PDP-11 COMPUTER FAMILY

PRODUCTS AND SERVICES

digital

JULY 1976

DIGITAL is specifically known as the developer and prime supplier of minicomputers. In general, we are known for a philosophy of providing the lowest cost system tools for a wide spectrum of users. The PDP-11 family is a key component of this success. It is a complete family of processors, peripherals, software and services that allows each user to precisely tailor computer systems to specific problems–and then change the system–or the problem. It is based upon a compatible set of processors–ranging from small microcomputers with 8K bytes of memory to multi-function computers with 4M bytes of memory–and includes a large array of peripherals, software and support services.

All processors have a common architecture with a similar input/output system and instruction set. Common architecture means you can move up to a more powerful processor with the certain knowledge that existing software and peripherals can move up with you. Common architecture means you can expand, since nearly all peripherals and software can be added to any system. Commonality also means you can mix systems and they will all be supported by a single development and documentation effort. But most of all, commonality means you can start where you want and the PDP-11 family will grow with you in any direction to meet any new needs.

Start Where You Want

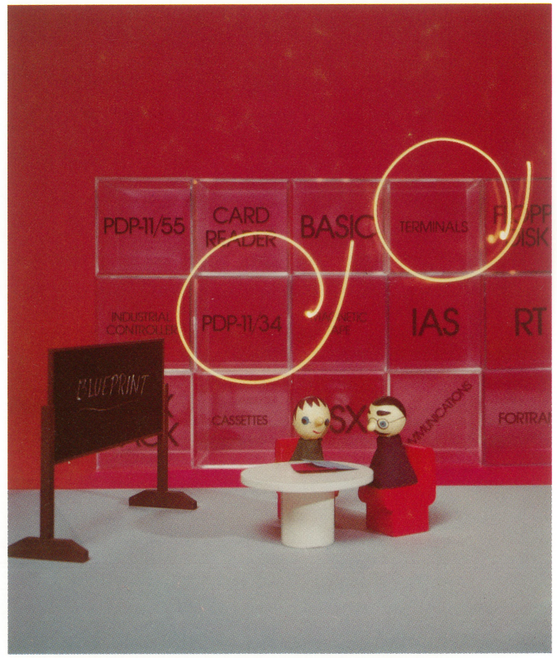
Some computer applications need enormous amounts of computing power. Others simply do not. For this reason the PDP-11 family currently includes six central processors.

If the application requires a computer to solve one problem at a time, and hence run one program at a time, one of the PDP-11 microcomputers or minicomputers is appropriate.

If the application requires a computer to solve many similar problems (like many ongoing real-time processes or many interactive terminal applications) and hence run many programs at a time, one of the PDP-11 system computers is appropriate.

If the computer must handle many different tasks concurrently (some batch, some timesharing, some real-time), then the PDP-11/70 is appropriate.

Use What You Need



A central processor may be all it takes to solve a problem. But, most probably it is not. So the PDP-11 family includes a large set of peripherals and software that lets you match exact computing power to exact requirements.

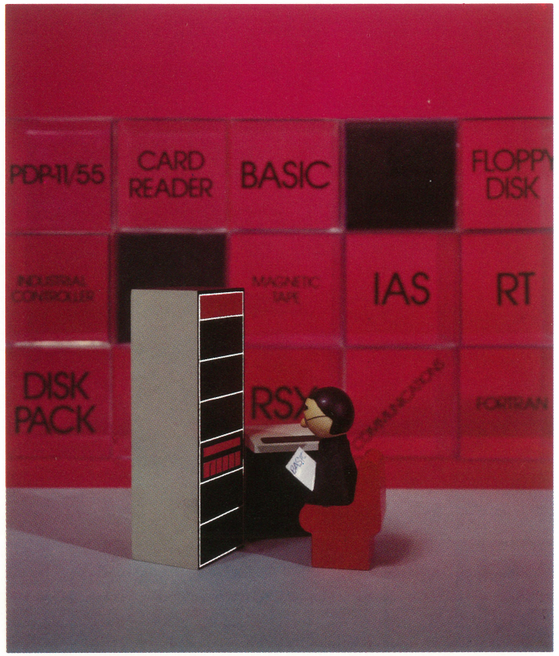
Peripherals *extend the power* of the central processor by providing storage and a means of moving data into and out of the processor. If you only need a small amount of on-line storage (a few hundred thousand to a few million characters) the 11 Family's low-cost mini-peripherals are for you. If more data (up to hundreds of millions of characters) or very high speeds are involved, the high-performance peripherals are appropriate. When the computer must communicate with people or other computers at distant locations, the 11 family communications options are there to meet this need. If a picture is worth a thousand pages of printout, the graphics capabilities can fit with any system. And if the problem is direct interfacing to real-time signals, the signal processing and industrial control subsystems are the appropriate tools.

Operating systems *extend the flexibility* of the central processor by automatically applying their power to the task(s) currently at hand. The PDP-11 family's single-user operating systems organize program development and execution on a sequential basis. The multi-task and time-sharing operating systems handle more than one task at a time. And the IAS multifunction operating system performs a mix of real-time, timesharing and batch operations simultaneously.

Computer languages *extend the convenience* of the central processor by allowing the people who understand the problem to write the programs—not just the people who understand the computer. FORTRAN IV is widely known in the scientific and industrial world. BASIC is widely known in the timesharing and educational world. And COBOL is the standard for the commercial world.

Supporting services *extend the usability* of the computer system by keeping it and the people who use it up to date and efficient. Maintenance services assure the correct operation of the hardware. Educational services assure that the people who use the computer know how to get the best possible results with the least amount of effort and cost. Software services provide the programming expertise to help with actual implementation. Software newsletters and user groups keep you up to date on the products you use. And the Special Systems group can be brought in to design and develop special hardware and software tools for unique requirements.

...In Any Combination



While a magnetic tape cassette system normally mates with a smaller minicomputer, it can just as well operate with a PDP-11/70, especially where the 11/70 and many smaller 11's are used in the same facility with cassettes as the medium of interchange.

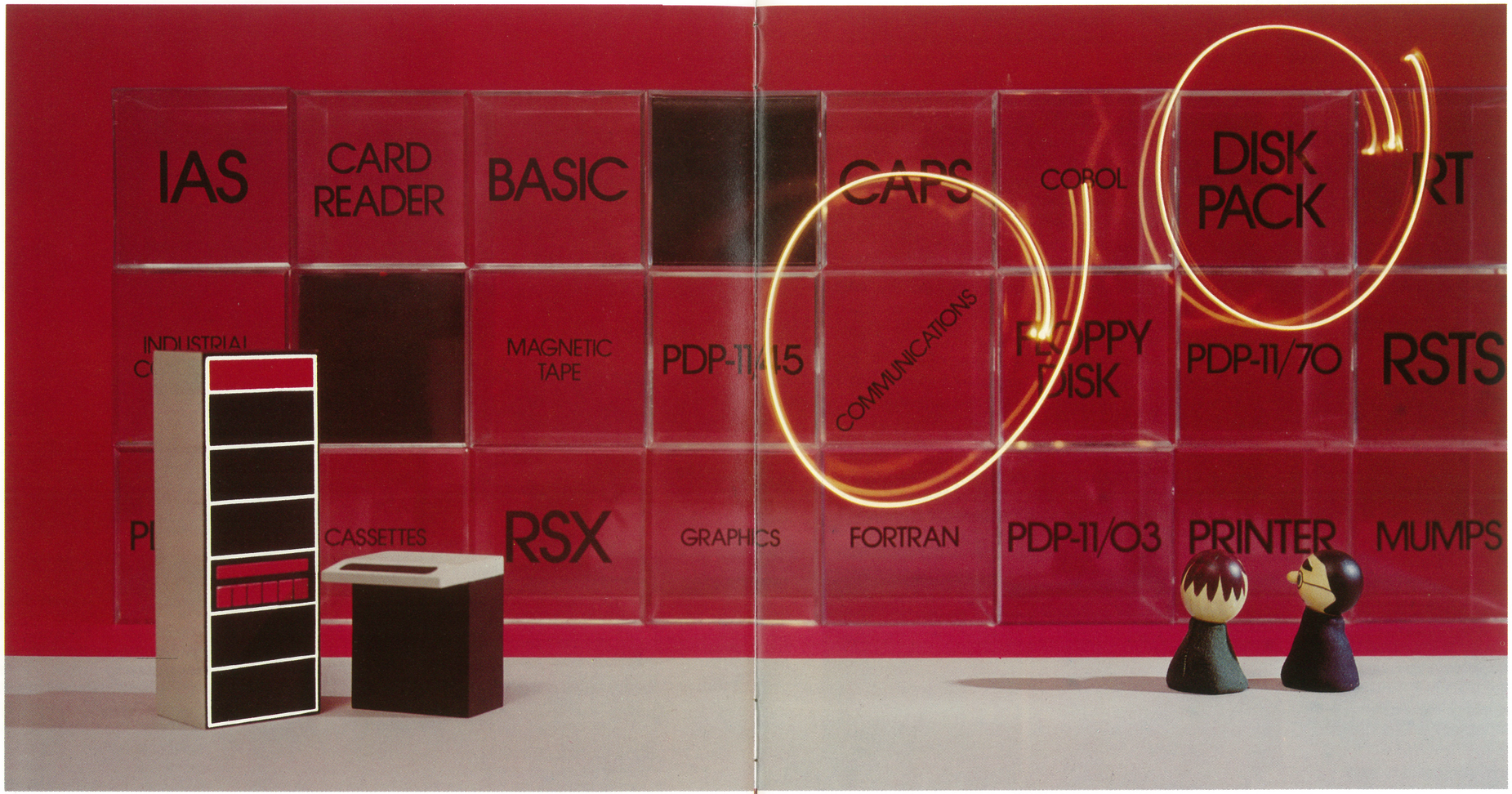
While the high-performance peripherals are most frequently joined to bigger processors, they don't have to be. A system performing data collection operations may need the storage capacity and speed of a 1600-bpi magnetic tape unit, but only the processing power of a PDP-11/04.

In similar fashion, the processors and operating systems can be mixed and matched to meet specific needs. Single-user operating systems generally team with smaller processors to handle "one job at a time". But, if the dedicated task is very demanding, a bigger and faster processor can be, and frequently is, used.

The one exception to this total freedom to mix and match hardware and software members is the PDP-11/03 microcomputer. To obtain minimum price, this processor is offered with a functional subset of the UNIBUS.

Support services, which range from do-it-yourself test equipment to turnkey support, are equally adaptable to the whole range of PDP-11's. Resident software specialists are most frequently used with bigger installations. But they can also save money on the smallest systems by doing initial programming, so you can take it from there without the need of a full-time programmer.

Grow When You Are Ready



The PDP-11 family compatibility is just as important after you buy, because upgrading the system is a step-by-step process:

- peripherals add on easily
- software subsystems such as graphics support and DECnet are processor and operating system independent.
- all levels of support are available for all levels of systems

If your needs expand from a dedicated minicomputer to a large system computer, you can upgrade only the central processor without changing the rest of the configurations. Application systems which use the high-level language subroutine packages can move from processor to processor, from operating system to operating system without reprogramming.

The rest of this brochure gives more detail on the system architecture, software options, and hardware options of the PDP-11 family. More details on each element may be found in:

- the Feature Sheets—one page summaries of each element, hardware or software, of the family.
- the PDP-11 Processor Handbook series—technical descriptions of all PDP-11 central processors.
- the PDP-11 Peripheral Handbook—technical descriptions of all PDP-11 peripheral products.
- the PDP-11 Software Handbook—descriptions of each operating system and high-level language available for the 11 family.

THE FAMILY PROFILE

Flexibility. Top price/performance.
The hallmarks of the PDP-11 Family.

They mean:

A processor structure that supports application needs.
An I/O structure that is responsive, fast, flexible.
Software that enhances performance and facilitates change.

Processor Structure

Data stored in memory must be accessed and manipulated. Since a large portion of the data handled by a computer is usually structured (in character strings, arrays, lists, etc.) the PDP-11 has been designed to handle structured data efficiently and flexibly. Eight general purpose registers and eight addressing modes, or ways of using them, permit the programmer to select the precise instruction needed for a specific operation.

Addressing Modes

Processor addressing modes include sequential, forward, or backward addressing, address indexing, indirect addressing, 16-bit word addressing, 8-bit byte addressing, and stack addressing. Variable length instruction formatting allows a minimum number of words to be used for each addressing mode. The result is efficient use of program storage space.

Registers

With eight general purpose registers, PDP-11 minicomputers give the programmer the flexibility of a large-scale computer. Since the registers are not dedicated to specific functions, the programmer can assign them dynamically—to manipulate a pointer, achieve speed or provide temporary storage.

The general registers may be used with an instruction in any of the following ways:

- as accumulators. The data to be manipulated resides within the register.
- as index pointers. The contents of the register are the address of the operand, rather than the operand itself.
- as sequential pointers which automatically step through core locations.
- as index registers. This allows easy access to variable entries in a list.

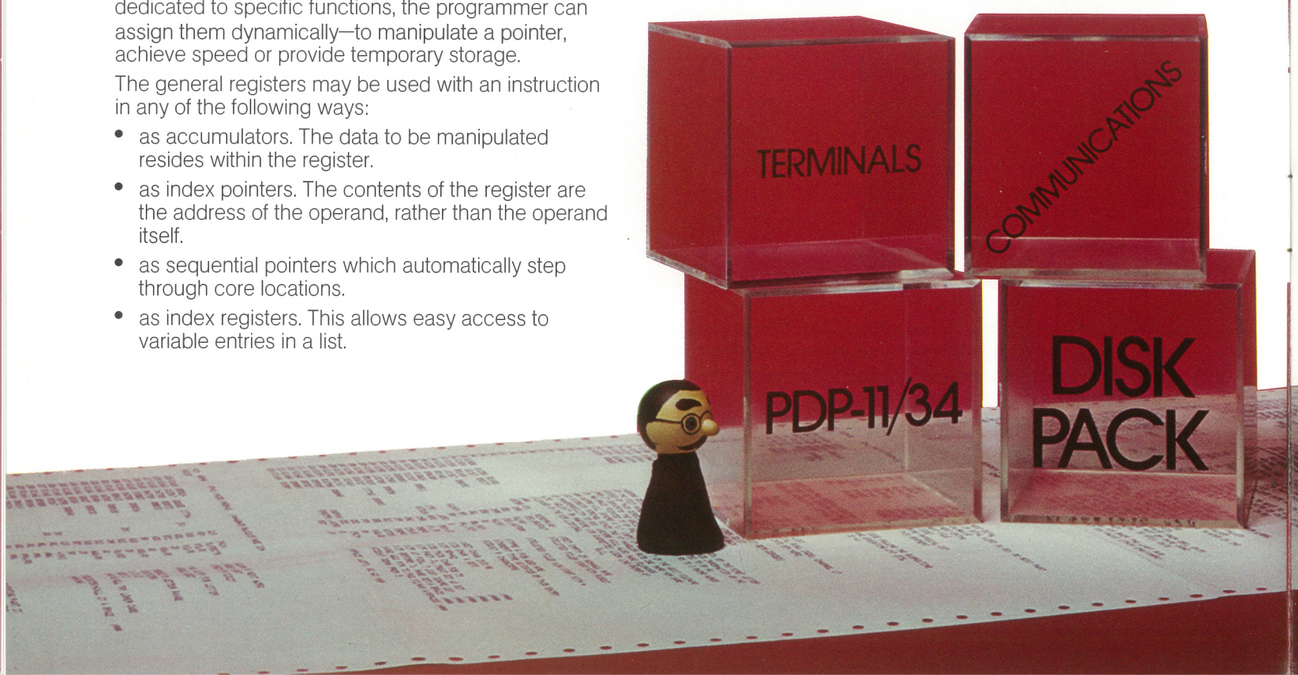
Stacks

For convenient handling of data, the PDP-11 employs a hardware pushdown stack, a powerful built-in data storage feature normally found only on large computers.

Stacks speed the servicing of structured data, interrupts and subroutine calls by providing fast temporary storage of program information.

Device Registers

Unlike conventional 16-bit computers, which usually have three classes of instructions (memory reference instructions, accumulator control instructions, and I/O instructions), all data manipulation operations are accomplished with one set of instructions. Since peripheral device registers can be manipulated as flexibly as memory by the central processor, instructions that are used to manipulate data in memory can be used equally well for data in peripheral device registers. For example, data in an external device register can be tested or modified directly by the CPU without bringing it into memory or disturbing the general registers. One can add or compare data logically or arithmetically in a device register.



Instruction Set

The basic instruction set combines with the addressing modes to form over 400 instructions. This comprehensive set provides large computer programming flexibility in a minicomputer mainframe. The primary instructions are double-operand instructions, allowing whole operations (such as ADD A to B with the result stored in B) to be performed in a single instruction. If both operands are general registers, the instruction requires no additional memory references; and if both operands are in memory locations, the whole operation is performed in memory, disturbing none of the general registers.

Bit, byte and word addressing in both single- and double-operand formats make memory saving possible and simplify the implementation of control and communications applications.

An example of the flexibility afforded by the combination of the PDP-11 instruction set with the general registers and addressing modes is the MOV (move) instruction. Among the operations performed by the instruction are:

```
MOV R0, R1        ;register-to-register transfer
MOV A, B          ;memory-to-memory transfer
MOV A, R0         ;load register from memory
MOV R0, A         ;store register to memory
MOV A, (SP)+      ;push memory location on stack
MOV –(SP), A      ;pop stack location to memory
MOV R0, (SP)+     ;push register on stack
MOV –(SP), R0     ;pop stack to register
```

In the above examples, R0 and R1 are general registers; A and B are memory locations, possibly external device registers, and SP is a register used as a stack pointer. In addition to the above examples, the MOV instruction is used just as simply and efficiently with other addressing modes to perform indexed and indirect address versions of the same operations.

High Performance Extensions

While all PDP-11's share the flexibility which is the family trademark, the smaller processors are optimized for price; larger processors provide increased functionality, speed, and control. Some of these high performance extensions include:

Memory Management

In order to most effectively utilize the power and efficiency of the CPU in medium and large scale systems it is necessary to run several programs simultaneously. In such multi-programming environments several user programs would be resident in memory at any given time. The task of the supervisory program would be: control the execution of the various user programs, manage the allocation of memory and peripheral device resources, and safeguard the integrity of the system as a whole by careful control of each user program.

In a multi-programming system, the Memory Management Unit provides the means for assigning memory pages to a user program and preventing that user from making any unauthorized access to these pages outside his assigned area. Thus, a user can effectively be prevented from accidental or willful destruction of any other user program or the system executive program.

Floating Point Processor

The Floating Point Processor is an integral asynchronous processor that works in parallel with the basic arithmetic and logical circuitry of the 11/45, 11/55 and the 11/70. Floating point instructions operate in the same flexible way as do other instructions, even down to the addressing modes. The only difference is that floating point instructions reference a dedicated set of six 64-bit floating accumulators, while other instructions reference the general registers. The complete set of 46 basic instructions include those necessary for converting between integer and floating representations to provide interchangeability of integer and floating point operations.

Floating point calculations are carried out in either single precision (32 bits) or double precision (64 bits). If the instruction being executed is single precision, references to memory automatically fetch or store four bytes; in double precision, references fetch or store eight bytes. All floating point registers are 64 bits in size, and hence operate in either single or double precision. The data formats provide seven decimal digits of accuracy in single precision, and seventeen decimal digits of accuracy in double precision.

Floating point processor operation is overlapped with CPU operations utilizing the general registers. This means that as much as 75% of the floating point execution time may be overlapped with concurrent non-floating point CPU operations.

Processor Modes
Protection of the system against accidental or malicious misuse is critical for a large multiprogramming system. The 11/45, 11/55 and 11/70 provide this protection for their users by using separate processor modes for the system and the user. Instructions such as HALT are inhibited in user mode to prevent programs from stopping the system. Additional hardware circuitry prevents a program running in a lower mode from accessing a higher mode except by means of a trap or interrupt.

Bipolar Memory
Solid-state memory provides the ultimate speed for critical system programs and data. It is tied directly to the processor by a second data path; therefore, the speed at which these programs execute is unaffected by UNIBUS transfers between peripheral devices and core memory. Mixed memories provide optimum price/performance. High-speed memory can be used just for the program and data areas that could best benefit from it. For example, overall system performance can be significantly improved by having the run-time segment of an operating system reside in fast memory. Alternatively, high-speed memory can be added later when increased performance is required.

Between 8K and 64K bytes of bipolar memory can be used in combination with core memory or by itself.

Cache
An integral cache memory is a standard feature of every PDP-11/70. The cache is a high-speed solid-state memory with a 2,048-byte capacity. It has a cycle time of 240 nano-seconds. The cache acts in many ways like a buffer between the CPU registers and main memory. Whenever a request is made to fetch data from memory, the circuitry checks to see if the data is already in cache. If it is, it is fetched from cache, and no main memory read is required. If not in cache, four bytes are transferred in parallel from main memory for execution. When a request is made to write data into main memory, it is written both into the cache and main memory. This assures that main memory always has the most up-to-date data.

Byte Parity Protection
Parity generation and checking is used throughout the PDP-11 Family. It is used on address as well as data transfers, between main memory, cache memory, peripheral controllers, and many peripheral devices. Parity errors are detected, the location recorded, and the system traps to a given location where a software routine may be executed to take whatever action is deemed appropriate. One parity bit per eight-bit byte is implemented.

I/O Structure
UNIBUS Architecture
A key factor in the PDP-11 family's success is that all system elements—processor, memory, peripherals—plug into a single asynchronous high-speed bus, which transfers all addresses and data. Known as the UNIBUS, this bi-directional bus enables easy interfacing, simplifying the construction of multiprocessor or shared peripheral configurations. The PDP-11/03 bus is a functional subset of the UNIBUS and like the UNIBUS is asynchronous and bi-directional. Unlike the UNIBUS it has only one interrupt level and utilizes simpler, less expensive device interfaces.

The UNIBUS prevents PDP-11 systems from becoming obsolete. Because it is asynchronous, the UNIBUS is compatible with devices that operate over a wide range of speeds. Faster devices or memory can always replace older versions without affecting the system.

Through the UNIBUS, fast devices have easy direct-memory access through cycle-stealing. They require no expensive multiplexers or synchronous DMA hardware. These devices can send, receive or exchange data without processor intervention and without intermediate buffering in memory. The PDP-11/70 supplements the UNIBUS with a high-speed 32-bit internal bus for high-speed devices.

Hardware Interrupts
The interrupt system for the PDP-11 is another departure in small computer technology. With fully-vectored interrupts, the system eliminates the high-overhead software to determine the device service routine and the code necessary to save system status. The multi-level hardware interrupt system is a standard PDP-11 feature for all processors above the 11/03, not an extra-cost option.

The PDP-11 interrupt system has four priority levels, each of which can handle an almost unlimited number of devices. The priority of the device is a function of the device's physical location—the closer to the processor the higher its priority on that level.

The priority system makes excellent use of the PDP-11's hardware stacks. When the processor services an interrupt, it first saves important program information on the stack. This information enables the processor to automatically return to the same point in the program and the same conditions, once the current interrupt has been serviced.

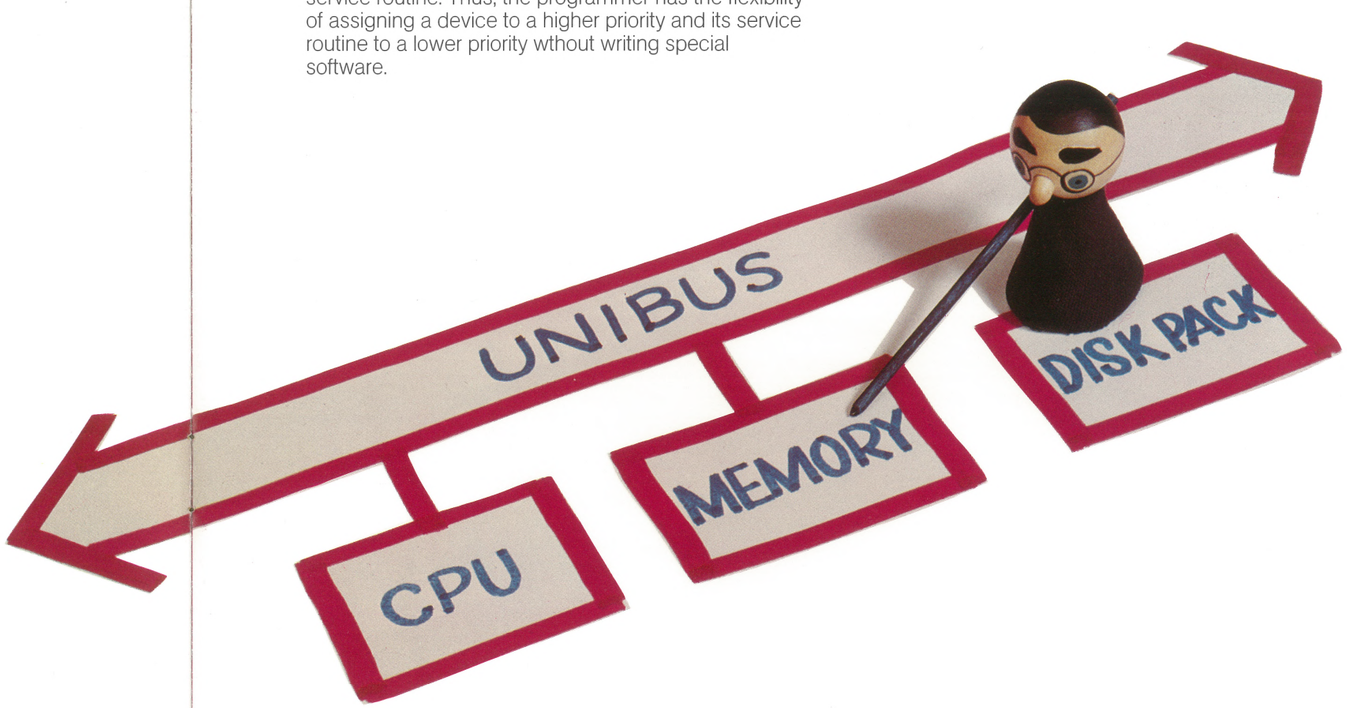
The device causing the interrupt(s) provides a direct vector to its own service routine—eliminating the slow and tedious operation of polling all devices to see which one interrupted.

The device also provides status information for its own service routine. Thus, the programmer has the flexibility of assigning a device to a higher priority and its service routine to a lower priority wthout writing special software.

The system also allows interrupts to be enabled or disabled, through software, during program operation. Such masking allows priorities to change dynamically in response to system conditions.

For example, a real-time program can disable data entry terminals whenever critical analog data is being collected. As soon as the scan is complete, the terminals can be automatically enabled and ready to input data.

Any number of interrupts can be enabled or disabled with the PDP-11 minicomputers. Other systems are restricted to 16 by virtue of their word lengths.



Software Options

To take advantage of the range and flexibility of the PDP-11 family, DIGITAL provides a broad spectrum of software: from single user program development systems to powerful general purpose operating systems; from scientific high level languages to commercial high level languages; from application packages which perform a specific function to packages which perform a range of functions in a specific environment.

The high degree of commonality among the languages, system programs, and files across operating systems facilitates growth from one operating system to another, as well as the mixing of different operating systems at a single location or in a network.

Operating Systems

The diverse PDP-11 operating systems enable you to tailor a specific solution to your problems. You select precisely those functions you need—without the overhead of those you do not.

CAPS-11

CAPS-11 (Cassette Programming System-11) is an entry-level system utilizing the TA11 cassette as the sole storage device on a PDP-11 with as little as 16K bytes of memory and a console terminal such as the LA36 DECwriter. CAPS-11 permits program development in the PDP-11 assembly language, or through an optional BASIC language processor. As an entry-level system it is usually operated on a PDP-11/04, but can be utilized on larger PDP-11 processors with memory expansion up to 56K bytes.

RT-11

RT-11 is an efficient single-user disk operating system designed for interactive program development and/or on-line applications. It supports both single job (S/J) and foreground/background (F/B) modes of processing. In addition to a variety of system and program development utilities, RT-11 offers optional support for FORTRAN IV, FOCAL and BASIC.

RSTS/E

RSTS/E (Resource Sharing Timesharing System/Extended) allows multiple users to interactively process large amounts of data easily and efficiently. It supports up to 63 simultaneous users through the BASIC-PLUS language, an enriched version of Dartmouth Standard BASIC. COBOL is available to enhance the business data processing requirements of certain applications, and FORTRAN IV is available for scientific and industrial applications.

MUMPS-11

MUMPS-11 is an interactive, multi-user, data base management operating system. The high-level MUMPS language supports string manipulation and a hierarchical file structure. The system is optimized for data base management functions, including the random retrieval of string-oriented data from large data files. Timesharing is accomplished by a memory partition system to minimize turnaround time between jobs.

RSX-11D

RSX-11D is a large, multi-user operating system for concurrent real-time applications execution, program development, and general data processing. Tasks to run in the priority scheduled event-driven multiprogramming system may be written in MACRO assembly language, FORTRAN IV, FORTRAN IV-PLUS or COBOL. The system features task accounting and reporting for system management, on-line device error logging and analysis for system maintenance, and batch stream processing for low-priority tasks.

RSX-11M

RSX-11M is the most flexible member of the RSX-11 family of real-time operating systems. It can be generated to run in a variety of hardware and application environments, from small, dedicated laboratory or industrial control systems to large, multi-user transaction processing and management systems. The system features event-driven priority scheduling for multiple real-time tasks. Tasks can be written in MACRO assembly language, FORTRAN IV, or FORTRAN IV-PLUS.

RSX-11S

RSX-11S is the smallest member of the RSX-11 family of real-time multiprogramming operating systems. It provides a dedicated, execute-only environment for monitoring and controlling many real-time processes concurrently. Program development and RSX-11S system generation takes place on a host RSX-11M system. This means that all of the RSX-11S system's resources are devoted to supervising real-time applications execution.

IAS

IAS is a general purpose operating system for the PDP-11/45, 11/55 and 11/70 computers. It provides the capability of simultaneous interactive, batch, and real-time program development and execution. In addition to being a flexible base for concurrent generalized applications (such as interactive batch), IAS can also support concurrent dedicated applications, by dedicating terminals to a specific function (e.g. editing or retrieval). This total system flexibility allows IAS to solve diverse problems in many different applications areas.

Facilities include:

- FORTRAN, BASIC, COBOL, and MACRO assembler
- A full set of system and user utilities
- Data management facilities for manipulation of records, files and volumes
- System management facilities
- Extensive user and system protection

High-Level Languages

High-level languages in turn allow you to move freely among operating systems. These languages span the breadth of the PDP-11 operating systems, and conform to the industry standards that exist. In some cases, two versions of a particular language are available on a single operating system, each optimized to meet a certain goal. Compatibility is assured by following industry standards, and by designing sets of a language that are compatible among operating systems.

BASIC

BASIC-11 is a high-level, easy-to-learn language compatible with Dartmouth standard BASIC. It is a conversational programming language which uses simple English words, abbreviations, and familiar mathematical symbols to perform operations. The BASIC instruction set contains powerful, yet easy-to-learn commands which allow novices to become accomplished applications programmers. With experience, the user can incorporate advanced techniques available in the language to perform intricate manipulations or express a problem efficiently and concisely.

DIGITAL has further extended and enhanced BASIC for the PDP-11 family. BASIC-11 is an immediate response, interactive language giving the user the capability to develop and debug a program in a minimum amount of time. It can be used for executing large data processing tasks as well as performing quick, one-time calculations.

BASIC-PLUS-2

BASIC-PLUS-2 is an optional compiler and object time system for RSTS/E, RSX-11M and IAS operating systems. It is upward compatible with BASIC-11 and BASIC-PLUS, and includes both new functions and enhanced performance.

COBOL

Cobol is an optional language processor for RSTS/E, RSX-11D and IAS. Included in the COBOL option package are:

- COBOL compiler and object time system
- Sort file sorting utility
- RFMT source reformatting utility
- COBRG report generating utility

PDP-11 COBOL provides terminal oriented, fast data processing for commercial applications. Source programs are written in the ANS-74 COBOL language, and are compiled into object format and executed in one operation. It is a fully implemented low-level compiler conforming in language element, representation, symbology and coding format to the ANS specification. In addition, it includes a number of high-level specifications. These include:

- Full Level 2 implementations of ACCEPT and DISPLAY
- INSPECT, STRING and UNSTRING verbs
- Sequential I/O modules
- Relative I/O modules
- A full Level 1 library function with partial Level 2 REPLACing facility.

FORTRAN IV

PDP-11 FORTRAN IV provides substantially improved performance for the entire PDP-11 family. New optimizations make programs small and fast, on any PDP-11 configuration. And the unmatched compilation speed of FORTRAN IV minimizes program development time.

PDP-11 FORTRAN is a superset of ANSI standard FORTRAN, allowing standard conforming programs written for other computer systems to run unmodified under FORTRAN IV. Powerful extensions included within PDP-11 FORTRAN IV permit markedly easier program coding. Some of the enhancements are:

- General expressions are permitted anywhere a variable or constant is called for by ANSI FORTRAN.
- Mixed mode arithmetic is supported everywhere and the use of a variable in an expression implies that the appropriate conversion will be done.
- Bit manipulation is provided by applying the LOGICAL operators to INTEGER quantities.
- End-of-file and error condition transfers allow program control of I/O and data format errors, as well as end-of-file conditions.

FORTRAN IV-PLUS

The FORTRAN IV-PLUS compiler and object time system is an optional language processing system for the RSX-11D, RSX-11M and IAS operating systems. The FORTRAN IV-PLUS language conforms to the specifications for the American National Standard FORTRAN X3.9-1966.

The FORTRAN IV-PLUS language is upward compatible with the PDP-11 FORTRAN IV language, and supports the same enhancements to the ANSI standard. In addition, FORTRAN IV-PLUS also includes the following extensions:

- Input/Output Statements
  - –OPEN and CLOSE—establishes connections with files
  - –Formatted direct access READ and WRITE
  - –List-directed input/outout
- Specification Statements
  - –INCLUDE—allows FORTRAN source text from a separate file to be included in a FORTRAN program
  - –PARAMETER—allows program variables to be defined in one statement
  - –ENTRY—permits multiple entry points in a program
- Subprogram Statements
  - –EXTERNAL name—permits function and subroutine names to be passed as arguments in a call.

The primary differences between the FORTRAN IV compiler and the FORTRAN IV-PLUS compiler are that the FORTRAN IV-PLUS compiler:

- produces highly optimized PDP-11 machine language code
- creates code which uses the Floating Point Processor option
- can produce shareable code

Application Packages

As a logical consequence of the operating system and processor independence of the high level languages, we have developed a series of application packages to provide functions which application users frequently need. Thus you may transport functions from processor to processor, from operating system to operating system.

Scientific Subroutine Package

The Scientific Subroutine Package is a collection of FORTRAN IV subroutines which provide the user with a large cross section of those mathematical and statistical routines commonly required in scientific programming. They are all I/O-free and are provided in source form. The source listings give a brief outline of the method used, as well as a bibliographical reference in the more complex routines.

Lab Application-11

The Lab Application-11 Library is an integrated set of program modules which perform standard signal processing functions, particularly those found in laboratories. Modules are available for operator console interaction, data acquisition, data editing, fast Fourier transformation, output printing, and displaying.

By selecting modules pertinent to a specific experiment or test, the user need not get involved with routines which service and implement the computer hardware, but can focus time and effort on the application requirements and algorithmic developments for his experiment or test.

COGO-11

COGO-11 is an easy to use, but powerful, programming system used to solve coordinate geometry problems. While there is virtually no limitation to the kinds of geometric problems that may be solved with COGO-11, typical applications center on land surveying, subdivision work, highway design and construction layout.

Graphics Support

For systems with a VT11 or VS60 Graphics Display Processor, both BASIC and FORTRAN provide a complete set of graphic routines, allowing the full utilization of the display processor's hardware features—such as vectors, alphanumerics, point, multi-intensities, and blinks. Additional commands perform tasks such as creating and tagging subpictures (graphic subroutines), and displaying figures and arrays.

The graphic extensions provide dynamic interaction with the system via functions for light-pen interaction, dynamic allocation/deallocation of display buffers, and saving and restoring display images as files on the system device. An optional plotting package for the LV11 electrostatic printer/plotter provides complete printing, plotting and shading capabilities independent of the display scope and also provides hard copy of the display image using only two commands.

The graphic extensions provide an uncomplicated, flexible, and complete interface between the user and the high-level language.

DMS-500

DMS-500 (Data Management Service is a series of software modules under the CTS-500/E (Commercial Time Sharing-Extended) of the DEC DATASYSTEMS 500 series. It provides general methods for organizing and processing logical data records, which may be stored in indexed random, indexed sequential and relative access file structures. Interactive utility routines define, allocate, and organize data in the file structures. Control of direct access device input/output, data buffering, and error handling is accomplished by selected software modules appended to user BASIC-PLUS programs. Application programs access stored data by identifying specific logical records to be added, retrieved, modified, or deleted from these file structures. System-level routines are used to control multiple, concurrently operating user programs which access the same data file structures.

SORT-11

SORT-11 is a utility which enables the user to reorder data from any input file into a new file, in a sequence based upon control or key fields with the input data records. It is supported by RSTS/E, RSX-11D, RSX-11M and IAS. The sort may accept as input a file from any input devices supported by the host operating system, and output the reordered file to any acceptable output device.

WISE

WISE is an integrated, easily expandable data base management system designed within an educational timesharing framework. WISE provides the means necessary to handle the data processing requirements of today's colleges and universities while also allowing simultaneous instructional timesharing.

POWER MANAGEMENT

DIGITAL's Power Management Systems combine proven industrial computer systems with the power management programs to provide a cost effective tool for reducing power demand and energy usage. All the programming is ready-to-use. Simplified messages and commands provide flexible system control without the need for a computer programmer or expensive operator training.

Communications Software

DECnet

Distributed processing. This extremely effective way to share resources requires equally effective software. DIGITAL has it. DECnet enables the user to build networks using serial asynchronous, serial synchronous, and parallel facilities. DECnet can be used as a component of distributed networks, hierarchical networks, and communications networks.

The basic goal in the design of DECnet is to create a general set of tools that facilitates:

- Device Sharing—the ability to control a device at a remote location as if it were local
- File Sharing—the ability to access remote files as if they were local
- Program Sharing—the ability to send loadable programs to another system for loading and execution
- Program Data Sharing—the ability to open a data path between programs on an interactive basis.

System features include:

- Route-Through—the ability to pass messages between systems that are not physically connected by a direct communications path.
- Independence from Line Characteristics—the ability to run on full or half duplex lines, serial or parallel lines.
- Down-Line System Loading—initial core images may be stored on the local system and loaded on request into other systems in the network.
- Down-Line Executive Directives—programs running on one system in the network may cause executive directives to be executed at remote systems in the network.

DECnet comes as an enhancement to the following DIGITAL operating systems:

Operating System	Processor
RTS-8	PDP-8
RT-11	PDP-11
RSX-11S	PDP-11
RSX-11M	PDP-11
RSX-11D	PDP-11
RSTS/E	PDP-11
IAS	PDP-11
XVM/DOS	PDP-15
XVM/RSX	PDP-15
TOPS-10	DECsystem-10

Different operating systems require differing amounts of memory space for DECnet software. This is because different systems have different subsets of DECnet. This is a more efficient and cost-effective use of DECnet since the smaller processors in real-time applications do not require all the capabilities needed by larger systems.

REMOTE

REMOTE/RT-11 is an RT-11 based system which uses DECnet compatible messages. It allows users having a minimum of 16K words (28K words for foreground/background) RT-11 system to communicate with a maximum of eight satellite PDP-11's. A satellite system has the facility to develop programs using RT-11 foreground/background (F/B) in the host system. In addition a satellite system can down-line load absolute programs.

Upon bootstrapping the satellite system, the user is automatically connected to the REMOTE editor. To begin editing, a standard RT-11 file specification is entered. There are several commands that allow the user to load programs through the serial line interface, execute programs, send messages, etc. The operator can use the background for any normal RT-11 operation if the host system is running the RT-11 foreground/background monitor.

2780 EMULATOR

The 2780 Emulator programs allow a DIGITAL operating system to emulate the features of an IBM Model 1 or 2 2780 data transmission terminal with the multiple record option. This permits communication between the PDP-11 and the following IBM remote job entry programs:

OS/HASP
OS/ASP
OS/RJE
DOS/POWER

In addition, the PDP-11 may communicate with a second PDP-11 with 2780 support. PDP-11 operating systems which have 2780 support are:

RT-11
RSTS/E
RSX-11D
RSX-11M

As with IBM 2780's, BISYNC (*Bi*nary *Sync*hronous Control) protocol is used for communication.

Hardware Options

Processors

PDP-11/03

The PDP-11/03 has been made possible through the use of Large Scale Integration (LSI) technology. Using LSI technology, DIGITAL has been able to create a chip set in the form and function of a standard PDP-11 yet small enough to be packaged along with 8K bytes of memory on a single circuit board. The PDP-11/03 includes the chassis, operator's console, processor, memory, backpanel with expansion space, power supply and interface modules.

The PDP-11/03 features full PDP-11 instruction set, vectored interrupts, an asynchronous, bidirectional bus, microcoded debugging facilities, operator interface and bootstrap loader, real-time clock input, and power-fail/auto restart.

PDP-11/04

The PDP-11/04 provides low-cost solutions to dedicated applications where the computer is being used to solve one or two problems by executing one or two programs. For example—data acquisition, converting analog signals to digital signals, analyzing pulse heights, storing accumulated data on magnetic tape. Memory sizes may be as small as 8K bytes for straight-forward applications, or as big as 56K bytes for more extensive programs, perhaps coded in a high level language such as FORTRAN IV or BASIC.

The unique feature of this computer is the flexibility it provides for the price. This means the full 11 family instruction set, the full choice of 11 family peripherals, and the choice of single-user or small real-time software.

PDP-11/34

The PDP-11/34 is a midrange member of the PDP-11 family. As a microprogrammed processor, the PDP-11/34 CPU is so compact that the entire CPU logic is contained on two circuit boards. This provides greater flexibility during later system expansion by making additional chassis space available.

A number of large system features incorporated into the PDP-11/34 processor as standard options increase its capabilities beyond those found in other computers in its class, and provide considerable flexibility in its use. These features include: integral memory management hardware that provides program protection, memory relocation and addressing of up to 256K bytes, and integral extended instruction set (EIS) that provides hardware fixed-point arithmetic in double-precision mode (32-bit operands).

PDP-11/45

The PDP-11/45 provides low-cost solutions to multiple-task applications where the computer must solve many similar problems or run multiple programs concurrently. For example—the automation of whole industrial processes, monitoring and controlling multiple operations in real-time while simultaneously preparing and printing production reports for management. Memory size may be as small as 16K bytes or as large as 256K bytes to accommodate several programs in memory simultaneously.

The unique feature of this computer is the processing power it offers for the price. This means the full capacity and speed of the 11 family high-performance peripherals, the full power of the timesharing and real-time operating systems, and an instruction cycle time as fast as 300 nanoseconds. Standard features include:

- Memory Management
- Floating point processor
- Solid-state memory
- Fast bus between solid-state memory and processor which is independent of the UNIBUS

PDP-11/55

Overlapped operations and high-speed components are responsible for the high performance of the 11/55. It takes full advantage of such advanced components as dual ported bipolar memory, a high-speed (5.43 microsecond double precision multiply) double precision floating point processor, and hardware memory management.

Overlapping occurs on several levels: instruction pipelining, wherein the fetch of the next program instruction is overlapped with the instruction currently in execution; CPU independent floating point calculation; and a dual bus structure which allows direct memory access without cycle stealing on the UNIBUS.

PDP-11/70

The PDP-11/70 is a multifunction computer offering a low-cost solution to applications which require real-time, timesharing, and batch processing applications to be run simultaneously. For example the 11/70 is ideally suited for a college computer center where it provides laboratory data acquisition, interactive student programming and administrative batch processing simultaneously. In its smaller configurations this computer is ideal for very demanding single-function applications such as timesharing or dedicated real-time applications.

The unique feature of this multifunction computer is the throughput it brings for the price. This means fast instruction processing, fast memory (an integral cache memory system brings effective memory cycle time down below 400 nano-seconds, while main memory is low-cost, non-volatile core), fast 32-bit data paths, and fast mass storage devices—all controlled by an efficient master operating system.

Peripherals

The processors are supported by an extraordinary range of peripherals:

from paper tape readers
to high speed disk packs

from small auxiliary printers
to full graphics subsystems

from a/d converters
to heavy duty industrial controllers

Below is a partial list of some of the available options. Complete details on these and other peripherals may be found in the peripheral feature sheets.

Disks

Disk offerings range from the RX11 floppy disk subsystem which provides 256K bytes of convenient on-line storage to RP06 disk pack subsystems featuring from 175.8M bytes to over 1406M bytes of on-line storage. The RK05 series subsystems afford a middle ground by providing data storage of 2.5M bytes per drive on-line using the convenient cartridge medium. For high-speed applications such as swapping, the RS03/04 series of fixed head disks is available.

Tapes

Tape systems range from perforated paper tape reader/punches and magnetic tape cassettes on the low end, to high performance 1600 bpi magnetic tape systems capable of backing up large disk data bases. Other offerings include DIGITAL's unique DECtape subsystem, featuring block addressable magnetic tape that acts as a random access disk system while affording a convenient storage medium on 5 inch reels. The tape spectrum also includes the TS03 and TU10 800 bpi magnetic tape subsystems.

Terminals

Terminal offerings feature the industry leading LA36 DECwriter II unit and the flexible VT50 DECscope series of alpha-numeric video displays. A range of optional features and capabilities are available with both the DECwriter II and DECscope families. A full line of graphics terminals include the inexpensive VT55 DECgraphics terminal, the VT11 graphics display processor and the high performance VS60 graphics subsystem.

Communications Interfaces

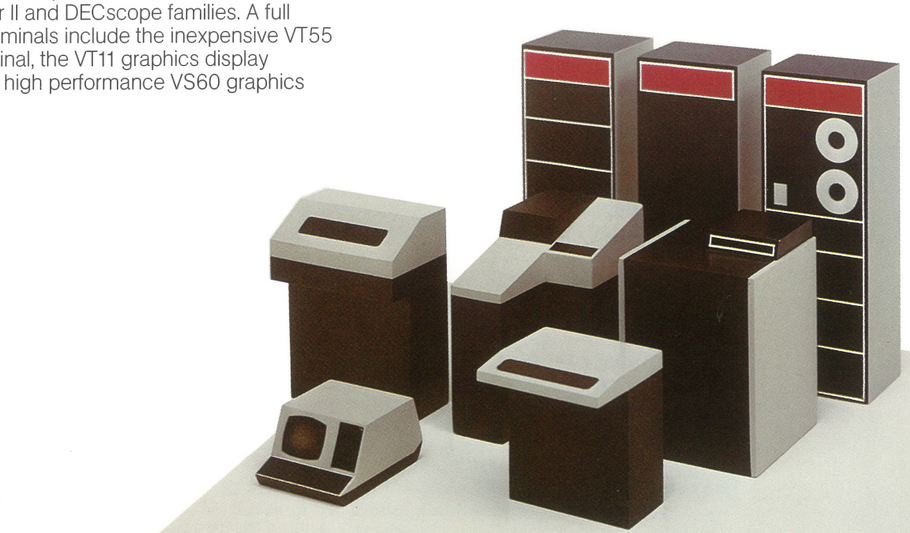
A full range of asynchronous and synchronous line interfaces is available. The range of asynchronous interfaces includes the DL11 single line interface, the DJ11 multiplexer with fixed characteristics, and the DH11 and DZ11 multiplexers with programmable characteristics. The range of synchronous interfaces includes the DU11 and DUP11 character interrupt single line interfaces, the DQ11 direct memory access single line interface, the DMC11 network link, and the DV11 direct memory access multiplexer. In addition to the complete set of synchronous and asynchronous line interfaces, there are a number of other interfaces permitting connection of PDP-11's to autocalling units, telegraph lines, or a non-DIGITAL computer.

Analog and Digital Interfaces

The range of interfaces for laboratory and industrial equipment includes the heavy duty ICS/ICR industrial control subsystem which are designed to interface both local and remote plant signal, actuators, and sensors to PDP-11s; the compact AR11 analog real-time system that accepts analog signals from laboratory systems and converts them to digital values; the high-performance, modular LPS11 which interfaces a wide variety of applications equipment to the PDP-11; and the ADK11 real-time analog data acquisition package.

Unit Record Equipment

Unit record equipment includes a number of card readers, line printers, and a printer/plotter. Card readers are available with speeds of 300, 1000, and 1200 cards per minute. Printers range from the LA180 DEC-printer I, an inexpensive 180 character per second matrix printer to the LP11 series of line printers rated from 230 to 1250 lines per minute. The LV11 electrostatic printer/plotter operates at 500 lines per minute in print mode and at 122,880 dots per second in plot mode.



OPERATING SYSTEM COMPARISON TABLE

TOPIC	CAPS-11	RT-11	RSTS/E	MUMPS	RSX-11D	RSX-11M	RSX-11S	IAS
SYSTEM TYPE	Single user; interactive program development	Single user, real-time application Foreground/Background–program development or batch job	General timesharing for up to 63 simultaneous BASIC-PLUS users	Data management Timesharing facilities for up to 40 simultaneous users	Large, multi-user, general purpose system for concurrent real-time applications, program development and general data processing	Compact, efficient real-time applications and development system	Execute-only real-time applications system; requires RSX-11M system for generation and program development	Concurrent interactive, batch and real-time processing system with multi-language support
CPU	PDP-11/04 PDP-11/34 PDP-11/45/55 (no memory management or parity support)	PDP-11/04 PDP-11/34 PDP-11-45/55 (no memory management or parity support)	PDP-11/45/55 with memory management PDP-11/70	PDP-11/04 PDP-11/34 PDP-11/45/55 PDP-11/70	PDP-11/34 PDP-11/45/55 with memory management PDP-11/70	PDP-11/04 PDP-11/34/45/55 PDP-11/70	LSI-11 PDP-11/03 PDP-11/04 PDP-11/34/45/55 PDP-11/70	PDP-11/45/55 with memory management PDP-11/70
TYPICAL SYSTEM DEVICES	TA11 dual cassettes	RK11 cartridge disk RPR02 disk pack RP03 disk pack RX11 floppy disk TC11 dual DECtapes RS03 fixed-head disk	RPR02 disk pack RP03 disk pack RP04 disk pack RK11 cartridge disk	RPR02 disk pack RP03 disk pack RP04 disk pack RK11 cartridge disk	RPR02 disk pack RP03 disk pack RP04 disk pack RK11 cartridge disk	RPR02 disk pack RP03 disk pack RP04 disk pack RK11 cartridge disk	None	RPR02 disk pack RP03 disk pack RP04 disk pack
TYPICAL LOAD DEVICES	TA11 dual cassettes	RK11 cartridge disk TC11 DECtape TA11 cassette RX11 floppy disk	TU10 magtape TU16 magtape TC11 DECtape	TU10 magtape TU16 magtape TC11 DECtape	TU10 magtape TU16 magtape	TU10 magtape TU16 magtape RX11 floppy disk	TA11 dual cassettes RK11 floppy disk TU10 magtape TU16 magtape TC11 dual DECtapes	TU10 magtape TU16 magtape
MINIMUM MEMORY (WORDS)	8K	8K Single job 12K Single job with Batch 16K Foreground/Background	32K parity memory BASIC-PLUS only 64K BASIC-PLUS, FORTRAN IV and COBOL	32K	48K for little or no program development 56K for simultaneous applications execution and program development	16K without concurrent program development 24K with concurrent program development and application execution	8K 16K for on-line task loading or execution of tasks written in FORTRAN	64K
MAXIMUM MEMORY SUPPORTED (WORDS)	28K	28K	1024K	124K	2048K	2048K	2048K	2048K
HIGH-LEVEL LANGUAGES	BASIC (opt)	FOCAL (opt) BASIC (opt) Multi-user BASIC (opt) FORTRAN IV (opt)	BASIC-PLUS (inc) FORTRAN IV (opt) COBOL (opt) BASIC-PLUS-2 (opt)	MUMPS (inc)	FORTRAN IV (inc) FORTRAN IV-PLUS (opt) COBOL (opt)	FORTRAN IV (inc) FORTRAN IV-PLUS (opt)	None	FORTRAN IV (opt) FORTRAN IV-PLUS (opt) COBOL (opt) BASIC (opt)

PROCESSOR COMPARISON TABLE

	PDP-11/03	PDP-11/04	PDP-11/34	PDP-11/45	PDP-11/55	PDP-11/70
STACK PROCESSING	YES	YES	YES	YES	YES	YES
GENERAL REGISTERS	8	8	8	16	16	16
HARDWARE FLOATING POINT	YES (opt)	NO	NO	32, 64-bit (opt)	32, 64-bit (opt)	32, 64-bit (opt)
MAX MEMORY SIZE (BYTES)	56K	56K	248K	248K	248K	4M
MEMORY PARITY	NO	OPT	YES	YES	YES	YES
MEMORY MANAGEMENT	NO	NO	YES	YES	YES	YES
PROCESSING MODES	1	1	3	3	3	3
AUTO HARDWARE INTERRUPTS	YES	YES	YES	YES	YES	YES
AUTO SOFTWARE INTERRUPTS	NO	NO	NO	YES	YES	YES
POWER FAIL/AUTO RESTART	YES	YES	YES	YES	YES	YES
REAL-TIME CLOCK	YES	OPT	OPT	YES	YES	YES

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