Digital Equipment DECSYSTEM-20

MANAGEMENT SUMMARY

In its fifth year of production and with over 320 installations in the U.S., the DECSYSTEM-20 family of computers combines traditional DEC interactive time-sharing experience with batch and distributed processing technologies.

The three models, the 2020, 2040, and 2060, are built around two different processors: the KS10 for the 2020, and the KL10 for the 2040 and 2060. All three models operate under the same operating system, TOPS-20, and use a wide variety of high-level languages. The model 2020 can also operate under a modified version of the TOPS-10 operating system and related software. TOPS-20 is a virtual memory operating system that will support various operations, such as concurrent multi-language interactive time-sharing and multi-stream batch processing. It has an easy-to-learn, easy-to-use command language. All three models are sold as packaged systems.

DEC has designed the low-end 2020 to reduce facilities requirements. It uses standard 110 volt current and draws only about 1400 watts of power, making it ideal for an office. Its compact size (the CPU needs only 3' x 3' of floor space) eliminates the need for a separate computer room.

Compatibility of programming languages and operating systems, as well as system packaging, makes it easy to upgrade to a larger system. Programs written on a 2020 can run on a 2060, and applications written on the larger machine can run on the smaller one, provided there are sufficient resources available on the 2020, such as memory and I/O capability. ▷

In Datapro's 1980 Annual Survey of Computer Users, DEC ranked third in overall satisfaction among users with mainframe computer systems. The versatile DECSYSTEM-20 series has three models; the low-end 2020, mid-range 2040, and the high-end 2060, with performance ranging from an IBM 370/125 to an IBM 3031. The systems have been designed for interactive time-sharing, batch, and distributed processing.

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation, Large Computer Group, 200 Forest Street, Marlborough, Massachusetts 01752. Telephone (617) 481-9511.

DEC is a worldwide corporation and the world's largest manufacturer of minicomputer systems. In addition to its involvement in the production of interactive timesharing and medium- to large-scale computer systems, the firm also manufactures peripherals, software, logic modules, and microcomputers. DEC employs about 50,000 persons and maintains sales and service offices in all major U.S. cities as well as major cities throughout Canada and the Western world.

MODELS: DECSYSTEM-20 Model 2020, 2040, and 2060.

DATE ANNOUNCED: See table.

DATE OF FIRST DELIVERY: See table.

NUMBER INSTALLED TO DATE: See table. ►

The low-end DECSYSTEM-20 Model 2020 is in the price/performance range of an IBM 370/125. It is a powerful, yet compact, system that operates in interactive time-sharing, batch, and distributed processing environments.

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▷ While the DECSYSTEM-20 and its predecessor, the DECsystem-10 (Report 70C-384-01), are functionally similar, the DECSYSTEM-20 is targeted for in-house time-sharing, batch, and distributed processing applications. The DECsystem-10 is generally used in large-scale commercial, educational, and scientific time-sharing operations.

A key feature of the DECSYSTEM-20 is packaging. Components such as the CPU, memory, and up to eight mass storage controllers (in the 2040 and 2060) are housed in the same cabinet. Peripheral subsystems are designed to support in-house time-sharing and batch processing.

The minimum DECSYSTEM-20 for any model configuration includes 256K words (36 bits) of memory, a single or dual ported disk drive, a tape drive, 16 asynchronous communications lines, and an I/O console. Maximum configurations include up to 3072K words of memory, 56 disk drives, a card reader, a card punch, 2 printers, 16 magnetic tape drives, and up to 128 asynchronous communications lines.

The DECSYSTEM-20 models 2040 and 2060 can be expanded up to 12 megabytes (3072K words) of main memory. The first 6 megabytes (1536K words) are housed in the CPU cabinet. An external cabinet holds the additional 6 megabytes on two backplanes. The additional 6 megabytes requires the use of the TOPS-20 Version 4.0 operating system.

An important feature of the DECSYSTEM-20 family (the 2020 and 2060) is a cache memory. It consists of 512 blocks of four words each (one block on the 2020). Access time is 160 nanoseconds. DEC estimates that about 90 percent of all memory requests will reference information already in the cache, resulting in effective memory cycle times of around 221.4 nanoseconds.

The PDP-11 front-end processor controls all low-speed peripherals and communications lines, and provides extensive diagnostic facilities to the DECSYSTEM-20. It is used only on the 2040 and 2060. The PDP-11 constantly monitors the data paths and control lines of the KL10 CPU. The DECSYSTEM-20 includes a special diagnostic bus that permits various testing routines. There is also a dedicated asynchronous line which can be connected, through a modem, to a remote service center for DEC diagnostic services.

The 2020 does not feature a front-end processor. All peripherals except the console are attached via a Unibus/Unibus adapter combination. Mass storage interfaces to the Unibus via an RH11-C Massbus Adapter.

The DECSYSTEM-20 also features memory mapping to extend the addressing range of the CPU beyond the 256K-word limitation. The mapping system increases the addressing range to 4096K words of physical memory.

Physical memory is divided into 512-word pages. A 512-entry page address map is contained in CPU hard- ▷

▶ **DATA FORMAT**

BASIC UNIT: 36-bit word. In core storage, each word location includes one additional parity bit. The processor handles halfwords, but parity bits are not associated with halfword data representation. Variable-length bytes from 1 to 36 bits in length are also handled.

FIXED-POINT OPERANDS: Either 36-bit words or 18-bit halfwords for add and subtract instructions. The multiply instruction produces a double-word product, and the divide instruction uses a double-word dividend. There are also integer multiply and divide instructions which involve only single words. All arithmetic operations are performed in binary mode.

FLOATING-POINT OPERANDS: Standard floating-point hardware is included in the KL10 processor. Single-precision floating-point uses one word, consisting of a 27-bit plus-sign fraction and an 8-bit exponent. Double-precision operands have 62-bit fractions and 8-bit exponents, including a sign. The first 36-bit word of a double-precision floating-point operand consists of the 18-bit exponent-and-sign and the most significant 27-bits of the fraction. The second word contains a sign bit and the 35 least significant bits of the fraction.

INSTRUCTIONS: For all but I/O, each instruction consists of one word with a 9-bit operation code, a 4-bit accumulator or flag address, and 23 bits for development of the effective address. The effective address field uses one bit to specify the type of addressing, 4 bits as an index register designator, and 18 bits to reference a memory location. In I/O instructions, the first 3 bits identify the instruction as I/O, and the next 7 bits address an I/O device, with 2 more bits as an operation code. The next 23 bits are used to develop an effective address just as in the non-I/O instructions described above.

INTERNAL CODE: Seven-bit ASCII. Each 36-bit word is used to represent five 7-bit bytes, with one unused bit per word. Bytes from 1 to 36 bits in length can also be recognized and manipulated.

MAIN STORAGE

STORAGE TYPE: See table.

CAPACITY: See table.

CYCLE TIME: See table.

CHECKING: Parity bit with each 36-bit word is generated with writing and checked with reading in all systems except 2020. Error correcting memory, which detects and corrects all single bit errors and detects all double bit errors, is employed in the 2020. Error correcting memory uses a Hamming code and special algorithm as the method of detecting bit errors.

RESERVED STORAGE: Two 512-word pages are reserved by the TOPS-20 software for the Executive Process Table (EPT) and the User Process Table (UPT). The EPT includes channel status information and is used for communications between the KL10 CPU and the front-end PDP-11 mini-computer (2040 and 2060). The UPT includes an arithmetic overflow vector address and contains the output from memory and instruction processor clocks. For the overflow vectors, only the user incurring the overflow is affected, leaving the system unaffected.

STORAGE PROTECTION: The KL10 CPU includes storage protection as a standard feature. A paging system reserves up to 256K 36-bit words of memory in as many as 512 pages of 512 words each. The individual pages need not ▶

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CHARACTERISTICS OF DECSYSTEM-20 FAMILY

	2020	2040	2060
SYSTEM			
Number installed to date (estimates, U.S. only)	125	80	30
Date of announcement	Feb. 1978	Jan. 1976	Feb. 1978
Date of first delivery	July 1978	July 1978	July 1979
Maximum On-line disk storage, megawords	316.8	633.6	2217.6
Maximum communications lines:			
Asynchronous	32	128	128
Synchronous	2	8	8
2780/3780	2	4	4
DECnet	1	1	1
Maximum card readers	1	1	1
Maximum card punches	0	1	1
Maximum paper tape units	0	1	1
Maximum printers	1	2	2
Maximum magnetic tape drives	4	16	16
CPU	KS10-A	KL10-E	KL10-E
Number of instructions	386	386	386
System capacity, no. of users	32	64	128
Concurrent jobs	25	36	120
Relative CPU performance	1.0	2.0	6.0
MEMORY			
Minimum capacity, 36-bit words	256K	256K	256K
Maximum capacity, 36-bit words	512K	3072K	3072K
Increment size, 36-bit words	64K	256K	256K
Memory control unit ports	1	1	1
Words accessed per cycle	1	4	4
Memory type	MOS	MOS	MOS
Memory cycle time, microseconds	1.05	1.05	1.05
Read access time	0.467	0.467	0.467
Read cycle time, 1 word; microsec	0.667	0.667	0.667
Read cycle time, 4 words; microsec	NA	1.267	1.267
Memory interleaving (software selectable)	—	4-way	4-way
Cache memory, words	512	—	2048
Access time, microseconds	0.160	—	0.125
I/O CONTROL			
Type of controllers	Integrated	Integrated	Integrated
Maximum DMA transfer rate, 36-bit words	16 million/sec.	16 million/sec.	16 million/sec.
Max. I/O transfer rate, 36-bit words	500,000/sec.	500,000/sec.	500,000/sec.
Maximum number of controllers	3	5	10
Buffering	16 words	16 words	16 words

▷ ware. Eighteen-bit effective addresses are translated into 22-bit physical addresses by appending a 13-bit entry from the page table to the low-order nine bits of the effective address. The page entry also includes a 3-bit protection code that indicates what type of accesses can be made to this page (no entry, read-only, read-write, written, etc.). Two page tables exist, one for user mode and one for executive mode.

Software is included in all DECSYSTEM-20 packages, as well as on-site consulting for application software development. Included in the system software package is the TOPS-20 or TOPS-10 (Model 2020 only) operating system, the GALAXY batch processing system, the macro assembler, the linking loader, the editor, and other utilities. Programming languages and the SORT-20 utility are separately priced at charges ranging from $3,450 for the SORT package to $34,500 for the DBMS data base management system.

TOPS-20 is a multi-user, multi-mode, virtual memory operating system that supports multi-language interactive processing plus multi-stream batch processing. Multiple batch jobs can be run concurrently with inter- ▷

▶ be located in contiguous memory locations, thus eliminating the need to shuffle program segments in memory to counteract checkerboarding. The paging registers effectively permit addressing of 4 million words of memory through use of special hardware. Three bits are used to denote the type of access possible for each page, such as read/write, read-only, proprietary, or denial of access.

CENTRAL PROCESSORS

There are three processors employed in the DECSYSTEM-20. The 2040 and 2060 use the KL10 CPU and a PDP-11/40 front-end processor, which provides control for all low-speed peripherals and system initialization.

The third CPU, the KS10 central processor, is used exclusively with the 2020 system.

System initialization on the 2040 and 2060 is accomplished through a dual-access disk drive that contains the system microcode. When the system starts, the PDP-11 performs a brief system checkout, after which it configures memory and loads the microcode into the KL10. The system software is then loaded into the DECSYSTEM-20 main memory and normal operation begins.

The front-end processor also controls all communications lines to user terminals, including the operator console, which is treated as any other user terminal. In addition to the initializing functions and low-speed peripheral control, the ▶

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▷ active processing, due to the use of the same command language for both time-sharing and batch operations.

Since the same command language is used for both types of processing, batch jobs appear as time-sharing jobs and can be run by the same monitor. The GALAXY batch processing software runs as a job under TOPS-20.

The latest version of TOPS-20 is Version 4.0. It permits main memory to expand to 3072K words, and includes PDP-11-based remote job entry, HASP multi-leaving and dynamic recognition of tape or disk drives associated with the system. It also features a command interface that incorporates scheduler controls, a program called Watch that prints out system performance statistics, and four error logging routines. It was delivered to customers beginning in May, 1980.

The programming languages supported by TOPS-20 include IBM-compatible COBOL and APL, BASIC, ALGOL, FORTRAN, PL/1, and CODASYL-compatible data base management system, and an interactive query language. All language processors are shareable and re-entrant under TOPS-20. All compilers are compatible under batch and time-sharing.

Between the DECsystem-10 and DECSYSTEM-20 lines, DEC's Large Computer Group offers a range of computational capability that is comparable to that of the IBM System/370, 4300, and 303X product lines. The 2020 also competes with the IBM System/38, Honeywell Level 62, and the Univac 90/30.

One key reason why the DECsystem models are so much less expensive than functionally comparable IBM systems is that DEC competes only in systems environments which favor the DECsystems' particular strengths. Those strengths are largely derived from the DEC operating systems ability to function in a "multi-mode" environment, including on-line, local, and remote batch processing, plus computer network requirements. In order for IBM, as an example, to satisfy these requirements, a full-scale OS or OS/VS system with the Time-Sharing Option (TSO) and a host of other ancillary software support products is needed. Even where part of the DEC software is now separately priced, the difference in the cost of the required hardware (main and auxiliary storage plus high-performance processor) usually leads to a sizable overall advantage for DEC. DEC's marketing efforts for mainframes in the 80's should continue to concentrate on in-house time-sharing applications, with greater attention to batch and distributed processing.

They won't, however, be calling on the typical batch-oriented computer user whose processing requirements are concentrated on conventional business applications. Instead, Digital's DECSYSTEM-20 market target includes "the top manufacturing and service companies" where the system can complement the processing capabilities of an already existing large computer installation. ▷

▶ front-end processor is interfaced to all KL10 control and data lines and constantly monitors these. In the event of failures, the PDP-11 reports the problem through the console terminal, and allows module-level diagnosis. The front-end processor is connected to the KL10 by the DTE-20 interface. The front-end processor then directly accesses the KL10 internal structure concurrently with normal processing activities. Through the DTE-20 interface, maintenance personnel may interrupt, examine and deposit data in registers, change data in main memory or registers, or transfer data during time-sharing operations.

On the 2020, system initialization is accomplished through the console. In addition the operator can perform microcode load and check, perform memory modification and examination, start and stop the CPU clock, single step the CPU clock, execute a given instruction and start the machine at a given location.

In addition to system initiation, the KS10 differs from the KL10 in that the KS10 employs a microprocessor-based simulator of the larger 36-bit KL10 processor. The KS10 processor is built from AMD 2901 bit-slice microprocessors and is implemented on four printed circuit boards. In comparison, the KL10 processor requires 52 printed circuit boards.

The KS10 processor, because it is a simulator, is slower than the KL10 processor, giving the DECSYSTEM-2020 about one-half the internal performance of the DECSYSTEM-2040. The KS10 also includes a smaller cache memory than the KL10 (512 words compared to 2048 words), and the cache replacement algorithm implemented in the KS10 is not as sophisticated as the one implemented in the KL10 processor.

The actual processor employed in the 2040 is the KL10-E. The 2060 employs the KL10-EE, a slightly modified KL10-E, designed to handle MOS memory.

CONTROL STORAGE: See table.

REGISTERS: The KL10 and the KS10 processors have 128 integrated-circuit general-purpose registers, contained in 8 blocks of 16 registers each, that can be used as accumulators, index registers, or for other high-speed memory functions. Register blocks are assigned to the operating system and to individual user programs to provide for rapid context switching.

In addition, the KL10 has five clock registers that are used for accounting and performance evaluation. These include the interval timer, the time base, the performance analysis counter, and two accounting meters. The interval timer is a programmable interrupt source with an interval range from 10 microseconds to 4096 milliseconds; the time base is a one-microsecond-based time-of-day clock used by the monitor for system accounting; the performance analysis counter monitors either the duration or rate of occurrence of designated hardware conditions; the two accounting meters are the instruction processor meter, which measures the amount of instruction processor time used, and the memory reference meter, which measures user-program accesses to memory.

ADDRESSING: Programs are capable of directly addressing 256K words through the 18-bit address field in each instruction. These addresses can be indexed through any of 16 accumulators in each register set. Multi-level indirect addressing can be combined with indexing (pre-indexing).

INSTRUCTION REPERTOIRE: The KL10 and the KS10 CPUs have 386 standard instructions, all of which are one word in length. The instruction set can be summarized by category as follows:

Boolean	64
Byte manipulation	5
Fixed-point arithmetic	24 ▶

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> Many potential DEC customers, particularly in DEC's targeted market, are used to purchasing or leasing their systems. And DEC customers, as indicated in the 1980 survey of computer users, prefer to purchase their systems by almost 4 to 1. DEC arranges both full-payout leases and monthly rental agreements, with the terms and prices quoted on an individual basis.

DEC's fundamental approach to the marketplace for the DECsystems is to avoid head-on encounters with IBM except upon DEC's terms. These terms specify a sophisticated user (generally in the top 20 to 30 percent of current computer installations) and one who generally meets the criteria outlined earlier. (For example, general-purpose commercial batch-oriented installations are definitely not sought after, if not actually discouraged.) Furthermore, DEC has historically been conservative in accepting business that is predicated upon heavy systems responsibility. This approach has resulted in a very high level of customer loyalty and has contributed to steady if not rapid growth for DEC's large-scale systems business. In this regard, DEC's current business plan remains essentially unchanged from previous years, and the company's realistic approach seems likely to yield continued market acceptance of the DECSYSTEM-20 at a pace satisfactory to DEC.

USER REACTION

In Datapro's recent survey of computer users, 38 firms responded on their DECSYSTEM-20 mainframes. Included in the survey were twelve 2020's, seven 2040's, ten 2050's, seven 2060's, and one unspecified DECSYSTEM-20 model. One firm had both a 2020 and a 2050. We also interviewed several firms around the country by telephone for their comments.

Memory ranged from a low of 128K words on a 2040 all the way to 2 megabytes on a 2050, with the average system having either 256K or 512K words. From the telephone interviews a number of users have migrated from an outside time-sharing source to their DECsystem, especially when the outside source also used a DECsystem. Average time of installation was about 2 years, with the oldest system installed June 1975 and the most recent in January 1980. Disk storage capacity ranged from 124 megabytes to 1 billion bytes. Once again, as in previous surveys, users were widely split on the prime programming language, with COBOL and FORTRAN the most widely used, followed by APL and BASIC. The number of interactive terminals varied from 0 to 100 terminals.

As a rule, most applications programs are developed by users and include accounts payable, accounts receivable, general ledger, payroll, personnel, inventory control, report generation, educational instruction, engineering and scientific problem solving, and service bureaus.

User ratings are tabulated in the table below:

> Floating-point arithmetic	44
Full-word data transmission	18
Half-word data transmission	18
Input/output	8
Program control	9
Stack	4
Shift and rotate	6
Arithmetic testing	66
Logical testing and modification	64

All instructions are capable of directly addressing a full 256K of memory without resorting to base registers, displacement addressing, or indirect addressing. Instructions may, however, use indirect addressing and indexing to any level. Immediate mode addressing is provided where the result of the effective address calculation is used directly as an operand.

In addition, the Business Instruction Set includes four double-precision, fixed-point operations and a string instruction that can be used for nine separate functions including editing, decimal to binary conversion, binary to decimal conversion, character detection, string move and string compare in both offset and translated mode. The Business Instruction Set affords faster processing because there are specific instructions for performing comprehensive string operations. Internal codes such as ASCII and EBCDIC can carry these instructions.

INSTRUCTION TIMING: In the tables below, all timings are in microseconds and are for the executive mode, using direct addressing without indexing and assuming no effects for multiprogramming, such as segment relocation, etc.

Fixed and Floating Point for 2040 and 2060

Fixed-point add/subtract (36 bits)	0.52
Fixed-point multiply	2.4
Floating-point add/subtract (single precision)	1.8
Floating-point add/subtract (double precision)	2.2
Floating-point multiply/divide (double precision)	4.8/10.2
Jump	0.5

Fixed and floating point instruction times on the 2020 are not available.

CACHE: The 2020 and 2060 systems include a fast-access MOS cache memory with a 160-nanosecond access time. The 2040 does not have a cache memory. The cache is 2,048 words on the 2060 and 512 words on the 2020. On the 2060, CACHE actually consists of four caches, each with a capacity of 512 words (or one page) that operate in parallel. Each cache is a two-dimensional array consisting of 128 horizontal lines and 4 vertical columns containing one word of data each. In addition, the cache addresses a list of physical page addresses calculated by the memory-mapping hardware that correspond to the four columns of program data. For each processor fetch operation, a simultaneous search is performed of all four cache pages to determine whether the data is present in the cache. If not, the referenced data must be retrieved from main memory. Data is loaded into the cache from main memory four words at a time, thereby providing an instruction look-ahead feature.

PAGING: The KL10 and KS10 processors provide a mapping capability from physical memory addresses of up to 4 million words (which require 22 bits for representation) to shorter effective addresses contained in 18 bits. The most significant half of the 18-bit effective address is used as an index to a page table which contains up to 4096 physical page numbers. The referenced physical page number is concatenated with the low-order 9 bits of the effective address (which indicates one of the 512 words on a page) >

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	Excellent	Good	Fair	Poor	WA*
Ease of operation	30	7	1	0	3.8
Reliability of mainframe	19	14	2	3	3.3
Reliability of peripherals	6	24	6	2	2.9
Responsiveness of maintenance service	7	14	5	1	2.2
Effectiveness of maintenance service	10	16	8	3	2.9
Technical support	8	17	8	4	2.8
Operating system	24	12	2	0	3.6
Compilers and assemblers	12	24	2	0	3.3
Ease of programming	24	12	2	0	3.6
Ease of conversion	10	19	5	1	3.1
Overall satisfaction	16	18	3	1	3.3

*Weighted Average on a scale of 4.0 for Excellent.

The first DECSYSTEM-20 user we interviewed was a mid-western insurance company using a 2060 for financial and insurance applications. When the 2020 was upgraded from a 2020 to the present 2060 the DP manager was very pleased with the transition. There were only 2 hours downtime during the conversion. DEC's field support was particularly helpful and the transfer of software into the 2060 was successful. The new system generally exhibits 99+% up time. Even though the company has occasional problems with the system's tape drives and has difficulty locating applications software, they are very pleased with the system. Two interesting applications of the system are the use of terminals by the field salemen for remote inquiry into the data base for rates and other sales-related information, and the use of a terminal at home by the company's chief actuary. In both cases, the users simply dial up the computer, and upon receiving confirmation, insert the receiver into a coupler with the terminal, and proceed.

A northeastern engineering and consulting firm uses its 2050 primarily for traditional payroll and financial applications, but also uses it for project management, so that project costs are correctly billed. The other major application is for scientific and engineering work using the system's interactive capabilities. An important point was the 2050's ease of use by non-computer oriented people. In general, the system has performed very well, with few problems. The firm is presently using the latest version of the TOPS-20 operating system. They are experiencing some minor problems with remote terminals, but are confident in DEC's ability to resolve the difficulty. Other problems have been relatively minor, and the firm commented on the very good service they have received from DEC over the years.

A large mid-western auto manufacturer went from a time-sharing situation using DECsystem-10's to its own model 2060, with another 2060 due to arrive soon. The firm also uses a number of large IBM systems at other corporate locations. The 2060 is used for a variety of corporate-level functions. With the exception of some minor disk drive and memory problems, the system is "very solid," and the response time for repairs typically is within 2 hours. The system has presented "no surprises" and was delivered as proposed.

to produce a 22-bit main memory address that can reference any of the 4 million words.

PROCESSOR MODES: The KL10 and KS10 processors have two modes: User Mode and Executive Mode. The Monitor operates in the Executive Mode, in which addresses are not relocated and all memory locations are accessible. User programs execute in the User Mode, and are relocatable and subject to memory protection restrictions. The Exec Mode is further divided into the Supervisor Submode and the Kernel Submode. Kernel Submode is used for the most frequently preformed segments of the TOPS-20 Monitor, which handle system I/O and any functions which affect all users of the system. The rest of the Monitor executes in the Supervisor Submode and performs general management of the system and functions which affect only one user at a time. All instructions are permitted for use in the Exec Mode.

User Mode permits the execution of all instructions except those which would cause interference with other users or the integrity of the TOPS-20 Monitor. User Mode is subdivided into the Public Submode and the Concealed Submode. Concealed Submode protects any program in that category from being copied or modified, even by the program itself, and is normally used for proprietary software. Concealed Submode programs can read, write, execute, and transfer to any Public location, while Public programs can access addresses in Concealed programs only by transferring to locations which have ENTRY instructions. In User Mode, a program can access up to 256K words.

INTERRUPT STRUCTURE: The KL10 and KS10 have seven standard prioritized channels associated with the I/O bus that transfers interrupt signals between system devices and the I/O Bus. The KL10 has an additional priority level (0) of higher priority than the seven programmable levels. This interrupt level is reserved for the front end processor. Twenty-one additional channels can be added for a maximum of 28. Assignment of the channels to specific devices is under user program control, and may be altered during processing. The processor itself is treated as a device, and internal overflow or priority checks can cause signals to be sent to the user program. Any number of devices can be connected to a single channel, and some devices may use two channels to transfer interrupts indentifying different conditions, such as device ready for data transmission or error condition encountered.

In addition to the seven-level interrupts, up to 135 Programmed Trap Instructions are available. The trap instructions can be executed in the same address space as the instructions which caused the trap. This allows user programs to handle their own interrupts by directing the monitor to place a jump to a user routine in the trap location. Up to 40 programmed traps may be specified which execute in the executive area.

INPUT/OUTPUT CONTROL

I/O CHANNELS: The DECSYSTEM-20 uses integrated channel controllers for tape and disk drives. These connect to the internal channel bus and operate either synchronously or asynchronously. Each controller has a 16-word buffer for input operations. The channel bus is a physically short, high-speed data path between the memory control unit and the integrated controllers. It has a peak I/O bandwidth of 6 million 36-bit words per second, and operates synchronously in a time-division multiplexing mode, permitting multiple concurrent memory accesses by the mass storage controllers.

The basic DECSYSTEM-20 is provided with integrated controllers, capable of handling either disk or magnetic tape. Depending on the model, up to eight disk or tape drives can

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▷ A western state government office has had a somewhat more unpleasant experience with a DECSYSTEM-20. Ever since their 2050 was installed in the mid-70's it has been plagued with problems, and typically goes down 2 to 3 times a day. The 2050 installed was an early model, and even with the initiation of audit teams and special trouble reporting procedures the 2050's performance has been "unstable."

According to the spokesman, the situation is now "in DEC's hands." Curiously enough, this user also has a DECsystem-10 and several DEC 1100 series systems, all of which have performed very well, compared to the 2050.

Heading back toward the Midwest, we called on a firm that operates motion picture theatres in 26 different states. Their 2020 is used for typical financial and payroll applications, and they also use it to compute individual theatre compensation based on receipts from the shows. The company's staff has developed an interesting software package, using FORTRAN, that assists them in the design of theatre buildings; all the way from seating arrangements to the design of the lens used in the projector. Prior to the 2020, the firm used a service bureau with CRAY and Control Data Corporation systems. They are investigating the acquisition of a PDP-11/04 in the near future to facilitate individual theatre usage of their data base. The firm is very impressed with the 2020, as it has been down only twice in the last ten months. Comments like "fabulous software capabilities for the price," and "runs circles around the (IBM) 4331," were typical of this user's enthusiasm. The firm is considering the latest upgrade to the TOPS-20 software, version 4.0, but is waiting until it has had more field use.

The subject of our last interview was a large time-sharing firm in the northeast that uses both a 2020 and a 2050, and is very pleased with both systems. Before installing their own systems, the firm worked through another time-sharing company using DECsystem-10's. The new systems are much easier to use than the DECsystem-10's, and their reliability is an important factor to the company. Their 2020 is used for internal financial and general management operations, while the 2050 supports their customer base. There are no plans to upgrade the 2020, but the 2050 will soon be expanded in memory.

The DECSYSTEM-20 series continues to be a successful product offering from DEC, as both the survey and user comments indicate. We were pleased with the response from the users we called. They generally feel very good about their systems, and, in most cases, would recommend them to others. It appears, though, that DEC's maintenance and technical support needs a shot in the arm, something we've noted in previous reports, and we encourage DEC to investigate this further.□

▶ be connected to a disk controller. Four TU45 tape drives can be connected to a tape controller. In turn, two tape controllers can be connected to a tape channel, thereby placing up to eight tape drives on a single channel.

Only high-speed mass storage devices are connected to the internal channel bus. On the 2040 and 2060, all low-speed devices interface through the PDP-11 front-end processor that is incorporated in the system. On the 2020, all devices are interfaced through a Unibus/Unibus adapter except the I/O console. Lowspeed devices offered with the DECSYSTEM-20 include line printers, a card reader, and communications lines. A card punch and paper tape reader/punch are also offered and are connected through a separate I/O interface.

SIMULTANEOUS OPERATIONS: Each of the integrated controllers is capable of transferring data to or from memory through direct memory access. DECSYSTEM-20 main memory is single-ported, but the 2040 and 2060 memory control units can queue four words transferred sequentially over the bus from the M-box and write these four words in MOS storage simultaneously. In a read cycle four words are read from MOS storage simultaneously and are queued for sequential bus transmission to the M-box. The 2020 memory writes or reads only one word in MOS storage per cycle.

CONFIGURATION RULES

2020: Devices integral to the processor cabinet in addition to the KS10-A processor include up to 512K words of MS10 memory (64K, 128K, or 256K words are optional), the console subsystem and two Unibus adapters. The first RM03 or RP06 disk drive is bundled in the system package. RM03s and RP06s may be mixed on the same system. Maximum configuration is 8 disk drives per system. Disk drives are attached to the 2020 via the RH11-C Massbus Adapter, which connects to one of the two Unibus/Unibus adapters.

A TAU45-EC (ED) Master Tape Drive must be ordered with each package system as field service contracts require one tape drive. Maximum configuration is 4 tape drives per system. The LP20A/B and LP20C/D are the only line printers supported on the 2020 at this time. DEC Field Service contracts require a hard copy printer device. Maximum configuration is one line printer per system. The DNHXX-AA/AB Expansion Cabinet is required and used only for the card reader controller. Maximum configuration is one card reader per system. The first 16 asynchronous EIA communication lines are bundled in the system package. Maximum configuration is 32 asynchronous lines per system. The additional 16 lines are provided by DZ11-AA (8 lines) and DZ11-BA (8 lines). Up to two synchronous lines may be attached through DN20-BA (one line) and DN20-BB (one line). Synchronous lines operate under TOPS-20 only, and require DECnet-20 software package QDT20-AM. The magnetic tape subsystem, printer, communications lines, and punched card equipment are all attached through the second Unibus/Unibus adapter.

2040 and 2060: With the exception of the KL-10-E processor in the 2040 and the KL-10-EE in the 2060, both systems share similar components: 1) up to 3072K words of memory, 2) a PDP-11 front-end processor, 3) synchronous front ends, 4) eight peripheral massbuses (includes one tape and one disk drive interface standard, an option for either one tape or disk drive interface, and an option for five additional disk drive interfaces), and 5) one I/O interface. A cache memory is provided in the 2060 only.

Both the TU45 and TU77 tape systems can be connected to the 2040 and 2060. Each TU45A and TU77 tape controller can have a maximum of four TU45A-EH/EJ and TU77-AF/AJ tape drives, respectively. These systems may be varied in configuration but must not exceed four tape drives per channel. On a second channel up to eight TU72 tape drives can be connected to a TX02 tape controller.

When using the new high-capacity RP20 disk drives: 1) only one RTP20 controller/drive per RH20 channel can be connected, 2) the RTP20 controller cannot share the RH20 ▶

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channel with any other device, 3) as many as six RTP20 controllers can be connected to a KL10 CPU, 4) the remaining two RH20 channels on a KL10 must be used for an RP06 disk drive and any tape drive, and 5) the RP20 drive cannot be used as a front-end device, hence the need for at least one RP06 drive.

Up to two line printers and either one card reader or paper tape reader/punch can be connected. The I/O console and all asynchronous lines are attached through the PDP-11 front-end processor. The DN20-C synchronous front-end handles up to eight lines in the 2040 and 2060. Each line can support up to 56K bps, in several combinations.

The rules for asynchronous communications on the 2040 and 2060 are contained in the following table.

Async. Lines	Features required			
	DC20-AA	DC20-DA	DC20-CC	DC20-EC ED
16	1	1		
24	2	1		
32	2	2		
40	2	2	1	1
48	2	3	1	1
56	3	3	1	1
64	3	4	1	1
72	4	4	1	1
80	4	5	1	1
88	5	5	1	1
96	5	6	1	1
104	5	6	1	2
112	5	7	1	2
120	6	7	1	2
128	6	8	1	2

On all DECSYSTEM 20 processors, hardware internally is EIA with support for EIA lines and terminals only. All 20 ma current loop terminals must be converted to EIA for use with DECSYSTEM-20. For asynchronous speeds up to 2400 bps, cabling must not exceed 1000 feet; for asynchronous speeds up to 9600 bps, cabling must not exceed 250 feet.

MASS STORAGE

RP06 DISK PACK DRIVE: Provides large-capacity random access storage. RP06 disk drive has a storage capacity of 39.6 million 36-bit words (or 176 million 8-bit characters). A maximum of two channel subsystems, each with up to four disk drives, can be connected to a DECSYSTEM-20 for a total of eight disk drives and 312 million words. The RP06 drive uses an industry-standard IBM 3336-11-type disk pack that contains 12 disks and uses 19 recording surfaces. Data is organized into 128 words per sector, 20 sectors per track, 19 tracks per cylinder, and 815 cylinders per pack.

RM03 DISK PACK DRIVE: This drive employs a technology similar to that of the IBM 3330 through the use of a track-following servo system. In this system, one disk surface of each pack is dedicated to servo control and tracking information. The pack contains five platters, with the top and bottom platters employed for protection. Recording is on five surfaces at 6038 bits per inch and 384 tracks per inch. Data is recorded on 823 tracks per surface (including 15 spare tracks). Formatted capacity is 67 megabytes.

RP20 DISK DRIVE: Announced in August, 1980, this drive is similar to the IBM 3370 direct access storage system and has a capacity of 1200 megabytes of unformatted storage. Each

RP20 unit contains two data modules with 469 megabytes of formatted storage. A module has 15 recording surfaces with two read/write heads per surface. The transfer rate is 1.2 megabytes per second. The systems have dual port and dual channel features. The RP20 is part of the RTP20 disk subsystem. The RTP20 subsystem includes one RP20 drive and a controller. Up to three additional RP20 disk drives can be added to an RTP20. The RP20 disk drive is designed for the DECSYSTEM models 2040 and 2060 only.

INPUT/OUTPUT UNITS

TU45A MAGNETIC TAPE DRIVE: A 9-track, 75-ips unit with program-selectable recording densities of 800 bpi; NRZI, or 1600 bpi, phase-encoded. The TU45A may operate in read mode in either forward or reverse direction. On the 2040 and 2060, up to eight drives per controller are possible. On the 2020, up to four drives are permitted. The TU45A is manufactured by Pertec.

TU72 MAGNETIC TAPE DRIVE: The TU72-E drives are 9-track, 125 ips units with program-selectable recording densities of 6250 bpi group encoded or 1600 bpi in PE mode. Up to eight drives per TX02-E controller are possible. The TX02-E/TU7X can be configured on any 2040 or 2060 system via the DX20 Data Channel.

TU77 MAGNETIC TAPE SUBSYSTEMS: The TU77 tape drive is a 9-track, 125 ips unit with program-selectable recording densities of 800 bpi NRZI or 1600 bpi PE. Both the TAU77 and TU77 controllers can have up to four tape drives each. The TAU77-EC/ED controller is for the 2020 only, and the TU77-CB/CD is used in the 2040 and 2060 models.

LP20A AND LP20B LINE PRINTERS: These are both versions of the Dataproducts 2230 line printer, a drum-type printer featuring a choice of either 64- or 96-character drums. Using the 64-character drum, the printer operates at 300 lpm, but when the 96-character drum is specified, the printing speed becomes 240 lpm. Both models are 132-position printers (10 characters per inch) that feature programmable vertical format units. Switches on the units permit line spacing of either six or eight lines per inch. Users have a choice of either EDP or scientific character fonts for both the 64- or 96-character models. Up to two line printers of any type can be connected to the DECSYSTEM-20 Models 2040 and 2060. Through the PDP-11 front-end processor, one line printer is available on the 2020, connected through its controller to the Unibus.

LP20C AND LP20D LINE PRINTERS: These are similar to the LP20A and LP20B printers above. They are versions of the Dataproducts 2290 line printer, which is a drum-type unit featuring a choice of either 64- or 96-character drums. Using the 64-character drum, the printer operates at 900 lpm, and with the 96-character drum, at 660 lpm. Both models are 132-position printers (10 characters per inch) with a 12 channel direct access vertical format unit containing its own memory loaded from the main memory via normal data lines.

LP200-B LINE PRINTER: A Dataproducts 2250-Charaband-type unit, this printer provides the flexibility and interchangeability of the train printer. It is a 1500-lpm unit with either 64- or 96-character fonts. It has 132 print positions at 10 characters per inch. Users have a choice of four Charabands, and both the 64-character and the 96-character set can be included on the same Charaband. Other features of the LP200-B include a 12-channel paper tape-controlled vertical format unit and operator-selectable line spacing (6 or 8 lines per inch). Users may optionally specify special character

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▶ fonts. Like the LP20 lint printers, the LP200B also interfaces the DECSYSTEM-20 Models 2040 and 2060 through the PDP-11 front-end processor.

CD20A CARD READER: A tabletop-mounted card reader manufactured by Documation. The unit reads 80-column cards at 300 cards per minute. The CD20A is recommended for use in remote batch entry applications. The controller for the CD20A is built into the unit and interfaces the Unibus of the PDP-11 front-end processor on all but the 2020 where the interface is to the Unibus of the processor.

CD20C CARD READER: A free-standing unit, manufactured by Documation, that reads 80-column cards at 1200 cpm. Like the CD20-A, the controller for the CD20-C mounts in the unit and interfaces to the DECSYSTEM-20 in the same fashion as the CD20-A.

CP20-C CARD PUNCH: A free-standing unit capable of punching at 160 columns per second (100 cpm if all 80 columns are punched up to 285 cpm if 1 column is punched). The CP20-C is interfaced to the DIB20 External I/O BUS Interface on the 2040 and 2060.

PC20 PAPER TAPE READER/PUNCH: Reads 8-channel paper tape at 300 cps, using a photo-electric reader, and punches tape at 50 cps by electromechanical means. The PC20 is an option on all DECSYSTEM-20 models except the 2020 and is interfaced the same as the CP20-C.

LA36 DECWRITER II HARD-COPY KEYBOARD TERMINAL (AND CONSOLE): Provides electromechanical impact printing at a rate of 30 characters per second in a "60-character-per-second-mode." Printable characters are stored in a buffer during carriage return and line feed, allowing subsequent bursts at 60 characters per second while multiple characters are stored in the buffer. The LA36 keyboard generates a set of 128 ASCII characters, including 96 upper and lower case letters and numbers and 32 control characters. Characters are formed in a 7-by-7 dot matrix and are printed at a horizontal pitch of 10 characters per inch and a vertical spacing of 6 lines per inch. The keyboard layout conforms to the most recent ANS standard. The LA36 features quietized operations to enhance its suitability for office environments.

LA37 DECWRITER II APL TERMINAL: Identical in mechanical characteristics to the LA36, but features a full APL keyboard as well as standard alphanumeric characters.

LA38 DECWRITER IV HARD-COPY TABLE-TOP TERMINAL: The LA38 is designed for entry-level applications with a maximum print speed of 30 characters per second. This model is an addition to the DECwriter IV series and features serial printing by 9-by-7 dot matrix, a 128-character buffer, and communication speeds of 110 or 300 bps. In the LA38, paper movement is by use of tractor feed. The unit prints 128 ASCII upper- and lower-case characters. The LA38 also has a 19-key pad for rapid entry of numerical data. Like other new terminals from DEC, the LA38 is microprocessor based and incorporates a self-check feature as standard.

LA120 DECWRITER III: This terminal has a maximum print speed of 180 characters per second. It is designed for highly interactive time-sharing applications. The standard character set features 128 ASCII symbols, uses a 7-by-7 dot matrix bidirectional printing mechanism, and a tractor paper-feed. The LA120 uses 132 print positions, and will accept data at 15 standard rates between 50 and 9600 bps; a 100-character buffer is standard, with 4000 characters optional. The LA120 is microprocessor based and incorporates a self check

feature as standard. The LA120 uses a typewriter-style keyboard with optional 14-key numeric pad. The keyboard generates any of 128 ASCII character codes. Control functions include Line Feed, Return, Break, Escape, Repeat, Caps Lock, Tab, Delete, Bell, Space, Backspace, Shift, and Control Shift. The keyboard also contains a cluster of 8 function keys and 5 status indicators.

LA180 DECPRINTER RECEIVE-ONLY TERMINAL: The LA180 is a serial impact printer that prints at the rate of 180 characters per second. It is a matrix unit that prints the full 128-character ASCII set using a 7 x 7 dot matrix. It also prints rows of 132 characters. Horizontal spacing is 10 characters per inch, and vertical spacing is 6 lines per inch. The LA180 will accept data at standard rates between 110 and 9600 bps. Operation can be full duplex, half duplex, or echoplex. The LA180 is manufactured by DEC.

VT61 BUFFERED VIDEO DISPLAY TERMINAL: The VT61 is an upper and lower case ASCII terminal with a 1920-character display, 19-key function pad, 12 user-defined function keys and a typewriter style keyboard. The VT61 can transmit in either block or character mode. It displays a 128-character set using a 7-by-8 dot matrix. Transmission speeds are switch-selectable and can be 75, 110, 150, 300, 600, 1200, 2400, 4800, or 9600 bits per second. The interface may be EIA or 20 ma current loop. The VT61 is manufactured by DEC.

VT62 MICROPROCESSOR DRIVEN VIDEO DISPLAY TERMINAL: A block mode terminal specifically designed for transaction processing applications. The VT62 is an upper and lower case ASCII terminal with a 24 line by 80 character display (1920 characters). The keyboard is typewriter style with 10 function keys, 15 user defined function keys, and a 19 key numeric pad. The VT62 features reverse video, automatic cursor positioning, local error detection capability, and left and right justification. The terminal can be connected to the DECSYSTEM-20 in single-point or multipoint configurations with either an EIA or 20 mA interface. An LA180 hard copy terminal can be connected to the VT62 via an interface port. The VT62 is manufactured by DEC.

VT100 VIDEO DISPLAY TERMINAL: This performance-oriented terminal contains a 12-inch screen with either an 80 characters by 24 lines or 132 characters by 14 lines display and a detachable keyboard with an 18-key numeric/function keypad. The VT100 features a 7x9 dot matrix character font displayed on a 10x10 space. Standard features include 44, 66, 80, or 132 characters per line, line-selectable, double-width and double-height characters, line drawing graphic characters, bidirectional scrolling, split screen, tabulation, and high-lighting attributes including dual intensity, normal or reverse video on a character by character basis, blinking, and underline. Advanced video adds selectable blinking, under-line, and dual intensity characters (in any combination) to the existing reverse video attribute. Data rates range from 50 to 19,200 bps. The asynchronous terminal is equipped with an EIA RS-232-C (VT52 compatibility mode only) or 20-ma current loop interface. All operating parameters are established via the keyboard in the Set-Up mode. The VT100 is manufactured by DEC.

COMMUNICATIONS EQUIPMENT

All terminals, including the operator console terminal, connect to the 2040 and 2060 through the PDP-11 front-end processor. The DC20 communications subsystem interfaces all system terminals.

DC20 COMMUNICATIONS SUBSYSTEM: The interfaces in this system support up to 128 asynchronous lines on the model 2040 and 2060. The DC20-AA multiplexer is standard with both systems and terminates 8 lines. It can be expanded to 16 lines using a DC20-DA 8-line expansion unit. Through ▶

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additional DC20-AA and DC20-DA units, plus up to three DC20-EC expansion cabinets, the maximum of 128 lines can be obtained.

DZ11 ASYNCHRONOUS LINE INTERFACE: These devices are designed exclusively for the DECSYSTEM 2020. Up to 32 lines can be connected to a 2020 that can be programmed to handle anywhere from 50 to 9600 bps. Controls are provided for the operation of a 300 bps data set (Bell 103 or equivalent).

DN20 DATA COMMUNICATIONS FRONT END: Two different processors are available for synchronous communications: the DN20-CA, with 32K words of core memory, and the DN20-MA, with 128K words of MOS memory and used with DECnet-20 Version 2. Up to two DN20-CA or DN20-MA processors can be connected to a 2040 or 2060. The DN20-CA can support up to 1 DECnet line, and the DN20-MA can support up to 8. Up to 6 bisync lines (2780/3780) are supported on both processors under TOPS-20. When the system is running 2780/3780/HASP the maximum number of lines on each processor is 4 running 2780/3780 and 2 running HASP. DECnet-20, 2780/3780, and 2780/3780/HASP software is ordered separately. Transmission speeds ranging from 2400 to 1,000,000 bps can be supported.

SOFTWARE

The DECSYSTEM-20 has a virtual-memory, multi-mode operating system and an extensive repertoire of programming languages and utilities. Included among the languages are FORTRAN, COBOL, ALGOL, APL, BASIC, a version of PL/1, and a macro-assembler. These languages are all priced separately. The operating system, TOPS-20, includes features that support full-language time-sharing for program development and for interactive and terminal-oriented applications, as well as concurrent multi-stream batch processing.

OPERATING SYSTEMS: In addition to TOPS-20, the operating system designed for DECSYSTEM-20, Model 2020 operates under a version of TOPS-10, the DECsystem-10 counterpart.

TOPS-20 has been designed to function as a stand-alone system with minimal operator requirements. Any remote or local user terminal can function as the operator console simply by identifying itself as the console, and more than one terminal can perform console functions. The system treats all terminals equally, and relies on passwords from users to determine authority rather than accepting commands only from designated privileged terminals. Certain functions can be restricted to specific terminals on an individual basis, though.

TOPS-20 is a full virtual-memory, process-structured monitor. The interface to the command processor is highly interactive, providing prompting at any point during the specification of a task or job.

An important feature of TOPS-20 is memory space reduction. Significant portions of the TOPS-20 operating system including the command processor, are non-resident and are brought into main memory through demand paging in the same manner as user programs. The system also makes use of re-entrant program modules, but still can generate private, dedicated copies of pages within modules whenever integrity is threatened.

The major portions of TOPS-20 include the following components:

● System Scheduler: Controls the scheduling of processes using either a single-level dynamically-recomputed

scheduling algorithm or an accounting system-based "class" scheduler. The Scheduler determines which user program is to be run during a given interval. In addition to the scheduling algorithm, two other components are used. The Memory Allocator provides access to sharable system resources and the Context Switcher saves and restores program conditions when paging. The Scheduler is activated by the system clock 100 times per second, and user jobs are given time-slices of 600 ms for execution. Jobs which do not issue I/O requests during their 600 ms time-slice are considered compute-bound, and migrate to a different queue where they get 2-second time-slices at less frequent intervals.

● Page Manager: The Page Manager is responsible for all transfers of disk pages from memory to disk and back. It moves jobs between drum/disk and main memory after the Scheduler determines which user programs are to be in memory for a job to run. The Page Manager also determines which programs are to be removed from memory based on their inactivity and scheduling priority.

● I/O Service Routines: These routines process user program requests for I/O devices, and consist of three non-cyclic routines. The System Call Handler traps user service requests to the operating system and is the only means by which the user can switch to Exec Mode for operating system service. Input/output routines are initiated by the System Call Handler to manage data transfers between peripheral devices and user programs in core memory. The disk I/O service routine includes optimization techniques for disk accesses, which according to DEC result in 25 to 50 percent faster disk thoughput than would otherwise be possible under the same loading conditions where the controller is saturated with transfer requests. The I/O System permits the use of symbolic device names and allows the user to have device independence. The File Handler permits users to define protected output files for permanent storage.

● TOPS-20 File System: Provides up to 4000 user accounts/directories per structure on a 2020 or 2040 and up to 12,000 on the 2060. The file system provides a multi-level directory structure and interuser security through directory and file access protection mechanisms. The user group definition facility of the file system allows arbitrary definition of user-groups desiring to have common access to files. This facility also provides simultaneous update capabilities within a file, allowing two or more cooperating users concurrent access to a file. The file system also provides user-level disk space quotes for space management, automatic space allocation and deallocation during program run time for file creation and deletion, automatic optimized file placement and I/O, a centralized file name parsing and look-up monitor facility, and centralized file operations monitor facilities.

● RSX-20 Operating System: This feature of TOPS-20 controls the front-end processor of the 2040 and 2060.

● TOPS-20 Exec: Implements the system command language for interactive and batch processing. The Exec also provides file handling, and operator level, and system information commands.

● Device Allocator: This feature schedules and allocates requests for peripheral device usage.

The DECsystem-20 Monitor allows three basic concurrent modes of operation: interactive time-sharing, batch and remote communications. Up to 128 interactive terminals can be handled by the Monitor. The DECSYSTEM-20 Monitor, as well as the Command Language for the Monitor, is common to all modes of operation. This hierarchy of

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capabilities within one operating system, as well as the flexible hardware boundaries between the models, permits relatively simply upward growth without extensive retraining or reprogramming.

Time-sharing users have the same command languages available to them as do multiprogramming batch users, allowing time-sharing terminals to initiate batch jobs.

Commands are available to let terminal users manipulate files and control their own programs from creation through execution. Individual peripherals can be dedicated to a user for his exclusive use on a given job, or he can create and access files on peripheral devices shared with others. File protection schemes allow sharing of files among multiple designated users, with differing degrees of access authorized to each. Mass storage devices can be exclusively dedicated to an individual user.

In multiprogramming mode, users are scheduled on a modified round-robin basis by the queue manager program, using disk to hold paged-out segments. Control information is passed through the Executive Bus to initiate swapping or memory transfers. This device attachment scheme permits independent overlapped operation between the paging of one program and the execution of another program in memory. The re-entrant or sharable nature of many monitor segments, as well as the sharable code segments produced by the sharable compilers, results in additional core utilization by minimizing paging.

Multiprogramming batch mode allows operation of up to 14 jobs concurrently with time-sharing. During concurrent operation with time-sharing, batch jobs may occupy any available area in main memory. No partitions are set up to separate main memory into areas exclusively reserved for time-sharing or batch processing.

Remote communications hardware and software capabilities will permit simultaneous use of multiple remote stations with other modes of operation. Asynchronous full-duplex communications between small remote computer stations allows remote users to send or receive data. The remote batch terminals may have printers, card readers, etc., locally attached, and may also support additional remote terminals.

TOPS-20 provides a demand-paged virtual memory environment that allows each job a unique 256K-word address space in 512-word pages. The system divides the pages of each active job into two groups, the working set and the balance set. The working set consists of all pages that have been referenced within a particular recent time interval.

The virtual memory system dynamically adjusts the time interval according to the assumption that, when the job next becomes active, memory references will probably occur to the same pages. The number of pages contained in a job's working set is determined by the program's characteristics. Working sets are also monitored, and pages that have not been recently referenced are swapped out.

Generally, the system administrative controls attempt to provide a nearly equal percentage of the processor to all users, but, at the same time, to optimize the use of all resources. File input and output are also demand-paged. An option is available that can define specific user "classes" that are allotted a percentage of the CPU. The system's resources can then be allocated under administrative control to specified classes, and the system will operate the same within the class as if it were operating under the regular scheduler.

Memory mapping and page-level access protection are provided through hardware and microcode. These features permit page sharing between programs and reduce

context switching overhead. Page status and age information are maintained in tables and are automatically updated for each page in main memory by microcoded routines. The system is supported by two hardware registers in the KS10 and KL10 CPUs that contain pointers to locate the physical pages in memory which contain mapping information for the operating system and the currently active user. These pages, referred to as the User Page Table (UPT) and the Monitor Page Table (MPT), contain page pointers for mapping information between the user's and the monitor's address space and the actual pages of physical memory being used by these elements.

There are three types of pointers—immediate, shared and indirect. Immediate mode signifies that entries in the User Page Table refer directly to physical pages in main memory. Shared mode indicates that two or more users are sharing the same page of coding. Indirect mode uses the shared pages table, but the entry in the table points to a second user page table. The entry in this second UPT then points to the physical pages.

TOPS-10 (for the DECSYSTEM-20, Version 6.03) permits five concurrent modes of operation: interactive time-sharing, real-time processing, batch processing, multiprogramming, and remote communications. Up to 32 interactive terminals can be handled by the TOPS-10 Monitor. The multiprogramming batch mode allows operation of up to 14 jobs concurrently with time-sharing, in which a batch job can occupy any available area in main memory. Real-time applications are handled by the Monitor using the system facilities available for time-sharing and multiprogramming. A full description of the TOPS-10 operating system can be found in Report 70C-384-01.

TOPS-20 GALAXY MULTIPROGRAMMING BATCH PROCESSING SYSTEM: Enables the DECSYSTEM-20 to execute multiple batch jobs with time-shared jobs. GALAXY is executed as a single-user job and uses the same command language as time-shared programs. Batch users can enter jobs using traditional card decks, with control cards defining the command options for a job, or create and submit a control file through a user terminal. This control file is then intercepted by the batch system and processed in the same manner as a job submitted on cards. Since the batch and time-sharing systems use the same command language, system overhead is reduced by the ability to have only one control processor resident in main memory. The system administrator can assign a guaranteed percentage of CPU time for batch jobs.

GALAXY also provides automatic line printer and card reader spooling plus job accounting functions. Jobs can be run in any order, and the user may specify the number of times each job is run.

TOPS-20 LINK: Besides the standard loading functions, Link provides a single region tree-structured overlay facility; load-time defined overlay structure independent of FORTRAN, COBOL, or ALGOL programs; a diagramming facility to portray the program overlay structure; and relocatable overlays.

TOPS-20 SORT/MERGE: A disk sort utility which operates stand-alone or in configuration with COBOL-68/74 and FORTRAN-IV. Sort/Merge reorders the records of ASCII files, sixbit files, EBCDIC files, and binary files produced by COBOL and FORTRAN in a sequence determined by the sorting parameters prepared by the user. Sort/Merge automatically controls the use and allocation of disk work space with user specified memory limits. The merging of files into a single sorted file can be invoked either stand alone or via the COBOL MERGE verb. Optional support of magnetic tape for input or output is provided by Sort/Merge.

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▶ **ALGOL-60 (under TOPS-20):** Consists of a one-pass, single-phase compiler capable of processing up to 5,000 ALGOL lines per minute, according to DEC; this speed assumes disk I/O with 24 unpacked significant symbols per line. Use of the compiler requires a 13K-word re-entrant segment in memory and a non-sharable user segment consisting of 2K words plus an amount of core dependent upon the size of the user's ALGOL program. The ALGOL-60 object-time system provides a basic I/O system including teletype I/O default with 16 logical channels, storage management, on-line debug tools, and a library of attachable routines including FORTRAN interface, byte-string manipulation, bit-field manipulation, single- and double-precision mathematical functions, etc. ALGOL-60 on the DECSYSTEM-20 also features a built-in debug utility. The minimum hardware required for ALGOL-20 is a 128K-word system.

APL-BASIC AND APL—SF (under TOPS-20): A conversational programming language that is particularly well suited for operating on numeric and character array-structured data, the DEC APL system runs under the DECSYSTEM-20 time-sharing Monitor. DEC's APL closely resembles the IBM APL/360 implementation, but provides additional features. DEC offers both basic and extended versions of APL, each of which can have double-precision arithmetic facilities. Extended APL includes the Divide-Quad, Execute, Quote, and Dyadic Format for performing matrix inversions, solving linear equations, and evaluating character strings, plus user-level file access to standard ASCII sequential files, internal format random-access and sequential files, and immediate I/O to any peripheral through and OUTPUT command.

Extended APL, with or without double-precision arithmetic, occupies 24K words of re-entrant code plus 7500 characters of user code area and a 5K or 6K user workspace. Basic APL, with or without double-precision arithmetic, requires 20K words of re-entrant code plus 7500 characters of user code area and a 5K to 6K user workspace.

APL-BASIC and APL-SF differ primarily in the APL-SF support of file I/O. APL-SF provides user level file access to standard ASCII sequential files, internal format random access files, internal format sequential files, binary random-access files, and immediate-mode I/O via any supported output device through the OUTPUT command.

BASIC-20: This is an extended implementation of the language. It is fully re-entrant, and provides these additional features: sequential access file handling for both data and text, random access capability for numeric and string files, file opening and closing under program control, string handling capability, and up to nine files open simultaneously. The minimum hardware required for BASIC-20 is 96K words of main memory.

FORTRAN (under TOPS-20): A new FORTRAN compiler that contains both extensions to the ANS 1966 FORTRAN-IV standard and global and local optimization capabilities for improving execution times. Both the compiler and Object Time System are re-entrant. FORTRAN under TOPS-20 requires a 96K-word DECSYSTEM-20.

MACRO ASSEMBLER: This two-pass symbolic assembler is device-independent, allowing the user to select I/O devices for source program entry, program listing output, and object code storage. Powerful macro capabilities permit creation of user-defined language extensions for frequently used coding sequences. The pure, re-entrant code for the macro assembler occupies 7K words of main storage, and each user's portion of the assembler requires a minimum of 1K words.

DECNET-20: DECNET permits users to create communications networks merely by adding appropriate software and hardware to existing computer systems.

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.

● Make more extensive use of memory-only systems.

DECNET is also the collective name for the set of software products which extend various DEC operating systems so they can be interconnected with each other to form computer networks. The DECNET user can configure a variety of networks by choosing the appropriate CPU's, line interfaces (and speeds), and operating systems software. Such networks typically fall into one of three classes: 1) those that move data from one physical location to another; 2) file-oriented networks, often the case for remote job entry systems; or 3) line-oriented networks, as occurs with the concentration of interactive terminal data.

BASIC PLUS-2 (under TOPS-20): Compatible with the BASIC PLUS-2 compiler developed for the DEC PDP-11 minicomputers. Some of the features included in this latest BASIC compiler include program manipulation commands that permit saving, running, and retrieving BASIC programs; immediate mode statements to simplify debugging; optional automatic line-by-line syntax checking; up to 30-character variable names; IF/THEN/ELSE programming constructions; string handling operations including string arrays; a full matrix operations package; extensive program editing facilities; record I/O, supporting sequential and relative (direct) access to files; and access to system files.

The minimum hardware required for BASIC PLUS-2 is 128K words of main memory and allocation of 50K words of permanent file storage.

COBOL-68, COBOL-74 (under TOPS-20): A complete implementation of American National Standard COBOL X3.23 (Level 4). Both the 1968 and 1974 versions are implemented. An ISAM package is also included in the compiler to allow access to data files which may employ a variety of file organizations. The COBOL Compiler may be used for line-by-line compilation or for batch compilation. The standard recording mode for COBOL is ASCII, in either 6-bit or 7-bit bytes; however, IBM-compatible EBCDIC code can also be read or written on magnetic tape after a code conversion to or from the internal ASCII code representation. The minimum hardware requirement is any DECSYSTEM-20 with 96K words of memory.

The Sort/Merge, included with both COBOL versions, can reduce sort times for disk data sets with more than 1000 records by about half.

CPL (under TOPS-20): DEC's Conversational Programming Language is an interpreter supporting a subset of the ANS PL/1 language. CPL is designed for beginning programmers or even nonprogrammers. It provides users with the option of immediately executing statements or saving them in a file for later execution. ▶

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▶ In general, nearly all PL/1 arithmetic, mathematical string-handling, array, and storage control functions are supported by CPL. The minimum hardware requirements for CPL is a 128K-word system, with at least 50K words available as user space and 50K words of permanent file storage space.

DECnet-20 is a phase II network product and as such has these phase II features: allows a suitably configured DECSYSTEM-20 to participate as a Phase II DECnet system in point-to-point computer networks; offers task-to-task communications using the DIGITAL Network Architecture (DNA) protocols; and communicates with adjacent systems over synchronous communications lines. Access to DECnet-20 is made via Macro-20 system calls.

DECnet programs are designed to simplify network configuration and generation and to provide computing networks for industrial, commercial, scientific, and educational markets. The programs allow "dynamic reconfiguration," the ability to switch lines without interrupting service in case of malfunction. A full point-to-point interconnect capability allows disk-to-task communications by which programs running on separate networks can exchange data. Remote resources access for use of peripherals at another node and remote sequential I/O files are also supported.

DECnet-20 supports full-duplex transmission in point-to-point operation using serial synchronous facilities.

DECnet-20 implemented on a DECSYSTEM-2040/2060 supports one point-to-point synchronous link. On a DEC-SYSTEM-2020, two point-to-point synchronous links may be supported with the proper hardware configuration. Only one physical link may connect any pair of nodes.

The synchronous line units interface to Bell System 208A modems for operation at speeds up to 4.8K bps to ICC COMLINK II modems for speeds up to 192K bps, and to Bell 303 modems (using a CCITT V.35 converter), for speeds in excess of 19.2K bps. Equivalent modems may also be used.

DECnet-20 is implemented as an ancillary process under TOPS-20 with DIGITAL-supplied monitor-level components and user-level utilities. DECnet-20 is implemented in two forms: For the DECSYSTEM-2040/2060, DECnet-20 resides in part in the central processor and in part in a dedicated communication front-end, the DN20; for the DEC-SYSTEM 2020, DECnet-20 resides entirely in the central processor.

TOPS-20 2780/3780/Multileaving: Emulates and/or terminates Model 76 Data 100 units, or equivalent. It enables a DECSYSTEM-20 equipped with a DN20 communications front end to submit 2780/3780 remote entry jobs to an IBM 360/370 and to process jobs submitted from 2780/3780 terminals.

TOPS-20 2780/3780/HASP Multileaving (DN22-AA/AB): Enables a 2020 with either TOPS-10 Version 7.01 or TOPS-20 Release 4 to act as a remote station to an IBM host in emulation mode. DN22 also allows the 2020 to act as a host and communicate with 2780, 3780 or HASP-multileaving style terminals in termination mode. With DN22, two communications lines are provided in any mix of emulation or termination. DN22 requires one DN20-B synchronous line from the 2020 with either synchronous modems for remote use or a single synchronous null modem for local use.

TRAFFIC-20 (TRANSACTION ROUTING AND FORM FORMATTING IN COBOL): A collection of CRT screen formatting and program-to-program communications subroutines available to DECSYSTEM-20 COBOL programs.

Traffic-20 includes a set of Transaction Formatting Routines; a set of Transaction Routing Routines, and a stand-alone utility program for defining and saving CRT screen format descriptions. The Transaction Formatting Routines enable a COBOL program to send formatted CRT displays to and receive data messages from user terminals. The Transaction Routing Routines enable a COBOL program to send and receive packets to and from cooperating COBOL programs.

DATA BASE MANAGEMENT SYSTEM: DBMS-10 and DBMS-20 are full-scale data base organization and management systems that use both COBOL and FORTRAN as their host languages and provide a data management language (DML) based largely upon the April 1971 CODASYL Data Base Task Group (DBTG) specifications. DBMS-10 and DBMS-20 support hierarchical data structures in simple tree format or in more complex network structures and provide a high degree of data independence from physical devices as well as user applications programs. Owner and member relationships are defined by chained pointers. DBMS-10 and DBMS-20 permit access to data through the DIRECT, CALCULATION, or VIA set location modes, permitting clustering of records normally accessed in groups. In addition to the Schema, multiple subschemas can be associated with the Schema to minimize the program modifications required due to the addition of data and new relationships to the files. A temporary subschema area is used to permit program testing on data without jeopardizing the integrity of the data base.

The Data Base Control System module is composed of re-entrant routines that permit concurrent retrievals to the same data areas. Data areas can be subjected to an exclusive update provision that grants exclusive update rights of a data area to a given processing program. The protected update option permits concurrent retrievals from a data area but proscribes concurrent updating activities. Concurrent updates to the same data area can be performed by a multiple-update queuing mechanism. Privacy of data within the data base is provided by privacy locks of up to 30 characters in length which are associated with the schema, subschemas, and data areas. Data base support utilities include initialization, print schema update, and statistics logging routines. Recovery files are maintained for each file each time it is opened for protected update. The COBOL extension module, LIBOL, provides an interface to an on-line communications network. DBMS-10 and DBMS-20 are separately priced program products. DEC claims that current users of TOTAL, from Cincom Systems, or IDMS, from Cullinane Corp., can migrate to DBMS-10 or DBMS-20 with only minor changes.

A detailed analysis of DBMS-10 and DBMS-20 can be found in Report 70E-384-01.

IQL-10 AND IQL-20: The DEC Interactive Query Language is an information retrieval and report writing system that uses English-like requests to read a file or group of files and process data contained in those files. IQL-10 and IQL-20 extract, summarize, reorganize, and copy file information, and produce reports in specified formats. The language interfaces both the file management system of the operating system and DBMS-10 or DBMS-20. Data files can be sequential DBMS data bases, or index-sequential with fixed and/or variable record length. IQL-10 and IQL-20 can perform sorting; conditional processing; computation, including multiply and divide; perform built-in functions, such as tallies, totals, and averages; generate multiple reports in nine or more formats; perform matrix reporting through manipulation of summaries or individual items; define, modify and examine dictionaries for the pre-sorting of files, records, or items; and operate in either interactive or batch ▶ mode.

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► IQL-10 and IQL-20 contain a DBMS interface. In interactive mode, IQL operating under control of a terminal front-end module can define dictionaries reflecting schema files for DBMS data bases.

PRICING

CONTRACT TERMS: DEC offers a purchase agreement for immediate ownership of the DECSYSTEM-20, conditional sales agreement, and full-payout accrued-equity lease contracts. The conditional sales agreement is used primarily by non-profit institutions and state and local governments. This agreement carries a three- to seven-year term and is noncancelable with the title passing to the user, DEC retaining a security interest. The most common is a five-year accrued-equity contract that yields DEC a full payout in four years. An end-of-contract option permits the direct purchase of the system for the then-fair market value, which DEC estimates will be 10 percent of the original purchase price. The monthly charges for accrued-equity contracts for new DECSYSTEM-20 systems are negotiated on an individual basis in order to reflect prevailing interest rates. These full payout leases may extend from three to seven years and are noncancelable. Five years is typical. There are no extra-use charges for the equipment, although maintenance contracts may be negotiated for any amount of daily maintenance from 8 to 24 hours (see below). Liberal educational discounts are given to qualified institutions.

SOFTWARE: A system software package is included with each system. This package includes the TOPS-20 operating system with the GALAXY batch processor or the TOPS-10 operating system the linking loader, editor, and other utilities; and the macro assembler. All other language processors and the SORT utility are licensed separately. License fees are listed in the Software Prices section of this report.

USER GROUP: The worldwide DEC Users' Society (DECUS) was founded in 1961 and currently has about 30,000 members in over 40 countries. This group is directly supported by DEC and schedules two international meetings annually in addition to publishing a bi-monthly newsletter, DECU-SCOPE. DECUS is composed of four chapters (listed below), special interest groups (such as the DECsystem 10/20 Group), local users groups, and national users groups. Symposia are held throughout the year in each of the DECUS chapters. The DECUS Program Library Catalog lists more than 2,600 programs written by DEC users, most of which are available at no charge, or in some cases for a nominal handling fee. DECUS Membership is limited to DEC users, although some meetings are opened to general attendance. Inquiries should be directed to:

DECUS Australia
P.O. Box 384
Crows Nest
New South Wales 2067 Australia
61-2-439-2566

DECUS Canada
P.O. Box 11500
Ottawa, Ontario
K2H 8K8 Canada
613-592-5111 Ext. 2115

DECUS Europe
12 Avenue des Morgines
C.P. 510
1213 Petit-Lancy 1
Geneva, Switzerland
022-93-33-11

DECUS U.S.
One Iron Way
Marlboro, Massachusetts 01752
617-481-9511 Ext. 4100

SUPPORT: System software is installed by DEC, followed by 90 days of software warranty support. The warranty support includes telephone and on-site assistance, and software maintenance periodicals, documentation, and software product updates that are released during the software warranty period.

Included with each system is a consulting services package that provides up to 50 days of applications consulting support to aid users in development of their applications software. These 50 days must be used within one year of operating system installation.

Self-Maintenance Service for Software (post-warranty) is available on a yearly contractual basis. This program includes Software Product and Documentation updates, which are sent automatically during the contract period. They include Software Dispatch, a monthly newsletter with information about new software developments and programming enhancements, and Software Performance Reports (SPRs), a more detailed publication on software problem diagnosis. The annual price for Self-Maintenance Service when using TOPS-20 is $2,462.

In addition to the Software Notebook Set provided with the system, an additional set may be purchased, including a one-year update capability, for $1,100. A one-year update service on the original Notebook can be purchased for $559. An additional Software Dispatch subscription is $440 annually. Additional consulting services are available on a per-call basis.

Ninety days of installation support (warranty) are provided at no charge following delivery of a system on an 8 hours per day, 5 days per week basis. More intensified coverage over a shorter period of time is also available (for example 24 hours per day, 7 days per week for 50 days). Thereafter, systems integration assistance and field support by DEC's Systems Engineering Group are available at several prices, depending upon the level of support provided.

The DECservice agreement for hardware provides on-call remedial maintenance between 8 a.m. to 5 p.m. and preventative maintenance between 8 a.m. and 8 p.m., both Monday through Friday. There is no additional charge for remedial service begun during the contracted hours of coverage but which must extend beyond these coverage hours. There is a guaranteed four hour response for service calls placed during the contract period and on-call maintenance on a best effort basis at per call rates with no charge for materials outside the contract period. The following table gives premiums to be added to regular rates (Monday-Friday, 8 a.m.-8 p.m.) for service outside the standard contract period.

	16 hours	24 hours
Daily Mon. through Fri.	8%	16%
Saturday or Sunday	11.2%	13.6%

The Basic service agreement for hardware provides maintenance between 8 a.m. and 5 p.m. Monday through Friday and priority response (typically next day) during hours of coverage. Extended coverage rates for Basic service agreements can be obtained by adding the premiums in the following table to standard Basic service rates. ►

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EQUIPMENT PRICES

		Purchase Price	Monthly Hardware Maint.*
ASYNCHRONOUS COMMUNICATIONS DEVICES			
DC20-AA	Basic Asynchronous Multiplexer; 8 lines, can be expanded to 16 lines with one DEC20-DA expander, max. 7 per system; for 2040 or 2060	5,600	99
DC20-DA	Expansion group for use with DC20-AA above; 8 lines, max. 1 per DC20-AA	1,700	86
DC20-EC/ED	Communications Expansion Cabinet; required for over 64 communications lines, includes one DC20-AA basic 8-line group, max. 1 per system; for 2040 or 2060	11,800	211
DC20-CC	Cables and Distribution Cabinet; for configuration between 32 and 128 lines	2,350	—
DZ11-AA	Asynchronous Line Interface and Distributor Panel; for 8 lines; required when more than 16 lines are ordered	2,450	38
DZ11-BA	Asynchronous Line Interface; for 8 lines; required when more than 8 or 24 lines are ordered; requires DZ11-A	1,950	33
SYNCHRONOUS COMMUNICATIONS DEVICES			
DN20-CA/CB	Data Communications Front End; requires DN20-BX synchronous line units and software; for 2040 or 2060	30,200	190
DN20-BA	Synchronous Line Controller; one allowed per DN20-C; includes DN20-BB; for all processors	3,850	36
DN20-BB	Synchronous Line Unit; for expansion of DN20-BA; max. of 3 DN20-BB per DN20-BA	1,500	16
DN21-BA	Synchronous Line Controller and Interface for speeds between 19.2K and 56K bps; for 2040 or 2060	3,250	35
DN22-AA/BB	IBM 2780/3780/HASP Multileaving Emulator/Terminator for 2020	13,400	156
TERMINALS			
DF01-A	Acoustic Telephone Coupler	345	14
LA36-CE/CJ	DECwriter II Hard Copy Terminal; 30 cps; KSR; 132 positions, 20 mA current loop, 14 position keypad	2,700	25
LA36-HE/HF	With EIA Interface	2,800	25
LA37-CE/CJ	LA36-C with dual APL/ASCII character set and 20 mA current loop	3,600	29
LA37-PE/PJ	With EIA Interface	3,700	29
LAXX-LG	EIA Interface with modem control	120	—
LA38-GA	DECwriter IV Hard Copy Table-Top Terminal; 30 cps; KSR; 132 positions, EIA interface, 14 position keypad	1,600	21
LA38-HA	With Universal power supply	1,700	21
LAX34-CL	20 mA Current Loop Interface for LA38	120	4
LA120-DA	DECwriter III; 180 cps, numeric pad, EIA interface	2,800	39
LA12X-AL	20 mA Current Loop Interface for LA120	130	—
LA180-EA/ED	DECprinter; 180 cps, serial, EIA interface	4,050	72
LA180-PA/PD	DECprinter for hardcopy use with VT61; parallel interface	3,450	65
VT62-AA/AB	Microprocessor Driven Video Display Terminal; designed for transaction processing; 20 mA current loop or EIA interface	3,350	65
VT100-AA/AB	CRT Terminal with detached keyboard, EIA keyboard, EIA interface supported in the VT52 compatible mode only	2,050	22
VT1XX-AA	20 mA Current Loop Interface for VT100	130	4
HARDWARE			
DNHXX-AA/AB	Expansion Cabinet for 2020	8,000	—
H956	Option Cabinet	1,575	—
844	Power Control for H956 cabinet	665	—

*Monthly maintenance is 5-day, 12 hours per day DECservice except for 2020 packages and terminal products; MS10-BA, MS10-HA, MS10-LA, RM03-A, TAU45-EC/ED, DZ11-AA, DZ11-BA, DF01-A, LA36-C, LA36-H, LA37-C, LA37-P, LA38-G, LA38-H, LA120-BA, LA180-EA/ED, LA180-P, VT61-A, VT62-A, VT100-A and VT1XX-A. For 2020 products, the quoted figure is DECservice for an eight hour day, 5 day week. For terminal products the quoted figure is the eight hour Basic maintenance.

SOFTWARE PRICES

TOPS-10	TOPS-20		One-Time License Fee	Monthly Self-Maint. Fee
QH502-XM	QT002-AM	ALGOL-60; binaries and source code supplied	$11,500	$66
QH072-AM	QT014-AM	APL; same as APLSF, but without file I/O; binaries only supplied	11,500	79
QH071-AM	QT012-AM	APLSF; binaries only supplied	23,000	132
QH503-XM	—	BASIC-10; binaries and source supplied	6,900	79
—	QT027-AM	BASIC-Plus-2; binaries only supplied	11,500	97
QH099-XM	QT099-AM	COBOL-74 plus QT011-AM; binaries and source supplied	15,000	115
QH060-AM	QT009-AM	CPL (ANS-76 PL/1 subset interpreter; binaries only supplied)	6,900	58
QH500-XM	QT001-AM	FORTRAN-66; binaries and source supplied	11,500	84
QH300-XM	QT007-AM	Sort/Merge; binaries and source supplied	3,450	31
QH101-AM	QT008-AM	DBMS; binaries only supplied	34,500	242
QH045-AM	QT016-AM	IQL extended with DBMS interface, both ISAM and sequential; binaries only supplied	19,600	106
QH074-AM	QT025-AM	APL to APLSF upgrade	17,300	—
—	QT028-AM	BASIC to BASIC-Plus-2 upgrade	5,200	—
QH509-XM	QT024-AM	Sort/Merge to COBOL-68 Sort/Merge	11,500	—

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SOFTWARE PRICES

TOPS-10	TOPS-20		One-Time License Fee	Monthly Self-Maint. Fee
QH681-XM	—	DECnet-10 Task to Task; binaries and source supplied	17,300	220
—	QT042-XM	2780/3780 Software for 2040, 2050, or 2060 (TOPS-20); binaries and source supplied	8,600	132
—	QTD01-AM	DECnet-20 for 2040, 2050, or 2060; binaries only supplied	5,800	88
—	QTD20-AM	DECnet-20 for 2020; binaries only supplied	5,800	88
—	QT037-AM	Traffic-20; binaries only supplied	6,900	88
ZH008-CM	ZH008-CM	Maintenance Programs for the KL10-E	44,000	—
ZT001-YM	ZT001-YM	Maintenance Programs for the KS10-A	25,300	—
QT046-YM	QT046-YM	KS10 Microcode	50,600	—
—	QT052-XM	2780/3780/HASP Software for TOPS-20	10,000	117
	Source Code			
QT029-EK/EL	QT029-EK/EL	TOPS-20 Front End Source Code on RP04 or RP06 Disk	23,000	220
—	QT030-EM	TOPS-20 Monitor Source Code on 9-track tape	28,800	264
—	QT038-EM	TOPS-20 Executive Sources (Command Scanner) on 9-track tape	8,100	88
—	QT040-EL	TOPS-20 Source Package; includes QT030, QT029, QT038; supplied on RP04 or RP06 Disk	46,000	351

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	12 hours	16 hours	24 hours
▶ Daily/no weekends	13%	26%	43%
Sat. & Sun.	10%	13%	17%

EDUCATION: Each DECSYSTEM-20 user is entitled to 10 man-weeks of training. On-site training, including course materials, is provided for specialized customer requirements at individually arranged rates.

Currently available courses include DECSYSTEM 20 User Course, Administration Course, Assembly Language Programming, Programming, Operating System, COBOL, and Operator Course.

UPGRADE POLICY: DEC offers a trade-in policy giving credits toward the purchase of more advanced DECsystem devices. Older PDP-10 equipment or slower DECsystem equipment may be upgraded to higher-performance devices. Traded-in equipment must be in generally good condition (i.e., DEC-maintained by Field Service) or is subject to a re-furnishing charge. Allowances depend upon device type and vary widely from about 20 to 50 percent of the original purchase prices.

EQUIPMENT: The following systems are representative of the types of DECsystem-20 configurations that are normally used and supported by the TOPS-20 operating system. All necessary controllers, processor features, and interfaces are included in the indicated prices.

MINIMUM DECSYSTEM 2020: Consists of KS10-A CPU with 256K words of MS10 Error Correcting MOS memory;

a 14.89 megaword (67 megabyte) RM03 Disk Drive; a TU45 Magnetic Tape Subsystem; an LA36 DECwriter II Console Terminal; an LP20-A Line Printer; a DC20 8-line asynchronous multiplexer; the TOPS-20 operating system including the GALAXY batch system, link loader, editor, and utilities; the macro assembler; installation and 90-day warranty; and 50 days of application software consulting. Purchase price is $186,400 and monthly hardware maintenance charge is $1,574.

MINIMUM DECSYSTEM 2040: Consists of KL10-E CPU with 256K words of memory; an RP06-B 39.6 megaword Disk Drive; a TU45 9-track, 800/1600 bpi tape subsystem; an LP20-A Line Printer; an LA36 DECwriter II console terminal; 16 asynchronous communications lines, asynchronous multiplexer; the TOPS-20 operating system including the GALAXY batch system, linking loader, editor, and utilities; the macro assembler; installation and 90-day warranty; and 50 days of application software consulting. Purchase price is $377,620 and monthly hardware maintenance charge is $1,963.

MINIMUM DECSYSTEM 2060: Consists of a KL-10-EE CPU with 2048 words of 160-nanosecond cache memory and 256K words of memory; a RP06-B 39.6 million-word disk drive; a TU45 9-track, 800/1600 bpi tape subsystem; an LP20-A Line Printer; an LA36 DECwriter II console terminal; 16 asynchronous communications lines; the TOPS-20 operating system including the GALAXY batch system, linking loader, editor, and utilities; the macro assembler; installation and 90-day warranty; and 50 days of application software consulting. Purchase price is $453,820 and monthly hardware maintenance charge is $2,670.■

EQUIPMENT PRICES

	Purchase Price	Monthly Hardware Maint.*

PACKAGED SYSTEMS**

DECSYSTEM 2020 Systems include the KS10-A CPU with 256 word virtual address cache memory, 256K words of 1.05-microsecond MS10 MOS Memory, and one integral data channel; an LA36-C DECwriter II Console Terminal; 16 asynchronous communications lines; 10 training credits; hardware installation and 90-day warranty; software installation and 90-day warranty; one set software notebooks and 90-day software update service; five sets of manuals; 25-day consulting services package; utilities; and macro assembler:

		Purchase Price	Monthly Hardware Maint.*
2020-PA/B	DECSYSTEM 2020 with one RM03 Disk Drive and TOPS-20 Operating System	$129,800	$831
2020-PC/D	DECSYSTEM 2020 with one RM03 Disk Drive and TOPS-10 Operating System plus sources	129,800	831
2020-SA/B	DECSYSTEM 2020 with one RP06 Disk Drive and TOPS-20 Operating System	144,800	831
2020-SC/D	DECSYSTEM 2020 with one RP06 Disk Drive and TOPS-10 Operating System plus sources	144,800	831
2020-JA/JB	DECSYSTEM 2020 with two RM03 Disk Drives, one TU45-Tape Drive, five Software Units, and TOPS-20 Operating System	168,500	1,075
2020-JC/JD	DECSYSTEM 2020 with two RM03 Disk Drives, one TU45-Tape Drive, five Software Units, and TOPS-10 Operating System plus sources	168,500	1,075
2020-KA/KB	DECSYSTEM 2020 with two RP06 Disk Drives, one TU45-Tape Drive, five Software Units, and TOPS-20 Operating System	198,500	1,138
2020-KC/KD	DECSYSTEM 2020 with two RP06 Disk Drives, one TU45-Tape Drive, five Software Units, and TOPS-10 Operating System plus sources	198,500	1,138

DECSYSTEM 2040 Systems include the KL10-E CPU with 256K words of 1.05-microsecond MF20 MOS Memory, and two integral data channels, an LA36-C DECwriter II Console Terminal; 16 asynchronous communications lines; TOPS-20 Operating System plus utilities and macro assembler; 10 training credits; hardware installation and 90-day warranty, software installation with 90-day warranty; one set software notebooks and 90-day software updating service; five sets of manuals; and 50-day consulting services package:

		Purchase Price	Monthly Hardware Maint.*
2040-SA/SB	DECSYSTEM 2040 with one RP06-B Disk Drive	324,600	1,970

DECSYSTEM 2060 Systems include the KL10-E CPU with 160 nanosecond cache memory, 256K words of 1.05-microsecond MF20 MOS Memory, and two integral data channels; an LA36-C DECwriter II Console Terminal; 16 asynchronous communications lines; TOPS-20 Operating System plus utilities and macro assembler; 10 training credits; hardware installation and 90-day warranty, software installation with 90-day warranty; one set software notebooks and 90-day software updating service; five sets of manuals; and 50-day consulting services package:

		Purchase Price	Monthly Hardware Maint.*
2060-PA/PB	DECSYSTEM 2060 with one RP06-B Disk Drive	399,100	2,120

*Monthly maintenance is 5-day, 12 hours per day DECservice except for 2020 packages and terminal products; MS10-BA, MS10-HA, MS10-LA, RM03-A, TAU45-EC/ED, DZ11-AA, DZ11-BA, DF01-A, LA36-C, LA36-H, LA37-C, LA37-P, LA38-G, LA38-H, LA120-BA, LA180-EA/ED, LA180-P, VT61-A, VT62-A, VT100-A and VT1XX-A. For 2020 products, the quoted figure is DECservice for an eight hour day, 5 day week. For terminal products the quoted figure is the eight hour Basic maintenance.

**All minimum systems require a magnetic tape subsystem and a line printer in addition to the basic package.

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EQUIPMENT PRICES

	Purchase Price	Monthly Hardware Maint.*
SYSTEM UPGRADES		
2060-UA/UB	2040 to 2060 Upgrade; includes cache memory (MCA-20) and TOPS-20 with extended features; may also include KLPV	100,000	—
2060-UC/UD	2050 to 2060 Upgrade; TOPS-20 with extended features; may also include KLPV	10,000	—
MEMORY		
MS10-BA	MOS memory modules for 2020 (error correcting):		
	64K words	8,000	63
	Memory for 2040:		
MB20-GC/GD	Expansion unit (second backplane)	28,900	169/unit
MB20-E	Core memory modules (3 max. per backplane)		
	64K words (1 unit)	28,900	130
	Memory for 2040 and 2060:		
MF20-LA/LB	Expansion controller (first backplane) with 256K-word memory module	42,000	559
MF20-LC/LD	Expansion unit (second backplane) with 256K-word memory module	42,000	364/unit
MF20-LH/LJ	External expansion controller (first backplane) with 256K-word external memory module	42,000	559
MF20-LK/LL	External expansion unit (second backplane) with 256K-word external memory module	42,000	364/unit
MF20-E	MOS memory modules (two max. per backplane)		
MASS STORAGE		
RP06-AA/AB	39.6-megaword Add-On Single-Access Disk Drive for use with integrated controllers on 2020 and DH20 Controller on the 2040 or 2060	34,000	247
RP06-BA/BB	39.6-megaword Add-On Disk Drive, dual-access version of RP06-A above; max. 7 per subsystem	39,140	273
RP06-C	Dual-access kit; converts one RP06-A single-access drive to RP06-B dual-access drive; not for 2020	5,150	26
RM03-AA/AD	14.89-megaword Disk Drive for 2020; max. 8 per system	20,300	175
RH20	Massbus Controller for disk or tape	11,200	33
RTP20	Disk Drive Subsystem for use with 2040 or 2060; includes controller and one RP20 1.2 gigabyte disk drive	140,000	NA
RP20	1.2 gigabyte Add-on Single Access Disk Drive; max. 3 per RTP20 subsystem	49,000	NA
MAGNETIC TAPE EQUIPMENT		
TU45A-EC/ED	Magnetic Tape Subsystem with tape controller and TU45 Tape Drive; for 2040 or 2060	28,200	345
TU45A-EH/EJ	Add-On Tape Drive for TAU45-EC/ED and TU45A-EC/ED; 75 ips, 800/1600 bpi, NRZI/PE; maximum of three	15,700	267
TAU45-EC/ED	Magnetic Tape Subsystem with tape controller and TU45A Tape Drive; for 2020	31,600	369
TAU77-EC/ED	Magnetic Tape Subsystem with tape controller and TU77 Tape Drive; for 2020	30,000	325
TU77-AF/AJ	Add-On Tape Drive for TAU77-EC/ED and TU77-CB/CD; 125 ips, 800/1600 bpi, NRZI/PE; maximum of three	20,900	228
TU77-CB/CD	Magnetic Tape Subsystem with tape controller and TU77 Tape Drive; for 2040 and 2060	30,000	306
TX02-EE/EF	Magnetic Tape Controller and DX20 Channel for TU72 Series Tape Drives; requires RH20; for 2040 or 2060	96,800	589
TU72-E	Add-On Tape Drive for TX02-E; 125 ips, 1600/6225 bpi, PE/GCR	35,300	195
TX03-A	Two Channel Switch for TX02-EE/EF	6,400	13
TX03-EE/FF	Two channel switch option and DX20 channel for TX02-E	54,600	244
TX03-FB	Two channel switch option for two TX02-E	12,800	26
TX05-EC/ED	Two control unit tape switch option and one TX02-E; requires one TX02-E	74,400	371
TX05-FB	Two control unit tape switch option; requires two TX02-E	25,700	26
PRINTERS		
LP20-AA/AB	Line Printer and Controller; 132 positions; 64-character, EDP or scientific font; 300 lpm	17,700	316
LP20-BA/BB	Line Printer and Controller; 132 positions; 96-character; EDP or scientific font; 240 lpm	18,700	316
LP20-CA/CB	Line Printer and Controller; 132 positions; 64-character; EDP font; 900 lpm	36,500	321
LP20-DA/DB	Line Printer and Controller; 132 positions; 96-character; EDP or scientific font; 660 lpm	37,900	321
LP200-BA/BB	Line Printer and Controller; 132 positions; Charaband-type mechanism; includes software, long line interface, and diagnostics; does not include Charaband; 900/1200 lpm; not for 2020	54,600	499
LP07-Y	Charaband for LP200-B line printer; dual-sided; choice of 64- and 96-character EDP fonts, two 64-character EDP fonts, two 96-character EDP fonts, 64- and 96-character OCR-A fonts, two 96-character scientific fonts, 96-character EDP and scientific fonts, two 96-character Swedish/Finnish fonts, 64- and 96-character British fonts, two 64-character open Gothic fonts, or customer specified character fonts	4,300	—
PUNCHED CARD EQUIPMENT		
CD20-AA/AB	Card Reader and Controller; tabletop mounting; 300 cpm	6,600	116
CD20-CA/CB	Card Reader and Controller; free-standing, 1200 cpm	23,300	199
PUNCHED TAPE EQUIPMENT		
PC20-CL/CM	Paper Tape Reader/Punch; includes cabinet and power supplied; requires external I/O bus interface DIB-20; 300 cpm Reader, 50 cps Punch	15,500	152
DIB-20	External I/O Bus Interface	5,900	49

*Monthly maintenance is 5-day, 12 hours per day DECservice except for 2020 packages and terminal products; MS10-BA, MS10-HA, MS10-LA, RM03-A, TAU45-EC/ED, DZ11-AA, DZ11-BA, DF01-A, LA36-C, LA36-H, LA37-C, LA37-P, LA38-G, LA38-H, LA120-BA, LA180-EA/ED, LA180-P, VT61-A, VT62-A, VT100-A and VT1XX-A. For 2020 products, the quoted figure is DECservice for an eight hour day, 5 day week. For terminal products the quoted figure is the eight hour Basic maintenance.