Honeywell DPS 4

MANAGEMENT SUMMARY

The small-scale DPS 4 multi-processor computer is designed for business data processing or data communications and can be operated in normal office environments. Intended as an eventual Level 62 replacement, the DPS 4 provides improved price/performance, maintains complete application software compatibility, and offers support of up to 15 concurrent batch, interactive, and communications programs. The entry-level DPS 4 is equivalent to the largest Level 62 models, and the top of the line DPS 4 offers 5.3 times the power.

Announced in April 1980 in Italy, the U.K., and Canada, the DPS 4 provides a smooth Level 62 user migration path. Honeywell emphasizes the compatibility of the two systems which enables DPS 4 equipment to run alongside and in conjunction with existing Level 62 small computers.

The Italian-developed and built DPS 4 is a bus-oriented system using a minimum of four processors dedicated to handling instruction execution, input/output, disk files, and memory management. Optional processors are available for multi-line communications, emulation, and foreign disk files. Each system can have multiple CPU's plus multiple special-processor units, the extra processors providing not only more power and configurability, but also high system availability or non-stop operation.

Software support for the DPS 4 system centers on the GCOS operating system. Based on the Level 62 operating system, DPS 4 GCOS is a modular, interrupt-driven operating system that offers both multiprogramming (up to 15 job streams) and multiprocessing capability. It handles any mix of batch, RJE, interactive, transactional, and satellite processing jobs, and features spooling dynamic memory allocation, automatic job scheduling, and fail-safe facilities that allow the system to survive certain memory, peripheral, and even processor failures.

Based on a new multi-processor architecture, the DPS 4 is an upgrade from, and eventual replacement for the Level 62 systems, providing improved price/performance with operating system and application software compatibility. The DPS 4 has a 32-bit system bus connecting specialized processors that can be configured for non-stop operation. The machine architecture, in conjunction with the GCOS 4 operating system, supports multi-programming of up to 15 interactive job streams. Computing power can be expanded 530% on site. An entry-level system with 256K bytes of memory, 56 megabytes of disk storage, video console, two workstations, and a matrix printer is priced under £30,000.

CHARACTERISTICS

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MODELS: The DPS 4 is a modular multi-processor system consisting of a minimum of four independent processors dedicated to various tasks. An entry-level DPS 4 system can be expanded to include up to three CPU's, two I/O processors, two disk processors, two main memory processors, and up to three network processors.

For the larger user, Honeywell's DPS 4 computer can include up to a total of 12 processors. The picture shows a large configuration including double-sized central processor cabinet, 792 megabytes of removable disk storage, two printers, and visual display terminals—all operating in a normal office environment.

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CHARACTERISTICS OF THE DPS 4

SYSTEM CHARACTERISTICS	
Date of introduction	April 2, 1980
Date of first delivery	Italy and Canada, July 1980; UK, June 1980
Number installed to date	Italy—533; UK—55; Canada—70
MAIN STORAGE	
Type	MOS/EDAC
Cycle time, nanoseconds	520
Minimum capacity, bytes	262,144
Maximum capacity, bytes	2,097,152
Increment size, K bytes	128 to 512K, 256 over 512K
Bytes fetched per cycle	4
CENTRAL PROCESSOR	
Number of registers	29 std., 4 opt.
Number of instructions	141 std., 24 opt.
CONTROL MEMORY	
Type	Bipolar
Cycle time, nanoseconds	120 (resident), 350 (transient)
Capacity, K words	64K (resident), 24K (transient)
Bytes fetched per cycle	2 (plus 4 parity bits)
INPUT/OUTPUT CONTROL	
Maximum channels	8
Maximum channel data rate, bytes per second	1,800,000
CONFIGURATION	
Minimum disk capacity, megabytes	56
Maximum disk capacity, megabytes	3,600
Magnetic tape transports, maximum	6
Communications lines, maximum	8 + 96 via MLCP

The modularity of GCOS ensures maximum user memory space. Only the supervisor module is permanently resident and this calls in the other modules as required. The system is available in two sizes: GCOS OS1, which can support most single-IDP (Interior Decor Processor) systems; and GCOS OS2, whose larger supervisor module can handle multiple-processor systems and networks that require maximum response speed.

An integral feature of GCOS is the Interactive Processing System (IPS) which gives DPS users a wide variety of easy to use computing options offered 'menu-style' on terminal screens. Users can interactively create, display and print files; define and produce reports; and enter data, modify records and make file inquiries.

IPS also allows terminal users to carry out program development and compilation, launch programs, inspect jobs during run-time, and access job print-out reports for examination on-screen.

GCOS provides three high-level programming languages, ANS COBOL-74, RPG II, and ANS FORTRAN. These provide wide-ranging diagnostic and debugging facilities, explicit and implicit program segmentation and extensive library facilities to aid development of users' programs.

DATA FORMATS

BASIC UNITS: 8-bit byte (plus parity bit). Each byte can represent one alphanumeric character, two packed BCD digits, or eight binary bits.

FIXED-POINT OPERANDS: 16-bit word in short form, 32-bit doublewords in long form. Operands are interpreted as signed, using the leftmost bit for sign storage.

FLOATING-POINT OPERANDS: 32-bit single-precision numbers or 64-bit double-precision numbers. The exponent is 7 bits including sign, and the fraction is 57 bits including sign.

INSTRUCTIONS: 141 plus 24 for floating point.

INTERNAL CODE: ASCII.

MAIN MEMORY

TYPE: Metal oxide semiconductor (MOS/EDAC) 16-bit chips; 64K-bit chips are planned for future use.

CAPACITY: See characteristics table.

CYCLE TIME: 520 nanoseconds per 4-byte access (i.e., read, memory refresh and write back).

CHECKING: Every Main Memory Unit (MMU) is provided with Error Correcting Code (ECC), which detects all memory parity errors and corrects them automatically. Every instruction extracted is double-checked for accuracy, and errors in reading or writing data are automatically trapped and corrected by the system. In the event of an error in the execution phase, each instruction is retried automatically up to 16 times.

STORAGE PROTECTION: A protective lock on records accessed in update or output mode prevents simultaneous modification of data by two users. The availability of password protection at both terminal and transaction levels allows the selective enforcement of privacy. Additionally, a wide range of safeguards helps ensure the correct handling of data during transaction processing. If an error occurs during the processing of a transaction, user files are not affected; the transaction is terminated and can be performed again. If an error occurs during user file update, access to the user file is inhibited and transactions accessing that file are terminated; log and work files can be used to restore the integrity of the user file. If an error occurs while a transaction is reading a file, the transaction is terminated and the system operator has the option of inhibiting further access to the file.

CENTRAL PROCESSOR

GENERAL: The DPS 4 system architecture is based on a series of processors operating together in a multi-processor environment. The processors are physically separated and independent of one another, but are logically linked by a 32 data-bit (98 bit) wide system bus.

Each processor is specialized and comprises two logical blocks: a Generalized Computing Unit (GCU) which provides universal processing facilities through a generalized micro-instruction set, and special firmware and hardware which 'personalizes' the basic GCU to carry out particular functions. The GCU of every processor consists of a microprocessor, LSI circuits, and both Random Access Memory (RAM) and Read-Only Memory (ROM). Each GCU has its own direct debugging interface and automatically enters self-diagnostic mode when not executing a system function.

The following processors and logical blocks comprise the main DPS 4 system:

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Honeywell also offers a large number of TRANSIT software conversion routines which permit users to convert existing programs for operation on DPS 4 systems.

Applications software includes a distribution inventory management system (DIMS), a sales order processing system (SOP), a general ledger system, accounts payable/receivable systems, payroll systems, and the Honeywell Industrial Management System (IMS-TD).

An entry-level DPS 4 system consists of four dedicated processors, 256K bytes of memory, 56 megabytes of disk storage, video console, two workstations, and a matrix printer.

A maximum of twelve dedicated processing units can be connected to the DPS 4 system bus, including two main memory units, yielding a maximum memory of two megabytes. A theoretical maximum of almost 1,000 workstations can be supported over 96 additional communications lines, provided by the inclusion of Multi-Line Communications Processors. Mass storage can be expanded to 3,600 megabytes, and additional printers with speeds ranging from 160 characters per second to 800 lines per minute can be configured to the system. Other peripherals include magnetic tape units and card readers.

Main memory is currently implemented in large-scale integrated MOS technology with a density of 16K bits per chip; 64K-bit chips are planned for the future. Up to two Main Memory Units (MMU's) can be configured to a DPS 4 system, providing a maximum of two million bytes of memory. Memory can be expanded from 256K bytes in 128K or 256K byte increments.

Each DPS 4 disk processor can handle up to six 300-megabyte disk drives. Two such disk processors provide a mass storage capacity of 3.6 million bytes. Peripheral equipment includes printers with speeds ranging from 160 characters per second to 800 lines per minute, magnetic tape units, and card readers.

Each Multi-Line Communications Processor (MLCP) provides up to 32 communications lines offering local or remote connection; synchronous, asynchronous, or current loop connection; and throughput of 200K bits per second. Three such processors can be linked to the DPS 4 system bus, providing 96 additional communications lines for supporting almost 1,000 workstations.

The number of terminals that can be connected to a single line depends on the terminal class. Unbuffered terminals (TTY-like) must be used in point-to-point connections, one terminal to a line. Buffered terminals (VIP-like and ISO-like) are used in multipoint connections, with several terminals on a single line. Computer systems must be used in point-to-point connections, with only one system per line at a time. The GCOS communications system permits different types of terminals to be mixed in the same job stream.

- **Interior Decor Processor (IDP)**
- **Input/Output Processor (IOP)**
- **Disk Processor (DP)**
- **Microprocessor for Main Memory Unit (MMU)**
- **Multi-Line Communications Processor (MLCP)—optional.**

In addition, an Emulator Processor (EDP) and a Foreign Disk Processor (FDP) can be linked to the DPS 4 system bus, which is capable of supporting up to 12 physical processors.

The Interior Decor Processor (IDP) fetches and executes each program instruction. Its microinstruction set is a superset of the Level 62 instruction set; thus full program compatibility at object code level is assured.

The IDP has three levels yielding relative performance measurements of 1.0, 1.3 times, or 2.1 times that of the top of the line 62/35. A maximum of three IDPs can be linked to the DPS 4 bus, boosting performance to 3.8 times or 5.3 times the 62/35.

The functions of the Input/Output Processor (IOP) are to handle the basic input/output of data to and from low-speed peripherals (e.g., console, diskettes, card readers, magnetic tapes, printers), and to provide up to eight communications lines which can be used to control up to 40 local or remote terminals. Up to two IOPs can be configured to a DPS 4 system.

The Disk Processor (DP) can handle up to six drives of various capacities, the largest being a 300-megabyte removable disk model. Two such disk processors can be configured, yielding a maximum storage capacity of 3,600 megabytes.

The Main Memory Unit (MMU) contains its own microprocessor which handles the temporary storage of data and programs in the main memory and controls the flow of information between all the different microprocessors. One or two MMUs can be connected simultaneously to each system, providing up to two megabytes of memory.

The Mulit-Line Communications Processor (MLCP) is optional, providing users with up to 96 communications lines from the IOP. The MLCP offers local or remote connection of any line; synchronous, asynchronous, or current loop connection of any pair of lines; throughput of 20K bits/second (each MLCP); and maximum individual line speeds of 72K bits/second. The MLCP also provides all programmed control functions over the whole of its intrinsic communications network (polling, selection, error handling, etc.).

The Emulator Processor (EP) includes a special Interior Decor Processor (IDP) microprogrammed to execute the instruction set of an emulated machine in coexistence with the native IDP.

The Foreign Disk Processor (FDP) enables disk units from another computer to be connected to DPS 4.

PHYSICAL SPECIFICATIONS: DPS 4 central processor systems are supplied in cabinets of different sizes to suit various operating requirements. The smallest cabinet is 1 meter long and may contain 4 processors or logic blocks in addition to the basic power supply, console and integrated diskette.

The standard cabinet measures 1.5 meters and contains six processors. A third cabinet is available as an extension for

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When the operating system is generated, the user must select the number and types of lines as well as the specific types of terminals to be used in the communications network. The following classes of terminals are supported by the DPS 4 hardware and software: TTY-like, VIP-like, ISO-like, and computer system and terminals that support the IBM HASP multi-leaving and Binary Synchronous Communications protocols for the support of 2780- and 3270-like devices.

Honeywell has implemented its Remote Maintenance System (RMS) in the DPS 4. RMS permits field engineering personnel to diagnose hardware, firmware, software, and operational "how-to-use" problems from a remote location. One major benefit that users can derive from RMS is the diagnosis of software problems and implementation of repairs by vendor personnel without the need for site visits or taking the system down for maintenance.

COMPATIBILITY AND COMPETITION

Honeywell Information Systems Limited introduced the DPS 4 into the U.K. market to compete with International Computer Ltd.'s ME29, launched one month earlier. The DPS 4 is also expected to overlap and therefore compete against the recently introduced Sperry Univac System 80. With deliveries strategically set to begin in July 1980, HIS planned to go after the IBM System/34 base by taking advantage of the delayed IBM System/38 deliveries.

Honeywell offers TRANSIT conversion packages enabling users of the IBM System/32, System 360/20, and System/3 to convert RPG II programs and files to DPS 4 RPG. In addition, users can migrate from the ICL 1900 Series or 2903/2904 Series—whether using PLAN or COBOL—as well as from the NCR Century Series. Source COBOL and MiniCOBOL programs can be transferred from Honeywell's Series 200/2000 or Level 62 systems or DPS 4. □

larger configurations: also 1.5 meters long, it can contain six extra processors and a power supply. The extra processors may be used to provide additional power and configurability or to provide a high availability or non-stop system.

When maximum availability of system resources is a fundamental requirement, a duplicate (or triplicate) of each processor or logic block can be configured to provide either extra power or idle standby until a major system failure occurs.

REMOTE MAINTENANCE SYSTEM (RMS): A standard feature of the DPS 4 system is Honeywell's Remote Maintenance System (RMS). Designed to provide immediate remote assistance for any problem, it allows Honeywell to access the system, with the user's agreement, to help in problem diagnosis. Three types of service are offered: one that answers how-to-use problems; another that responds to software and firmware needs with a down-the-line patch; and a third that identifies a hardware fault and the required replacement part. Honeywell's access to the system is fully controlled by the user and complete security is assured automatically.

CONTROL STORE: Each generalized computing unit has a control store comprising two areas: resident microcode, stored in 8K bipolar PROMs and transient microcode, stored in 4K MOS RAMs. Up to 64K words are available for resident microcode, with an access time of 120 nanoseconds per word. 24K words of transient microcode are currently implemented, with an access time of 350 nanoseconds per word.

ADDRESSING: Four levels.

INSTRUCTION REPERTOIRE: The DPS 4 has an instruction set that includes arithmetic instructions for performing decimal and binary operations (add, subtract, multiply, and divide) on packed or unpacked data, logical operations, editing functions, and operations for address computations. The IDP executes 141 instructions. Operands can be binary, fixed point or decimal; in packed or unpacked format; on bytes, byte strings, or bit strings. The optional Scientific Instruction Set adds 24 instructions and floating point capabilities.

INTERRUPTS: Interrupt signals are generated by conditions such as successful completion of I/O operations, I/O errors, arithmetic overflow, timer runout, attempts to reference out-of-bounds storage locations, etc. Interrupts are referred to microprogrammed routines located in the GCU read-only memory for initiation of the appropriate servicing routines.

CONSOLE: The console for controlling and communicating with a DPS 4 system consists of devices and elements which allow the operator to start and run the system. System start-up begins with the operator pressing the "Power On" and "reset" buttons on the control panel and continues by means of a simple dialogue between the operator and the system. This system dialogue takes place at the console station, which is either a video or printer console.

SYSTEM OPERATOR PANEL: The system operator panel contains the main power switches (Power On, Power Off, Reset) and status indicator lights (AC PRESENT, DC ON, MAINT, TRAFFIC, SYSTEM ERROR). The system operator panel is positioned in the top left-hand corner on the front of the main cabinet. The panel is built into the front of a drawer that can be opened to display the system fault stautus and power-on clock indicators.

CSU 3002 VIDEO CONSOLE: This video console provides conversational message transfer, status display, and operator control facilities. The console consists of a 12-inch CRT display unit, providing 24 lines of 80 characters each and a separate keyboard with 86 keys with multi-key depression/protection features. The console can generate 95 ASCII upper and lower case characters, and a full 129 ASCII code character-set. A log of the operator/system dialogue is maintained on a system disk file when the video console is used. The log can be recalled interactively on the screen and may also be output on the main system printer.

CSU3001 PRINTER CONSOLE: This printer console provides the same conversational message transfer, status display and operator facilities as the CSU 3002, but in hard copy form. The printer itself has a dot-matrix serial mechanism with print speeds of 30 or 120 characters per second. The keyboard is divided into two major areas: one is a touch-typing area, which closely resembles a standard typewriter keyboard. The other incorporates keys which provide a number of controls over the functions of a DPS 4 system. Up to four copies can be provided when using multi-part stationery.

INPUT/OUTPUT CONTROL

I/O CHANNELS: The Input/Output Processor (IOP) handles the basic input/output of data to and from unit

record devices. The maximum data rate for eight communications lines may not exceed 50K bits/second, and no one line may exceed 9,600 bits/second.

SIMULTANEOUS OPERATIONS: The independent DPS 4 processors are able to work in parallel, executing several diverse operations concurrently. For example, while the appropriate processor (IOP) receives and handles the input data, a disk processor (DP) can take charge of filing other data on magnetic disks; meanwhile, the IDP (Interior Decor Processor) processes other data. The DPS 4 can support a maximum of 15 job streams, plus full spooling.

CONFIGURATION RULES

An entry-level DPS 4 system comprises four processors, 256K bytes of memory, 56 megabytes of fixed/removable disk storage, video console, two workstations, and a matrix printer. Up to 12 processing units can be connected to the system bus, (3 IDPs, 2 IOPs, 3 MLCPs, 2 DPs, 1 EP, and 1 FDP available in combinations) and two main memory units can be supported, yielding a maximum memory capacity of two megabytes. By inclusion of Multi-Line Communications Processors, 96 additional communications lines are available for supporting almost 1,000 workstations. Mass storage can be expanded to 3,600 megabytes, and additional printers with speeds ranging from 160 characters/second to 800 lines/minute can be configured to the system. Other peripherals include magnetic tape units and card readers.

MASS STORAGE

MSU1640/1680 MASS STORAGE UNITS: The MSU1640 unit consists of a 16-million byte removable disk cartridge and a three-platter fixed disk containing 40 million bytes, providing a total capacity of 56 million bytes. The removable cartridge records up to 20,160 bytes per track on 808 tracks, and the fixed disk records 100,800 bytes per cylinder with 404 cylinders available. Average access time is 25 milliseconds, average rotational delay is 8.3 milliseconds, and rotational speed is 3600 rpm. The data transfer rate is 1.2 million bytes/second. The MSU 1680 uses a double-density version of the three-platter fixed disk, providing 80 million bytes in addition to the 16-million byte capacity of the removable cartridge, for a total of 96 million bytes. Two such units can be housed in a single cabinet, providing a capacity of 192 million bytes.

MSU0337/0338 MASS STORAGE UNITS: Each unit consists of a five-platter removable disk pack providing 80 million bytes. Two such units can be housed in a cabinet; the MSU0337 is housed in the top drawer, and the MSU0338 in the lower drawer. Capacity per cabinet is 160 million bytes. 19.8 kilobytes of data are recorded per track, with 4040 tracks per pack. Average disk seek time is 300 milliseconds, average latency is 8.3 millseconds, and rotational speed is 3600 rpm. Transfer rate is 1.2 million bytes per second.

MSU1080/1160 MASS STORAGE UNITS: The MSU1080 and MSU1160 disk drives provide storage capacities of 80 million and 160 million bytes respectively. These devices are housed in a cabinet that can contain one or two equal-capacity disk drives. The MSU1081 and MSU1161 are similar to the MSU1080 and MSU1160, but are housed in the lower drawer of the cabinet. Thus, a complete cabinet could contain either two 80-million byte drives or two 160-million byte drives. Average access times are 38.3 milliseconds for the MSU1080/81, and 38.3 milliseconds for the MSU1160/61.

MSU0370/380/390 MASS STORAGE UNITS: The MSU0370, MSU0380, and MSU0390 disk units provide storage capacities of 100, 200, and 300 million bytes respectively, each on a 12-platter removable disk pack. Average access time for each disk unit is 31.3 milliseconds.

DISKETTE UNITS: A central cabinet can house one or two diskette units, offering both single-sided, single-density and double-sided, double-density diskettes.

Each single-sided, single-density diskette has 77 tracks. The first is an index track and the last two are reserved for use if errors are found on any of the other tracks. Data is stored in the remaining 74 tracks, giving a total capacity of 240K, 277K, or 296K bytes (depending on the number and length of the sectors into which each track is subdivided). Transfer rate is 32K bytes/second.

Each double-sided, double-density diskette has 77 tracks per side for a total of 154 tracks per diskette. Data is stored on 148 tracks, giving a total capacity of 962K or 1184K bytes (depending on the number and length of the sectors). Transfer rate is 64K bytes/second.

INPUT/OUTPUT UNITS

MTU0100/0101 MAGNETIC TAPE UNITS: The MTU0100 master unit supports two tape transports and controls the operation of MTU0101 dual transport slave units. The drives operate at 18.75 ips and are available as 9-track, 1600 bpi, PE, 30,000 bytes/second units, or optionally, as 7-track, 200/556/800 bpi, NRZI units. A 9-track, 800/1600 bpi, NRZI/PE dual density version is also available. Drives of different configurations can be intermixed.

MTU0200/0201 MAGNETIC TAPE UNITS: These units differ from the MTU0100/0101 units only in tape transport speed, which is 37.5 ips, and in data transfer rates, which are twice as high.

CRU0300/0500 CARD READERS: These units read 80-column cards at either 300 cpm (CRU0300) or 500 cpm (CRU0500). Both units feature mark-sense options that permit reading of mark-sense cards in either Honeywell or IBM mode. Cards are read column by column, and each column is read twice to eliminate errors. The input hopper and output stacker each hold up to 1000 cards.

CRU0306 CARD READER: This unit reads 96-column cards at a speed of 300 cpm. The CPA2016 addressing feature is required with this reader. The input hopper and output stacker each hold up to 600 cards.

PRU0050/51 LINE PRINTERS: These models print 75 lines per minute using a 64-character set. Characters are formed in a 7 by 7 dot matrix. Print format is 10 characters/inch and 6 lines/inch. Line width is 132 characters.

PRU0055/56 LINE PRINTERS: These models are bi-directional versions of the PRU0050/51 printers and operate at 150 lines per minute.

PRU0308/309 BELT PRINTERS: These units print 300 lines per minute using a print belt/cartridge with a 64-character set. The standard format is 132 print positions per line, spaced 10 characters per inch, with 6 or 8 lines per inch vertical spacing.

PRU0448/449 BELT PRINTERS: These belt-type units print 400 lines per minute with a 64-character set. Each line can contain up to 132 positions. Five carbon or 10 non-carbon copies can be printed.

PRU0648/649 BELT PRINTERS: These models have the same characteristics as the PRU0448/449, but can print at a speed of 600 lines per minute.

PRU0848/849 BELT PRINTERS: These models are similar to the PRU0448/449, but can print 800 lines per minute.

TERMINALS: DPS 4 will support TTY-like, asynchronous, unbuffered terminals such as TTY33/36/37/38, TN300,

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TTU8124/8126, TE318, DTS7200, and DTU7170; VIP-like, synchronous, buffered terminals such as VIP7700/7760, VIP7001/7006, VIP7250/7255, VIP 7852, KDS7255/7265, KDU7250, and Incoterm's 770/RDE; Olivetti synchronous buffered terminals such as TCV260/275, TC349 BI, and TC380/800; and other processors and terminals that support IBM's Binary Synchronous Communications protocol including Honeywell Series 60 Level 61, 62, 64, and 66; IBM's System/370 computers and 3741 terminals; and Olivetti's TCV275 terminals in BSC3 mode.

The number of terminals that can be connected to a single line depends on the terminal class. Unbuffered terminals (TTY-like) must be used in point-to-point connections, one terminal to a line. Buffered terminals (VIP-like and ISO-like) are used in multipoint connections, with several terminals on a single line. Computer systems must be used in point-to-point connections, with only one system per line at a time. The GCOS communications system permits different types of terminals to be mixed in the same job stream.

COMMUNICATIONS CONTROL

The input/output processor, common to all DPS 4 systems, provides an initial set of communication line connections that can be used for terminal or computer-to-computer links. It provides up to eight line connections, giving a maximum individual line speed of 9,600 bits per second and a total throughput of 50,000 bits per second.

Up to three Multi-Line Communications Processors may also be connected. Each processor may support up to 32 communications lines, giving a maximum line speed of 72,000 bits per second and a total throughput of 200,000 bits per second (each MLCP). The 96 communication lines may all be synchronous, asynchronous, current loop, or a mixture of all three. The DPS 4 provides remote, direct, point-to-point connections to terminals and to other computers.

A DPS 4 communication system is physically subdivided into pairs of lines. The user can select pairs of synchronous and/or asynchronous lines (with standard EIA RS 232, CCITT or current-loop interfaces). Each line can be specialized for remote connection (via a modem) or for direct connection (up to 3,000 feet).

SOFTWARE

OPERATING SYSTEM: The DPS 4 system runs under the GCOS 4 operating system which is based on the Level 62 GCOS operating system. GCOS 4 features multiprogramming, spooling, dynamic memory management and fail-soft operations. System resources are allocated at the beginning of a job step and de-allocated at the end of a job step. If resources required for a job step are not available, the job step is placed in a "wait queue." The job is automatically started when resources become available. Up to 15 job streams can be processed concurrently, limited only by the amount of physical memory present in the system. GCOS also maintains a "run queue," a list of jobs ready for initiation. Whenever an executing job is interrupted, the operating system selects a ready-to-run job from the run queue and processes the job.

The spooling feature employs a scheduling facility to optimize the use of system resources. It restricts the direct use of slower peripherals (such as card readers, cassette tape drives, diskette drives, and line printers) to system programs called Input Readers (IR's) and Output Writers (IW's).

IR's read input streams job-by-job onto a spooling file. An IR occupies 14K bytes of memory and can be permanently memory resident or used in a roll-in mode so that its memory space is released to user programs when all of the job description statements have been read. When user programs terminate, the IR can be reloaded to process additional job description statements. Two or more IR's can be used concurrently.

The spooling file is a special sytem file which stores job description statements awaiting execution, data associated with those jobs, and output reports awaiting printing.

The dynamic main memory feature provides automatic memory management. GCOS maintains a map of the locations and sizes of all available memory areas. When a job requires additional memory space, the operating system searches the map for a suitable area and assigns the area to the requesting activity. If no single area is large enough to accommodate the request, GCOS dynamically reallocates memory areas to create one contiguous area large enough to accommodate the request.

GCOS 4 uses segment-relative addressing to optimize the use of main memory. All programs are executed as fully relocatable segments. Machine instructions refer to segment-relative addresses, without regard to the physical location of the referenced operand. A segment may reside anywhere in memory, and at different times may reside in different places.

With GCOS, the segments of a program are defined by the compilers and, optionally, under the control of the programmer. Segments are variable in length, permitting the segmentation to follow the logic of the program and ensuring that distinct elements, such as iterative loops, are not split between segments.

When a program is ready for execution, the Initiator routine first loads a portion of the memory image onto the system disk file and subsequently loads the core image into memory.

Whenever a new segment is needed, GCOS searches main memory for a large enough space to load the segment. If there is no space large enough, GCOS relocates the segments already in memory to collect all available space into one continuous area. As a last resort, GCOS may remove the least active segment in main memory to make room for a new segment. The removed segment is only written back to disk if it has been changed while in memory. Instruction coding is re-entrant. Therefore, these segments never have to be written back to disk and can be overlaid. Swapping and moving of the segments is invisible to the programmer, who has apparent access to a memory capacity equal to the size of the backing store.

Job flow through the system is controlled by GCOS job management. The input reader reads the job input while other jobs are executing and translates the job control information into an internal format to speed job processing. A job scheduler schedules the execution of the jobs using a system of job classes and priorities within each class. Resources are allocated at file, volume, and device levels to each job step, and deallocated when each job step is completed. GCOS allocates resources to job steps rather than to whole jobs to ensure effective use of the available resources. Space is allocated for files, and files are assigned to programs at the start of the job step requesting them. The files are then unassigned, and space for temporary files is normally released as soon as the job step has completed.

When assigning a file, the user defines the file as either permanent or temporary. If the user wishes to retain a temporary file for several job steps, a parameter in the ASSIGN statement prevents the file space from being released until the end of the job.

To request space for a file, the user specifies the type of device, the identity of the volume, and the amount of space required. GCOS then searches the specified volume and automatically

allocates any space available. Disk space need not be contiguous; GCOS can allocate space for a file using up to 16 extents on any one volume, and can spread the file over a number of volumes if required.

When a new file is created, file management automatically creates the appropriate labels, and these are subsequently checked every time the file is opened for processing. On disk, labels are stored in a special area called the volume table of contents (VTOC). On tape, the labels are created at the head and tail of each file. Disk files are shareable under GCOS 4.

The GCOS 4 data management facilities support five file organizations: sequential, indexed, relative, queued-partitioned, and queued-linked. The latter two organizations are used only by the GCOS operationg system and are transparent to the users.

Sequential files are organized soley on the basis of their successive physical locations in the file. The records are also arranged in a logical sequence according to their keys as well as in physical sequence, and are usually read or updated in the same order they appear.

Indexed files are similar to sequential files in that rapid sequential processing is possible. The indexed organization makes it also possible to locate individual records quickly for direct (random) processing. Moreover, new records can be inserted by referring to sequentially ordered indexes associated with the file and physically added at the end of the file. This makes it unnecessary to rewrite the entire file, a process that would usually be requred when adding records to a sequential file. Although the added records are not physically in key sequence, the indexes make it possible to retrieve the added records in key sequence, permitting rapid sequential processing. The retrieval of records added to the file can be accomplished immediately and without any need to sort the index. Two types of records are available for indexed organization: primary records (P-records), which are logical records that have a key and associated disk address in the main index, and complementary records (C-records), which are logical records that do not have index entries in the main index. Each C-record is associated with a P-record via a pointer in the P-record. A C-record can in turn point to another C-record.

The indexed file organization permits up to eight secondary indexes to be created by a utility program that constructs index entries according to a key, other than the prime key, without distinguishing between P-records and C-records.

Relative files are characterized by a predictable relationship between the key of each record and the address of that record on a disk device. This relationship is established by the user. Relative file organization is used when the time required to locate individual records must be kept to an absolute minimum. This technique is useful for direct inquiry and transaction processing systems in which file size is relatively stable and the control field (key) can be easily used to develop a relative record number.

The GCOS fail-soft feature allows the operator to reconfigure at the Main Memory Unit Level in the event of a memory failure, or to bypass or make a substitution for certain malfunctioning processors and peripheral devices. If a memory module fails, only those jobs directly affected by the failure are aborted. The operator can allow unaffected jobs to run to completion and then reconfigure the Main Memory Unit, or all executing jobs can be suspended, memory reconfigured, and suspended jobs restarted.

INTERACTIVE PROCESSING SYSTEM (IPS): The Interactive Processing System provides comprehensive computing facilities to terminal users. User-written programs and system functions, interactive applications, and batch applications are all equally available to both local and remote terminals.

IPS comprises five sub-modules. The *Interactive System Management* (ISM) and the *Interactive Screen Formatting Service* (ISFS) are always available in an IPS environment. Facilities optionally available include *Interactive Job Management* (IJM), *Transaction Programming System* (TPS), and *Interactive File Service* (IFS).

INTERACTIVE SYSTEM MANAGEMENT (ISM): ISM facilities allow the system administrator to generate the required IPS environment, to maintain the environment and to ensure the efficient and satisfactory availability of IPS to its various users, to control the security aspects of IPS, including the creation and maintenance of each user menu, to control passwords to user and file names, and to create back-up copies of the IPS support file after a system failure (such as a power failure) and to restart the interrupted IPS session.

INTERACTIVE SCREEN FORMATTING SERVICE (ISFS): ISFS is used for interactive compilation of screen formats used in data entry.

INTERACTIVE JOB MANAGEMENT (IJM): IJM provides the terminal user with a set of interactive facilities that include text editing and the use of the system's batch processing capabilities. Data entry, verification, editing, display and remote printing are available for both unformatted and formatted subfiles stored within the IPS support file. Unformatted data subfiles contain data entered and edited as complete screens, using one or more screen formats prepared by means of the Interactive Screen Formatting Service (ISFS).

Job descriptions of any type of job can be prepared and submitted for execution under the Interactive Job Management facility. If a terminal user wants to know the status of his submitted jobs as well as the status of any other job in the system, the system will automatically provide this information at specified time intervals, and upon specific request. Reports in the spooling file can be inspected from a terminal and displayed on a screen or printed. Source programs in COBOL, RPG, and FORTRAN can be entered and edited. Programs can be compiled, linked, and tested; any of the standard DPS 4 system control utilities can be used.

TRANSACTION PROCESSING SYSTEM (TPS): TPS permits users to execute real-time functions through a network of terminals. These functions are user-defined interactive transactional programs (ITP's) and are developed using COBOL and an RPG-like language. TPS manages a set of predefined (active) ITP's each of which may access files that have been declared as belonging to the particular environment of the TPS activity.

Multiple ITP's can be initiated through a user terminal. When this condition occurs, the TPS controls and insures the integrity of each active program and its respective file updating requirements. TPS activities can be run concurrently with other batch or communications activities.

TPS currently supports a wide range of Honeywell and other manufacturers terminals. Terminals cannot directly establish and maintain dialogues with other terminals.

INTERACTIVE FILE SERVICE (IFS): IFS allows the interactive creation and updating of indexed data files. It also provides a means of accessing indexed files for on-line inquiry and report generation applications. IFS processing is carried out by using record selection criteria based on the contents of the various types of records present in a file. Up to 32 record types, based on up to 60 code fields, are permitted. Up to five

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secondary indexes can be used to access records, in addition to the primary index. Both primary and complementary records can be accessed. Report creation can include simple arithmetic operations and the creation of decimal accumulator fields at several control-break levels. IFS sorts records dynamically prior to producing a report—simultaneously sorting records for two or more reports, if necessary.

LANGUAGES: Honeywell provides three popular programming languages for DPS 4 systems: COBOL, RPG, and FORTRAN.

DPS 4 COBOL (ANSI 74): This compiler succeeds Honeywell's COBOL-68 and conforms to American National Standard specification X3.23-1974, which includes several enhancements over the older version. The level of implementation of each of the functional processing modules is as follows:

Module	Level of Implementation
Nucleus	2
Table Handling	1
Sequential I/O	2*
Relative I/O	2*
Indexed I/O	2*
Sort	2
Segmentation	2
Inter-Program Communication	1
Debug	2
Library	1
Communications	2

*Not a complete implementation.

Three modules are incomplete implementations of the indicated levels. The Sequential I/O module omits variable-length and spanned record capabilities, and the indexed I/O module omits ALTERNATE KEY and variable-length record capabilities.

Honeywell, however, has implemented enhancements of its own design in certain modules. The Indexed I/O module has provisions for complementary records, and the Communications module has extensions that improve message processing. In addition, the Nucleus module contains enhancements to some basic functions.

Features not in COBOL-68 and added to the COBOL-74 compiler include: augmented debugging facilities that permit users to specify the debugging techniques in the program and later eliminate them from the final compilation; improved capabilities for terminal communications; the ability to call other programs, including those written in other languages; device independence for sequential files; enhanced text copying capabilities, expanded sequential file functions, and improved indexed I/O techniques that effectively enlarge mass storage capacity.

The compiler is disk-resident and accepts input from 80- or 96-column cards or from the source unit library disk. It produces object-code modules from disk work files that can be linked into executable load modules. Users can specify different equipment environments at compile time and at execution time. Compilation can be performed from mixed peripheral inputs or the source library, since all input is integrated into common disk work files.

Comprehensive diagnostic and debugging tools are included with DPS 4 COBOL. The diagnostic routines produce listings, data maps, card maps, and cross-reference listings. The debugging routines permit specification of data items and procedures to be monitored during program execution. All debugging statements can be automatically omitted from the compilation once the program is finished.

The DPS 4 COBOL compiler requires 40K bytes of main memory, one line printer, one sequential input device, and one mass storage unit.

FORTRAN: DPS 4 FORTRAN is a version of ANSI FORTRAN IV with some extensions. The language processor consists of two packages, the FORTRAN compiler and the FORTRAN run-time package. DPS 4 FORTRAN requires the implementation of the scientific instruction set. The language processor executes either in a compile-only environment (with or without the production of compile units) or in a compile-and-go environment in which the output is submitted directly to a linking loader and the resulting program is executed as part of the job stream. The compiler produces two levels of diagnostic messages: syntax errors and fatal errors.

The DPS 4 GCOS FORTRAN compiler requires the following resources: 36K byes of memory, a disk workfile, and input/output and listing files.

RPG: the RPG compiler used in DPS 4 systems permits the interchange of data files among RPG, FORTRAN, and COBOL programs. Object programs written in RPG can also be linked with programs written in COBOL or FORTRAN.

The RPG compiler features automatic file manipulation and disk handling, support for sequential, indexed, and relative file organization, physical sequential reading of indexed files, relative access to index files, device independence of sequential files, dynamic table handling capabilities, and the use of standard data management access routines by object programs.

RPG uses five files: two work files; a compute unit library for the generated program; and two input files, one for job control and one for input data. The processor accepts data from card, tape, or disk, and its output can be directed to any device supported by the GCOS output writer.

The RPG language processor features a fixed logic cycle that uses default values and specifications for certain control functions. The need to make many processing decisions (such as file selection, record input, input record formatting, and description of matching fields) is eliminated by the fixed logic cycle. Record selection and output are reduced to operations described by previously defined specifications rather than by individual procedural statements. During each cycle, the fixed logic presents the user with a single input record already in the form required for calculations. Any number of output records can be produced by one cycle.

The DPS 4 RPG compiler occupies 28,672 bytes of memory, and requires one mass storage unit, one line printer or report out file, and one sequential input device.

OTHER SOFTWARE

The TRANSIT software package is a complete conversion package, containing automatic translators for files and source programs written in COBOL, as well as a comprehensive manual detailing all the steps necessary for complete conversion to a DPS 4 system. The TRANSIT conversion packages allow data files and RPG source programs from IBM System/3, System 360/20, and System/32 to be transferred to a DPS 4. In addition, users can migrate from the ICL 1900 Series or 2903/2904 Series, as well as from the NCR Century Series. Source COBOL and MiniCOBOL programs can be transferred from Honeywell's Series 200/2000 or Level 62 systems to a DPS 4.

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UTILITIES: DPS 4 GCOS provides three utilities to assist users in managing data and testing software.

The SORT routine can handle up to eight record classes. All files to be sorted must be on disk and organized as sequential, indexed, or relative. Output files are organized sequentially. The MERGE routine can process up to five sequentially organized disk input files and can handle up to eight record classes. Omitted records from either the sort or merge routine can be output to an exception file.

The Test Data Generator (TDG) generates data files for debugging user-written programs. TDG produces either indexed or sequential files. The sequential files can be written on disk, tape, or cards; indexed files are only written on disk. The format of the generated records is controlled by definitions submitted to the utility on control cards.

The DPS 4 GCOS General Utility package consists of 15 multi-function utility programs for volume/file management and file/library maintenance. The functions performed by the DPS 4 GCOS utilities include:

- Prepare new disks for use in the system
- Allocate space for new user files and libraries
- De-allocate space for user files and libraries
- Compare any two volumes or files
- Duplicate volumes or files
- Handle all system and user output data via the Output Writer
- Read source decks
- Reproduce source programs
- Copy library members or entire libraries into other libraries
- Move source and object programs between files and libraries
- Merge source programs
- Create indexed files from other file types
- Delete library members
- Re-name source and object programs

APPLICATION PROGRAMS: Packaged programs available for a DPS4 system include Sales Order Processing (order entry, billing and shipment, inventory accounting, and sales analysis); accounts payable/receivable systems for the management of current expenditures and sales ledger transactions; a Distribution Inventory Management System (stock forecasting and amendment); a General Ledger System for classifying, summarizing and recording the cumulative effects of all transactions on assets, liabilities, revenue and expenses; a Payroll System; and the Industrial Management System (IMS-TD) which comprises ten functionally independent modules (inventory reporting, materials requirements planning, bill of materials management, routing and work center management, order/demand management, simulation and standard cost control, master production scheduling, operations sequencing (finite), and capacity requirements planning (infinite). PAYE and NHI routines help UK employers calculate the total tax due to date for weekly and monthly paid employees, and to calculate employees' National Health contributions to date.

Locally developed packages are available in individual countries. To obtain a list of the packages available in your country, contact the local Honeywell office.

PRICING

In common with legal requirements and business practices, the financial arrangements for acquiring DPS 4 differ from country to country. Precise terms must therefore be obtained from the local Honeywell office.

In general, however, hardware and software are priced separately. Hardware can be rented or leased as well as purchased. Software is rented on a monthly basis.

The hardware purchase price may include free maintenance for an initial period after installation with different periods for different categories of equipment.

Hardware rental periods are usually up to two years; leasing is generally for five years. Non-standard periods are negotiable in each case. The hardware rental charge includes maintenance; the leasing charge does not—a separate maintenance contract involving an additional charge is obligatory.

Services such as training, program development, system/network design, implementation and conversion, are also charged separately.

The following hardware and operating system software prices of sample configurations apply only in the United Kingdom, but may be taken as a guide.

EQUIPMENT

Compact-cabinet configuration 1.3 times the power of an entry-level system, and comprising four processors (IDP, IOP, DP and MMU) with 384K memory, 56 megabyte disk (40 megabytes fixed, 16 megabytes removable), 75 lpm printer and two screens: £32,960.

Compact-cabinet system 1.3 times entry-level power, comprising four processors with 512K memory, two 80 megabyte disks, 150 lpm printer and four screens: £44,350

Compact-cabinet system 2.1 times entry-level power comprising four processors with 512K memory, three 80 megabyte disks, 300 lpm printer and seven screens: £64,390

Standard-cabinet system 3.8 times entry-level power comprising six processors (including an extra IDP and an MLCP) four 80 megabyte disks, 600 lpm printer, four 160 cps printers and twelve screens: £113,630.

SOFTWARE: The first three configurations above would utilize GCOS OS1; the fourth, GCOS OS2. Rental for OS1 is £80 per month, and for OS2 is £180 per month. ■