms; horizontal control; and skip 1, 2, or 3 lines.

RT-11/2780 requires a disk-based foreground/background RT-11 system with 32K bytes of memory and DU11 or DUP11 and KW11-L, KG11. Output devices supported include a line printer or any disk supported under RT11. Input devices supported include a card reader, paper tape reader, or any disk supported by RT-11. Forms control consists of top of forms; skip 1, 2, or 3 lines; skip modulo 8; and horizontal control. Spooling is not supported.

All DEC networks will typically use DECnet, but DECnet is not a turnkey solution. At the very least, customers must purchase communications links such as a telephone line or private wire, one or more of DEC's communications interfaces for each computer in the network, and often a modem for each end of every link. Some of the more complicated applications will require considerable programming, as well.

DECnet allows customers to:

- **Transmit data files across a room or around the world, with less expense and greater speed than is generally possible through other media.**
- **Share expensive peripherals among several CPU's, some of which may be remote.**
- **Use another tool in the creation of high-availability (super-reliable) systems, adding to the Unibus links and multi-port options that Digital already supplies.**

The Digital Data Communications Message Protocol (DDCMP), the link protocol for DNA/DECnet, performs the physical line control for most of the synchronous communications hardware interfaces noted in Table 3. DDCMP performs line scanning, error detection and error recovery. On half-duplex lines, DDCMP controls the direction of traffic, while on full-duplex lines, DDCMP controls bidirectional traffic; on multi-point lines DDCMP performs the polling function. Outgoing transmissions are enveloped with control characters mainly to enable the receiving device to perform error detection. The CRC-16 polynomial checking technique is employed in creating an error detection code. Incoming transmissions are stripped of control characters after passing error detection checks. To accommodate for the relatively long transit time for satellite destined messages, DDCMP can support the transmitting up to 255 messages before halting transmissions to await acknowledgements for the previously transmitted messages.

DECnet software to handle the DDCMP protocol line handling is intended for use with medium speed communications systems. The software will perform the function for both the program-interrupt and the DMA types of communications hardware interfaces. When volume increases substantially and begins to consume too much central processor overhead or when high-speed communications lines are used, the DMC11 interface can be employed. Containing a dedicated microprocessor, the DMC11 will perform, via firmware, the line handling function, thus relieving the central processor's DECnet software of this time-costly burden. With the DMC11, a user could employ DDCMP protocol without using the other functions of DECnet.

While DECnet represents a generalized approach to computer networks within the DEC family, the company is continuing development of remote terminal emulators for other manufacturers' host mainframes. In the PDP-11 family, the previously discussed IBM 2780 emulator is now available under RSX-11M, RSTS/E, IAS, and RT-11. Multi-leaving HASP emulation is now available under IAS and RSX-11M, as well as in a stand-alone version. Direct channel interfaces to IBM and Univac computers have also been sold as specialty features, and are supported under the RSX-11M operating system. In addition, DEC recently announced software modules supporting IBM 3271 emulation which run under RSX-11M, RSTS/E and TRAX.

PRICING

DEC generally provides the PDP-11 minicomputers on a purchase basis, with separately priced maintenance agreements. Leasing arrangements are available through DEC's joint venture with U.S. Leasing Corp. or through TEC Leasing Corp. of New York. Lease rates vary with the prime interest rate, the customer's volume of business with DEC, and the value of the equipment being leased.

Software maintenance is offered through several levels of optional service, ranging from a periodic software newsletter to automatic updates of software and manuals (software subscription service). In addition, software components, including documents and updates, can be purchased separately from Digital's Software Distribution Center.

The Digital Equipment Computer Users Society (DECUS) is a voluntary, non-profit users' group supported by DEC. DECUS provides an extensive program library, users' groups, special interest groups, and workshops/symposia.

Field maintenance services are offered on several levels which vary depending on specific customer needs. The monthly charges shown are for the 8 hour/5 day on-site Basic Service Agreement, and include all parts and labor required for system maintenance. Software license fees are for single system use, and may vary depending on medium.

DEC PDP-11 Family Communications Capabilities

HARDWARE

	Typical Processor Configurations	Purchase Price	Monthly Maintenance
SR-VXSSA-BA	PDP-11/03 with 32K bytes memory, diskette controller and two drives, console terminal, RT-11 license	$10,500	$112
SR-20SSA-BA	PDP-11/04 with 64K bytes memory, disk controller and two drives, console terminal, RT-11 license	14,500	152
SM-30LLB-LA	PDP-11/34A with 128K bytes, disk controller and two drives, console terminal, RSTS/E license	30,300	215
SR-30JJA-LA	PDP-11/34A with 64K bytes, disk drive, console terminal and RSX-11M license	27,500	249
SA-60UVC-LA	PDP-11/60 with 256K bytes, disk controller and 67M-byte disk pack drive, magnetic tape controller and transport, console terminal and IAS license	89,900	543
SA-70CVB-LA	PDP-11/70 with 256K bytes, controller and 176M-byte disk pack drive, magnetic tape controller and transport, console terminal and IAS license	138,000	611
	PDP-11/03 Communications Options		
DLV11	Single line asynchronous interface	250	5
DLV11-E	Single line asynchronous interface	300	7
DLV11-F	Single line asynchronous interface	250	7
DLV11-J	Single line asynchronous interface	465	9
DZV11-B	Four-line asynchronous multiplexer	850	9
DUV11-DA	Single line synchronous interface	750	7
	Communications Options; All Other PDP-11		
DL11-E	Single line asynchronous interface	770	6
DL11-WA	Single line asynchronous interface	770	5
DL11-WB	Single line asynchronous interface	770	5
DZ11-A	Eight-line asynchronous multiplexer	2,310	25
DZ11-B	Eight-line expansion for DZ11-A	1,800	21
DZ11-C	Eight-line asynchronous multiplexer	2,360	25
DZ11-D	Eight-line expansion for DZ11-C	1,850	21
DZ11-E	16-line asynchronous multiplexer	3,850	46
DZ11-F	16-line asynchronous multiplexer	3,950	46
DH11-AD	16-line asynchronous multiplexer	7,600	56
DH11-AE	16-line asynchronous multiplexer	6,700	46
DUP11-DA	Single line synchronous interface	1,380	9
DQ11-DA	Single line synchronous interface	3,570	24
DQ11-EA	Single line synchronous interface	5,450	25
KG11-A	CRC, LRC, BCC generation/check option, for use with DUP11 or DQ11	1,270	6
DMC11-AL	DDCMP control; requires either DMC11-AL or -MA	1,600	13
DMC11-MA	Interface for DMC11-AL	1,100	6
DMC11-MD	Interface for DMC11-AL	1,100	6
DMC11-AR	DDCMP control; requires either DMC11-DA or -FA	1,600	13
DMC11-DA	Interface for DMC11-AR	1,100	6
DMC11-FA	Interface for DMC11-AR	1,100	6
DV11-AA	16-line async./sync. control	4,840	29
DV11-BA	Eight-line synchronous interface group	3,960	15
DV11-BB	Eight-line asynchronous interface group	3,860	15
DV11-BC	Eight-line async./sync. interface group	4,160	15
DN11-AA	Control for four autocall interfaces	520	5
DN11-DA	Line interface for autocall unit	640	5
	Specialized PDP-11 Configurations*		
DN87S	PDP-11/40 front end; basic system, for DECsystem-10 mainframes only	33,000	269
DN20	PDP-11/34A front end; basic system, for DECsystem-10 or -20 mainframes	28,200	190
DN200	PDP-11/34A remote communications node, basic system	21,300	121
DX11-B	IBM 360/370 channel adapter; does not include processor; interface assembly only	25,000	NA

*Configuration prices do not reflect communications interfaces/controllers. Software is included with host packages.

DEC PDP-11 Family Communications Capabilities

SOFTWARE

		License Fee*
QJ681-AD	DECnet-11M	$2,700
QJ685-AY	DECnet-RT	1,500
QJ691	DECnet-11S	1,100
QR680-AT	DECnet-IAS	3,750
QP690-AT	DECnet-E	2,950
QP405-AM	TRAX/TL	2,500
QJS60-AE	RJE/HASP emulation for IAS, RSX-11M	4,500
QJD63-AY	2780 emulation for RT-11	3,030
QJD68-AT	2780 emulation for RSX-11M	3,180
QRD03	2780 emulation for IAS	3,180
QPD10-AT	2780 emulation for RSTS/E	4,675
QJD76-AE	3271 emulation for RSX-11M	4,500
QRD05	3271 emulation for RSTS/E	5,000
QP404-AM	3271 emulation for TRAX	4,500
QJ170	UN1004 emulation for RSX-11M, IAS	5,500
QJ070	MUX200 emulation for RSX-11M, IAS	6,600

*Includes maintenance service.■

Digital Equipment Corp.
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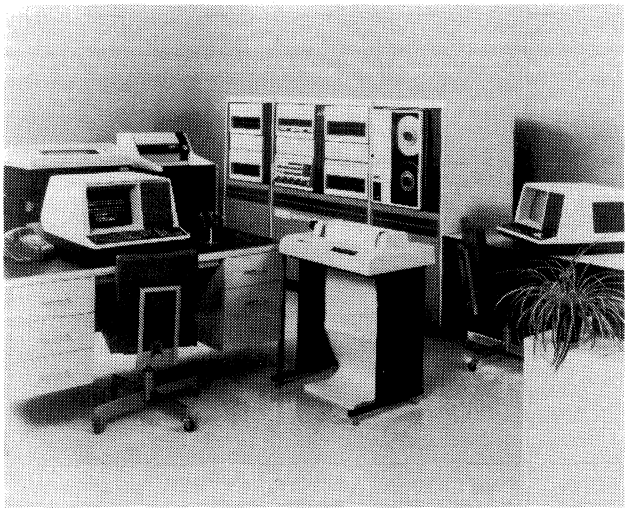


The top-of-the-line PDP-11/70 processor is shown above surrounded by peripheral devices. When DECnet is fully installed, the peripherals can operate as if they were attached to other remotely-located processors included in the DECnet network.

A family of minicomputers employable both as communications processors and as data processors. When driven by DECnet software, a PDP-11-based network provides all of the capabilities of distributed data processing.

Asynchronous lines up to 9600 bps and synchronous lines up to 1,000,000 bps are supported. System throughput determines the number of lines of a given speed that a processor can support.

A specially modified PDP-11 serves as a front-end to DEC's System 10/20.

A typical configuration consisting of a PDP-11/34 processor, a floppy disk drive, 32K words of memory, which can support 32 communications lines with a total throughput of 38,400 cps can be purchased for $44,280. The price includes the cost of the DECnet software and the operating system, but not utility and language software.

MANAGEMENT SUMMARY

Centered around the UNIBUS, the PDP-11 hardware architecture has served DEC and its customers well. The UNIBUS provides an orderly approach for universal connectability of input/output devices to any member of the PDP-11 processor family. In a similar fashion, the DECnet network software implements a set of orderly communications ground rules that represent the Digital Network Architecture. (Portions of the DECnet specifications are scheduled for implementation in 1978.) This straightforward hardware and software has produced a truly distributed data processing environment—an environment that permits any device, whether mass storage or terminal, to function as if it belonged to any processor on a DECnet network. DECnet provides a network environment where all processors can operate on an equal basis, as opposed to the more conventional master/slave network.

This approach permits DEC to be responsible to each unique customer demand, especially in providing communications interfaces. The total interface offering is so vast that Datapro has limited the interfaces listed in this report to those that currently make sense from a price/performance standpoint.

The proliferation of interfaces represents the continual demands for processing an increasing number of communications lines at ever increasing speeds. These demands have taxed the throughput capabilities of the well-respected PDP-11 minicomputer family. Evidence is starting to mount that DEC is in the process of modifying the architecture to gain speed break-throughs. Architecture departures include the capability of the processors to access semiconductor memory directly, the ▷

CHARACTERISTICS

VENDOR: Digital Equipment Corporation, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

DATE OF FIRST ANNOUNCEMENT: March 1970.

DATE OF FIRST DELIVERY: August 1970.

NUMBER DELIVERED TO DATE: Over 16,500 PDP-11 processors.

SERVICED BY: Digital Equipment Corporation.

CONFIGURATION

With the appropriate software, a PDP-11 minicomputer operates as a combination communications processor and a data processor. The PDP-11 can be connected, along with other Digital Equipment processors, to a Distributed Data Processing Network (DECnet). The extent a given PDP-11 within the network performs as a communications processor and as a data processor is dependent on the hardware resources, the application requirements, and the network ground rules. At one extreme, the PDP-11 can function as a front-end to either a DEC Systems 10 or 20 or to other manufacturer's hosts, such as IBM's Systems 360/370. At the other extreme, the PDP-11 can operate in a host-like fashion as a file maintenance computer with data coming from other PDP-11's functioning as front-ends. In the latter extreme sufficient mass storage would be a necessary hardware resource. In the first extreme the hardware resource would be a special interface attachment to the foreign host computer.

The network ground rules are codified by Digital Network Architecture and implement by software support called DECnet.

Physically, DECnet refers to the software modules in each of the DEC operating systems that permit each operating system to ▶

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

inclusion of cache memory in the top of the PDP-11 model line, use of dual UNIBUS's with different speeds, and the two-stage processing capability (for floating-point arithmetic) offered in the newly announced PDP-11/60.

The variation in Direct Memory Access data transfer options shown in the abridged Table 1 interface list is an example of the continual search for speed. Another result of architectural changes, in addition to increasing speed, may be a reduction in the number of interfaces supported, which would reduce the amount of inventory funds and manufacturing capacity consumed by so broad an offering. Currently, DEC is experiencing shipment stretch-outs of up to nine months despite an almost continuous manufacturing expansion program.

The quest for additional speed to handle a larger data processing load may lead users to upgrade facilities to include one of DEC's larger mainframes, such as the DECsystem 20, which uses special software in a PDP-11 to accomplish a front end function. While inclusion of a larger processor in a DECnet arrangement does not in and of itself establish a master/slave relationship, obviously some processors will be more equal than others. Natural migration of processing tasks and file storage to the larger host may cause a leader (if not a master) to develop on the network.

Whatever the future holds for DECnet, it does represent a laudable achievement in distributed data processing. It supports communications between remote programs (with different operating systems), device sharing by distantly located processors, and handling routing and protocol activities transparently to the user and his terminals.

handle communications lines in the DECnet prescribed fashion. DECnet also prescribes certain administrative commands that most of the software modules recognize and process.

The result is that, in addition to handling terminals attached to communications lines, each of the DECnet operating systems can pass or route data and administrative commands between each other via communication lines. It is this capability that permits DEC processors interconnected over communications lines to operate in the Distributed Data Processing fashion. This Routing function of DECnet is scheduled for release in 1978. Until then, other functions dependent on the Routing function will require application program assistance. Virtual Terminal support is one of the functions dependent on the Routing function.

An example of these capabilities is illustrated in the network, with four remotely located processors, depicted in Figure 1. In the illustration, Terminal A sends transactions to Processor A, which acts as a concentrator and switching processor and routes the transaction to either Processor B or D depending on the nature of the transaction. Until 1978, the routing must be performed by an application program in Processor A. Processor B or D will update its respective mass storage file and transmit to Processor A a response, where applicable. Processor A will present the response to Terminal A. In this arrangement, Terminal A is a virtual terminal to Processors B and D, each treating the terminal as if the communications link was direct. From the terminal user's standpoint, the data files appear to be one virtual file attached to the same computer as the terminal. In reality, parts of the data file are *distributed* between two different physical devices in two physical locations. Of course, the file could have been distributed to more than two locations.

Processor B receives transactions from Terminal B and from Terminal A by way of Processor A. Processor B updates its data file on Mass Storage B and, as required, transmits a response to Terminal B or to Processor A. The latter will present the response to Terminal A.

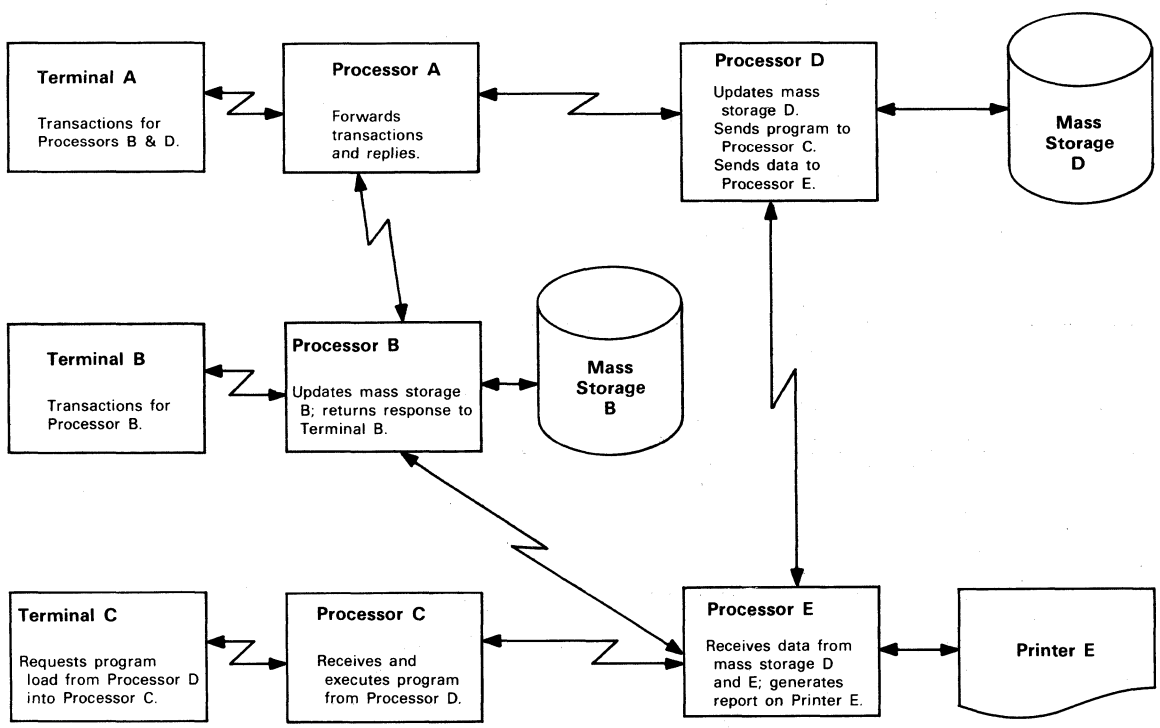


Figure 1. A DECnet Distributed Processing Network. Additional description is contained in the text.

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

USER REACTION

In April 1977, Datapro talked to three users of DECnet. One user had a network of PDP-11/45's; another had a network of PDP-11/20's, 34's, 40's, 45's, 70's and an IBM System/370; and the third user had a network of a PDP-11/34, several 55's, and a DECSystem 10. One user is up and running with a sensor-based application. The other two are still testing their data processing applications. The data processing applications employ RSX11-D and M for their operating system. The users' ratings are summarized below.

	Excellent	Good	Fair	Poor	WA*
Overall satisfaction	0	2	1	0	2.7
Ease of installation	1	1	1	0	3.0
Throughput	0	3	0	0	3.0
Hardware reliability	2	0	1	0	3.3
Promptness of mfr.'s maint	1	1	1	0	3.0
Quality of mfg's. maint.	1	1	1	0	3.0
Mfr's software	1	1	1	0	3.0
Mfr's technical support	1	1	1	0	3.0

*Weighted Average based on 4.0 for Excellent.

The reader must not infer that there is one happy user (in the Excellent column), one moderately satisfied user (Good column), and one unhappy user (Fair column). The user, for example, that rated the Ease of Installation, Promptness of Maintenance, and Quality of Maintenance as Fair, rated the Hardware Reliability as Excellent. (Such a reaction suggests a localized maintenance problem).

While the detailed ratings of this small sample are not conclusive of themselves, the weighted averages do tell a story borne out by discussions with these users. In particular, the Overall Satisfaction rating is lower than any specific category. This suggests that the user's expectations were greater than were actually experienced, or for that matter, greater than needed. Illustrative of such expectations is one user's complaint about the amount of memory required for the software. The same user felt that DEC's products were excellently priced. (Despite this user's feeling, the memory requirements of the software

Meanwhile, an operator at Terminal C wants to run a special program that is stored on Mass Storage D. Terminal C issues a request to Processor C causing it to issue a command to Processor D to load the program over the communications lines into Processor C. Since Processor C is not directly connected to Processor D, the command is sent to Processor E. Processor E, recognizing that the command is intended for Processor D, forwards the command to Processor D. The latter retrieves the object program and sends it along to Processor E, which in turn passes it to Processor C. In this manner, processors on the network can bootstrap and share programs among each other. This Routing function, as stated above, is scheduled for release in 1978.

Finally, at the appointed hour, Processor E sends command to both Processors D and B for selected information in each of their respective data files. The file information is transmitted to Processor E which produces a report on its Printer E. In this case, Processor E serves as the number cruncher and voluminous report generator using files maintained by other processors in other locations.

It should be noted that there is no master/slave relationship among processors. While Processor A operates as a front-end to both Processor A and D, Processor B acts as both a front-end and as a host. Processor E is attached to processors that can be considered hosts in their own right, and yet, Processor E operates unquestionably as a host. (Well, except when it's not passing notes between Processors C and D).

PDP-11 HARDWARE

The foundation of the PDP-11 hardware architecture is a standard I/O bus that DEC calls the UNIBUS. All elements of the system are connected to the UNIBUS, including the central processor, main memory, I/O hardware interfaces, and communications interfaces. With certain exceptions, data is transferred between the elements of the system only by passing through the UNIBUS. One exception is memory. Central processors without cache memory have access to core memory through the UNIBUS, but semiconductor memory can be attached so that the central processor also has direct access. I/O interfaces normally transfer data to and from memory via central processor interrupts, but several communications interfaces do have direct memory access without processor intervention. Central processors with cache memory (PDP-11/60, 70) have direct access to all types of memory without having to go through the UNIBUS. Additionally, high-speed mass storage units have direct access to cache memory and thus can bypass the UNIBUS when transferring data to and from memory.

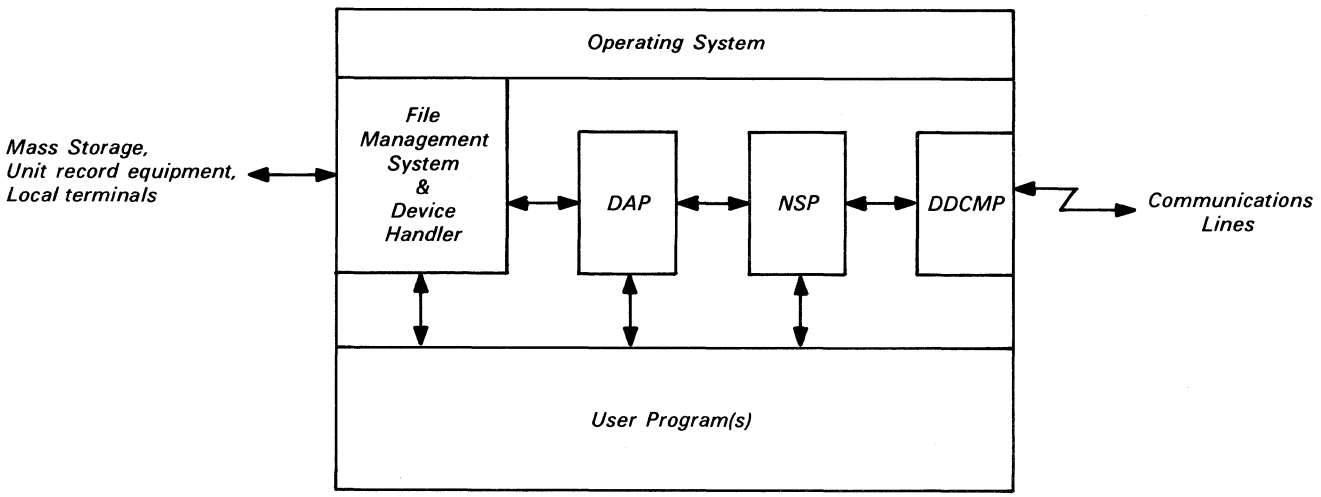


Figure 2. Digital Network Architecture Major Functions (italics) Performed by DECnet software.

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

Table 1. COMMUNICATIONS HARDWARE INTERFACES

Unit	Line Interface	Timing	Max. Line Speed, bps	Mode (1)	DMA Data Transfer In	DMA Data Transfer Out	Lines per Unit	Max. Units per System (2)	Max. System Throughput, cps	Backplane Requirement (3)	DECnet Support	Operating System Support (4)
DV11-AA*	EIA/CCITT	Sync. Asyn.	9600	F/H	Yes	Yes	16	2	38,400	9	Yes	I, S, M, D
DMC11-AL*	Local line	Sync.	1000K	F/H	Yes	Yes	1	2	250,000	H	Yes	All
DMC11-AR*	Remote line	Sync.	19,200	F/H	Yes	Yes	1	16	4800	H	Yes	All
DZ11-A	Bell 103, 113	Asyn.	9600	F	No	No	8	16	19,200	E & H	No	All
DZ11-E	DZ11-A expansion	Asyn.	9600	F	No	No	16	8	38,400	E & 2H	No	I, S, M, D, E
DZ11-C	20 ma current loop	Asyn.	9600	F	No	No	8	16	19,250	E & H	No	All
DZ11-D	20 ma current loop	Asyn.	9600	F	No	No	16	8	38,400	E & H	No	I, S, M, D, E
DH11-AA*	EIA/CCITT,	Asyn.	9600	F/H	No	Yes	16	16	38,400	E & 9	No	I, S, M, D, E
DH11-AD	20 ma current loop	Asyn.	9600	F/H	No	Yes	16	16	38,400	E & 9	No	I, S, M, D, E
DUP11-DA	Bell 200 Series	Sync.	9600	F	No	No	1	16	2400	H	Yes	I, S, M, D, T
DQ11-DA	Bell 201, 8, 9	Sync.	10,000	F/H	Yes	Yes	1	16	2400	4	Yes	I, S, M, D
DQ11-EA	Bell 303	Sync.	1000K	F/H	Yes	Yes	1	16	250,000	4	Yes	I, S, M, D
DR11-C	16-bit parallel direct attach	Sync.	—	—	No	No	—	—	—	Q	No	S, M, D, E, T
DR11-B	16-bit parallel direct attach	Sync.	—	—	Yes	Yes	—	—	—	Q	No	I
DL11-WA	20 ma current loop	Asyn.	9600	F	No	No	1	16	2400	Q	Yes	All
DL11-WB	EIA	Asyn.	9600	F	No	No	1	16	2400	Q	Yes	All
DL11-E	Bell 103/113/202	Asyn.	9600	F	No	No	1	16	2400	Q	Yes	All

(1) F represents full-duplex; H, half-duplex.
(2) Usually, more than the number indicated can be physically attached; message processing throughput is the limiting factor.
(3) E represents need for Small Expansion Panel.
9 represents need for special 9-slot backplane; 4 for special 4-slot backplane
H is 1 Hex slot; 2H is 2 Hex slots; Q is 1 Quad.
(4) I represents IAS; E, RSTS/E; T, RT-11; S, M, and D represent RSX-11S, M, D.

*Line adapter required.

do not appear to be unreasonable for the complex tasks performed.)

Neither of the data processing users were planning to decentralize their data bases, and both included a master computer in their networks.□

Connections to the UNIBUS are via the backplane, a printed circuit board with sockets. The backplane that is provided with the central processor consists of nine rows of sockets. Each row, called a slot, has six records. Two slots have two sockets reserved. This results in seven slots of six sockets per slot (Hex slot) and two slots of four sockets (Quad slot) per slot. To connect most I/O interfaces require six sockets, four sockets, or multiples thereof. The combination of devices is limited to the mix of sockets and slots required. Slots as well as sockets must be taken into consideration. A Hex or six-socket interface requirement could not use two Quad slots even though eight sockets are available.

The four reserved sockets are for connection of the bootstrap memory, the parity control, and for expansion of the UNIBUS.

The backplane of the basic PDP-11/34 with 8K words of core memory, for example, requires two Hex slots for the CPU, along with one Hex and one Quad slot for the core memory. Since three Hex and one Quad slots are utilized, three Hex and two Quad slots are available for I/O interfaces.

Two expansion panels are available. One expansion panel provides four slots (two Hex and two Quad) and another expansion panel provides nine slots (seven Hex and two Quad).

Memory cycle time for PDP-11 processors is 1.2 microseconds for core memory, 0.45 or 0.3 microseconds for MOS memory, and 0.3 microseconds for bipolar memory. The top of the PDP-11 line can support up to 1.024K words of memory plus a 1K bipolar cache memory with a cycle time of 0.24 microseconds. The PDP-11 word consists of 16 bits.

Table 2. LINE ADAPTERS FOR COMMUNICATIONS HARDWARE INTERFACES

Communications Hardware Interface	Line Adapter	Line Adapter Type
DV11-AA	DV11-BA	8-line; synchronous
	DV11-BB	8-line; asynchronous
	DV11-BC	8-line; 4 lines asynchronous and 4 lines synchronous
DMC11-AL	DMC11-MA	1-line, 1,000,000 bps, up to 6000 ft.
	DMC11-MD	1-line; 56,000 bps, up to 18,000 ft.
DMC11-AR	DMC11-DA	1-line; Bell 200 Series, up to 19,200 bps
DH11-AA	DM11-BB	16-line; Bell 103/202 (model control only)
	DM11-DA	4-line; 20 mA
	DM11-DB	4-line; EIA
	DM11-DC	4-line; EIA/CCITT (used with DM11-BB)

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

Mass storage includes the following devices:

	Maximum On-line Capacity
Floppy disk drives	512K bytes
Cartridge disk drives	20 million bytes
Fixed-head disk drives	8.192 million bytes
Disk pack drives	320 million bytes
DECassette drives	2.304 million characters

CONNECTION TO HOST COMPUTER

PDP-11 processors are interconnected over communications lines in the same fashion as terminals. No special interfaces required. A specially modified PDP-11/40 is used as a front-end to a DEC System 10/20. Connection to the host provides for parallel data transfer. A special adapter is available to use a PDP-11 as a front-end to an IBM System 360/370.

TRANSMISSION SPECIFICATIONS

Communications lines are attached directly to DEC communications hard interfaces (CHI) or to line adapters which are themselves connected to the communications hardware interfaces. Single-line, 8-line, and 16-line CHI's are available with asynchronous speeds up to 9600 bps and synchronous speeds up to 1,000,000 bps. EIA, CCITT, and 20 mA interfaces are supported. Some of the interfaces include microprocessors with direct memory access for outgoing and incoming data. Processing throughput, rather than physical restrictions (backplane socket availability) usually limits the number of lines that can be supported. For instance, a maximum of 32 asynchronous lines can operate simultaneously at a 9600 bps rate. However, if the rate if lower, a proportionate number of additional lines can be added to the system. Table 1 lists the best price/performance CHI's offered from a broader, but redundant or special purpose, product line. Table 2 lists the line adapters available for those CHI's that require them; this occurs when the CHI supports more than one interface standard.

SOFTWARE

The PDP-11 operating systems that include DECnet modules are:

- RT-11 — A two-partition, disk system with one of the partitions used for real-time applications.
- RSX-11D — A real-time multiprogramming system.
- RSX-11M — A subset of RSX-11D.
- RSX-11S — A subset of RSX-11M with the operating system always resident in memory.
- RSTS/E — Resource-Sharing Timesharing system. Permits up to 63 simultaneous interactive time-sharing users.
- IAS — A multi-user interactive and batch processing system for the PDP-11/70 and 45.

Figure 2 depicts the major functions performed by DECnet software. The first major function (DDCMP) is handling of the physical link between the line and the processor. The second (NSP) is handling of the logical link between the physical line and the user program. The third function (DAP) is the additional software interface needed to permit the system's file management software to retrieve data for or accept data from a remote prcessor or terminal.

The Digital Data Communications Message Protocol (DDCMP) performs the physical line control only for the communications hardware interfaces noted in Table 1 as DECnet supported. DDCMP performs line scanning, error detection and error recovery. On half-duplex lines, DDCMP controls the direction of traffic, while on full-duplex lines, DDCMP controls bi-directional traffic; on multi-point lines DDCMP performs the polling function. Outgoing transmissions are enveloped with control characters mainly to enable the receiving device to perform error detection. The CRC-16 polynomial checking technique is employed in creating an error detection code. Incoming transmissions are stripped of control characters after passing error detection checks. To accommodate for the relatively long transit time for satellite destined messages, DDCMP can support the transmitting up to 255 messages before halting transmissions to await acknowledgements for the previously transmitted messages.

DECnet software to handle the DDCMP protocol line handling is intended for use with low or medium speed communications systems. The software will perform the function for both the program-interrupt and the DMA types of communications hardware interfaces. When volume increases substantially and begins to consume too much central processor overhead or when high-speed communications lines are used, the DMC11 interface can be employed. Containing a dedicated microprocessor, the DMC11 will perform, via firmware, the line handling function, thus relieving the central processor's DECnet software of this time-costly burden. With the DMC11, a user could employ DDCMP protocol without using the other functions of DECnet.

The Network Services Protocol (NSP) software provides a logical connection between the physical link and the user program. When NSP receives a message for transmission from a program, NSP affixes the receiving program's identifier and sends it to the appropriate physical link for DDCMP protocol line handling. Incoming messages are stripped of their envelope characters and given to the appropriate program. When two remotely located programs must talk to each other by passing a high volume of a particular type of data (as in remote program loading), NSP can establish a Dynamic Logical Link between the programs and will pass only the specified type of data through the link.

When a remotely located program wants access to a file, NSP does not supply the request to a user program, but to another DECnet module, the Data Access Protocol (DAP). This module goes through the same steps a local user program would take to get at data from mass storage. Namely, it issues an open and a read/write command to the File Management System. If the remote command was a Read, DAP would obtain the data and pass it to NSP for transmission. NSP will treat the data as just another outgoing message from just another user. DAP will also interface with the Device Handler software that controls unit record equipment and locally attached terminals.

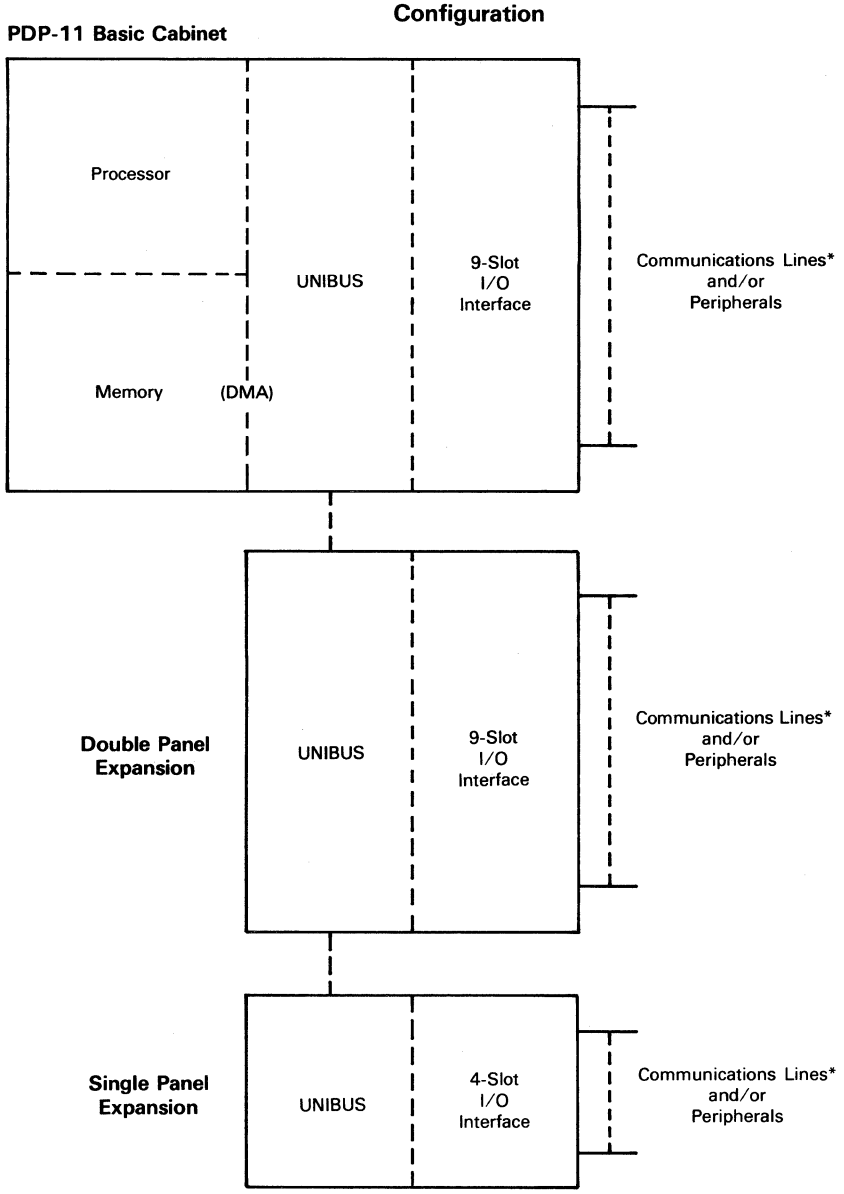
To summarize, the communications hardware interface is the physical connection, which assembles characters; DDCMP software controls the physical line; NSP channels incoming data into logical links with one or more user programs; and DAP is a specialized user-like program for remote data retrieval and update. Of course, all of this is under the watchful control of the operating system.

Under DECnet the RST/E operating system supports only synchronous transmission at speeds up to 19,200 bps. The other operating systems under DECnet support synchronous transmission at speeds up to 40,800 bps and asynchronous transmission at speeds up to 9600 bps.

DEC's Fortran includes the necessary support for the DECnet modules of each Operating System. A 1978-scheduled release of COBOL will also support DECnet. The user, writing in the above languages, can issue DECnet inter-system commands and have compilations that will interface properly with NSP.

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

Configuration



*Throughput considerations determine line configuration alternatives; see Table 1.

PRICING

DEC's offering to the end user, as opposed to the original equipment user, consists of PDP-11 packages with a standard amount of main memory and peripheral set. To this, the user can add additional communication interfaces (subject more to the throughput limitations than to physical limitations). Because of the way DEC offers the PDP-11 to end-users, we have supplied the price of typical standard configurations, indicating the remaining usable slots available in the processor panel backplane. Each configuration can be expanded with a four-slot Expansion Panel and a Nine-slot Expansion Panel. Table 1 indicates the slots required for attachment of each communications interfacc.

The PDP-11 equipment is offered on a purchase basis only. A field service maintenance contract is offered. The service includes the cost of all parts and labor for maintenance during the standard eight hour business day. Regularly scheduled preventive maintenance and installation of engineering improvements are included. Most field installed equipment carries a one time charge. Maintenance contracts for additional coverage, including round-the-clock coverage, is available at additional charge.

Software is provided under a license agreement with a one time charge for use of the software in a single computer system.

		Purchase Price	Monthly Field Maint.
PROCESSORS			
1104-DM	PDP-1104 with 32K bytes MOS memory; provides 4 Hex slots, 2 Quad slots, and 3 SU's*	$ 7,970	$ 66
1134A-DE	PDP-11/34 with 32K bytes MOS memory, and Single-Line Interface; provides 3 Hex slots, 1 Quad slot, and 3 SU's*	11,520	71

Digital Equipment Corp.
PDP-11 Family Communications Capabilities

PROCESSORS (Continued)		Purchase Price	Monthly Field Maint.
1134A-ME	PSP-11/34 with 64K bytes core memory and Single-Line Interface; provides 1 Quad slot, and 3 SU's*	15,400	96
11T40-AA	PDP-11/40 with 64K bytes core memory, LA 36 DECwriter, and 2 disk cartridge drives; provides 3 Quad slots, and 3 SU's*	45,220	287
11T55-BA	PDP-11/55 with 64K bytes bipolar memory, Single-Line Interface, LA36 DECwriter, 2 cartridge disks, and floating-point; provides 2 Quad slots and 2 SU's*	73,100	504
1170-VA	PDP-11/70 with 128K bytes core memory, 2K bytes cache memory, and LA36-C DECwriter II; provides 4 Quad slots	63,000	241
EXPANSION FEATURES			
H960-DH	Sliding draw extension mounting box for 9 SU's* (Power supply provides power for up to 64K of core memory)	3,630	16
DD11B	Backplane Mounting Unit for up to four peripheral controllers; 2 Hex and 2 Quad slots	350	—
DD11-D	Backplane Mounting Unit for 7 Hex slots, 2 Quad slots, and 2 SU's* (for maintenance only)	660	—
	*One SU equals four Hex slots.		
COMMUNICATIONS HARDWARE INTERFACES			
DV11-AA	16-Lines; sync./async., EIA/CCITT, multiplexer	4,840	29
DMC11-AL	1-Line Local; sync. (includes Line Card)	2,370	13
DMC11-AR	1-Line Remote; sync. (includes Line Card)	2,370	13
DZ11-A	8-Lines; async. Bell 103/113	2,310	25
DZ11-E	16-Lines; async., Bell 103/113	3,740	46
DZ11-C	8-Lines; async., 20 mA current loop	1,710	21
DZ11-F	16-Lines; async., 20 mA current loop	3,740	46
DH11-AA	16-Lines; async., 115V	5,170	32
DH11-AD	16-Lines; async., EIA, CCITT	5,170	32
DUP11-DA	1-Line; sync., Bell 200 Series	1,380	9
DQ11-DA	1-Line; sync., Bell 201/8/9	3,570	24
DQ11-EA	1-Line; sync., Bell 303	5,450	25
DR11-C	16-bit Parallel Direct Attachment (general purpose interface)	540	5
DR11-B	Direct Memory Access Interface	1,620	13
DL11-WA	1-Line; async., 20 mA current loop, frequency real-time clock	770	5
DL11-WB	1-Line; async., EIA, CCITT, no modem control	770	5
DL11-E	1-Line; async., EIA/CCITT, modem control	770	6
LINE ADAPTERS			
DV11-BA	8-Lines; sync.	3,750	15
DV11-BB	8-Lines; sync.	3,750	15
DV11-BC	8-Lines; 4 sync. and 4 async.	3,750	15
DMC11-MA	1-Line; 1,000K bps at up to 6,000 ft.	850	6
DMC11-MD	1-Line; 56K bps at up to 18,000 ft.	850	6
DMC11-DA	1-Line; Bell 200 Series	850	6
DM11-BB	16-Lines; Bell 103/202	1,650	19
DM11-DA	4-Lines; 20 mA	250	5
DM11-DB	4-Lines; EIA	650	5
DM11-DC	4-Lines; EIA/CCITT	1,120	11
MASS STORAGE			
RJS03-BA	Fixed-Head Disk Drive and Control; 52K bytes	16,900	75
RJS04-BA	Fixed-Head Disk Drive and Control; 1024K bytes	21,120	85
RX11-AA	Floppy Disk Drive and Control; 256K bytes	3,350	25
RX11-BA	Dual-Floppy Disk Drive and Control; 512K bytes	4,300	33
RK11J-AA	Cartridge Disk Drive and Control; 2.5 megabytes	10,400	81
RPR11-AA	Disk Pack Drive and Control; 20 megabytes	22,550	219
TA11-AA	DECassette; dual transport and Control, 90,000 char. per reel	4,200	38
TC11-GA	DECtape and Control; dual transport, 288K char. per reel	14,490	45
MASS STORAGE FOR PDP 11/60, 70 only			
RP04-AA	Single Access Disk Drive; 88 million bytes	27,200	190
RP04-BA	Dual Access Disk Drive; 88 million bytes	32,340	210

SOFTWARE

Operating Systems	License Fee
RT-11	1,380
RSX-11D	6,050
RSX-11M	2,750
RSX-11S	1,650
RSTS/E	6,050
IAS	8,580
DECnet-11S	1,100
DECnet-11M	1,650
DECnet-11D	2,750
DECnet-IAS	2,750
DECnet-RT-11	Not yet available
DECnet-RSTS/E	Not yet available ■