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The Xerox 560 computer system is a highly superior, multi-use computer system which satisfies the most demanding commercial, engineering and real-time data processing requirements. The 560 is targeted directly at the needs of the user. Five concurrent modes of processing offer the user unusual flexibility in the implementation of even the most complex applications; these are multiprogrammed batch, remote batch, conversational timesharing, transaction processing and real-time. Up to 128 time-sharing and transaction processing users, 16 local and/or remote batch jobs, along with multiple real-time tasks, may all simultaneously utilize the resources of the Xerox 560.

The Xerox Control Program-Five (CP-V), the operating system for the Xerox 560, provides a virtual memory capability which maximizes memory utilization as well as increases the effectiveness of other system resources. The modular way in which the Xerox 560 system configuration can be structured assures that a user's current and future requirements will be met with an unusual simplicity and flexibility.

Implemented with state-of-the-art technology in computer, peripheral and software design, the Xerox 560 computer system provides enhanced capabilities; it fulfills the fast throughput, high reliability and ease of use requirements of the multi-use environment, while offering substantially improved price/performance.



Features

Fast Response

The Xerox 560 architecture offers extensive throughput capabilities. The architecture features a multi-unit memory permitting high throughput and a multiple memory bus structure allowing independent processors to simultaneously access memory. Input/output transfers can take place simultaneously with computing operations.

The Xerox 560 architecture offers high configuration flexibility. The modularity of the system elements allows the Xerox 560 system to be optimized for each application.

Reliable Performance

The Xerox 560 control software, Control Program-Five (CP-V), utilizes the capabilities of the Xerox 560 hardware to meet a wide variety of multi-use requirements. The use of the Memory Map and the Master/Slave/Master Protect modes of operation to insure program integrity permit CP-v to offer time-sharing, remote batch, real-time, local batch and transaction processing all running concurrently.

To maximize the availability of the Xerox 560 system, comprehensive reliability and maintainability capabilities are designed into both the hardware and software. Extensive availability features are designed into the Xerox 560 hardware, the Diagnostic Programming System, and CP-v. Operating within a hierarchial structure, this capability permits verification of each level of system operation before proceeding to test the next. The Xerox Remote Assist capability further enhances maintainability by permitting all diagnostic operations to be controlled remotely via a telephone connection.

The Xerox 560 computer achieves maximum availability. The watchdog timer monitors instruction execution time to assure that instructions exceeding the maximum time allowed for their completion do not affect system integrity. The power monitor automatically shuts down and then resumes processing in the event of a transient power failure.

Ease of Use

The Xerox 560 computer system allows you to select the optimum programming processor needed to meet your requirements. A comprehensive set of programming languages from assemblers through compilers to interpreters is available, in addition to problem-oriented languages which do not require a knowledge of programming to get your job done.

The Xerox 560 computer allows you to develop fast running, tightly coded programs quickly and easily. The Xerox 560 offers a comprehensive set of instructions, requiring only two instruction formats. Index registers automatically align themselves to the data type being accessed.

The File Management System offers identical services to programs operating in any of the processing modes. On-line and batch programs may simultaneously access the same data base. The system provides enqueue/dequeue facilities to allow a program to access a data base being utilized by others, totally transparent to the other user programs and the data base.

When a special requirement is outside the Xerox 560 system's broad range of capabilities, Xerox will help. The Xerox Custom Systems organization will assist in defining these requirements and in identifying and optimizing potential solutions. If requested, Xerox will also implement such solutions including hardware development, software development, system integration and documentation. The Xerox Application Services organization can handle your complete conversion requirements. Application Services will assist you in achieving your program conversion objectives in a controlled and orderly manner. Application Services is prepared to provide fixed-task, fixed-price services ranging from program translation to complete operational system testing.



Hardware

Architecture

Architecture The architecture of the Xerox 560 system is both flexible and modular. Only the elements required for each application need be included in a 560 system. If these requirements subsequently change, so can the 560 configuration.

Main Memory Main memory is divided into units, each of which may be accessed simultaneously. This overlap greatly increases total memory bandwidth. To automatically increase the occurrence of access overlap, unit addressing may be interleaved. The number of units and their size can be selected for the application.

Memory Bus Structure The parallel memory bus structure allows all clusters to independently access main memory. Each bus serves one cluster and has a port into each memory unit. Clusters may access different memory units simultaneously. Coincident accesses to a single unit are serviced by port priorities.

Cluster Configuration Clusters are groups of processors which are available in two standard configurations - the Basic Cluster and the I/O Cluster. The 560 Basic Cluster includes a Basic Processor and a Multiplexer Input/Output Processor (MIOP). Along with a System Control Processor, the Basic Cluster incorporates all the computing capability required for many applications. Each Input/ Output Cluster permits adding up to three additional MIOPs and one high-speed Rotating Memory Processor (RMP). Processors within a cluster share the bandwidth of a single memory bus but access memory independently. Additional Basic and I/O Clusters may be configured as required by each application.

System Control Processor The System Control Processor (CP) is a centralized manager for interrupts, clocks, configuration and operator control. The optional Direct I/O Interface also is controlled by the CP. A separate processor bus provides a centralized responsive communication link between clusters and the CP. Intercommunication proceeds independently of memory operation.



System Specifications

Memory Word Size

Memory Cycle Time

Memory Size

Memory Unit Structure Memory Unit Size

Interleaving

Number of Busses

Number of Ports

32 bits plus 1 check bit per 8-bit byte 645 nanoseconds per word (full cycle) 16,384 words (65,536 bytes) expandable to 262,144 words (1,048,576 bytes)

1 to 8 memory units 16,384 or 32,768 words Modulo 2 between memory units

One per processor cluster Up to 6 per memory unit

Bandwidth per I/O Processor Number of Processor Clusters Types of Processor Clusters Up to 1 million bytes/sec

Up to 6 per system Basic Cluster I/O Cluster

Types of Processors

System Control Processor

Basic Processor

Multiplexer I/O Processor (up to 3 per I/O Cluster)

Rotating Memory Processor (1 per I/O Cluster)

Basic Processor & System Control Processor

The Xerox 560 Basic Processor contains an arithmetic and logic unit operating under microprogrammed control. Also included are four blocks of sixteen (64 total) general registers and the Memory Map. The System Control Processor is a centralized interface for controlling Basic Processor execution and synchronizing the operation of all processors.

Instruction Format

Programming the sophisticated and powerful instruction set of the 560 is extremely straightforward. Only two instruction formats, Basic and Immediate, are required. The Basic format is:

I	INST.	R	x	MEM
0	1-7	8-11	12-14	15-31

1 = Indirect addressing flag (1 bit)

INST = Instruction code (7 bits)

- R = General Register select (4 bits)
- $\mathbf{x} =$ Index Register select (3 bits)
- M = Memory address operand (17 bits)

The register block in use is accessed as the first 16 memory locations. As a result, no additional set of special register-to-register instructions is required. The resulting status of each executed instruction is automatically stored into the Condition Code Register. Use of this register greatly simplifies compare and branch operations. The 17-bit memory address field permits 131,072 words of memory to be addressed directly. Base registers are not required. The Memory Map allows this directly addressed area to be relocated, at the programmer's option, anywhere in physical memory.

Frequently, constants are required whose precision is considerably less than 32 bits. The 560 immediate format combines the memory address and index register fields into a single 20-bit data field. This format, illustrated below, eliminates the requirement for a second memory access.



Addressing

In addition to the word format, memory may be accessed in byte, half-word, and double-word modes. When indexing is invoked, the index register automatically scales itself according to the size of the data involved. For example, if the selected index register contains a 27, an indexed Load Byte instruction automatically loads the 27th byte; an indexed Load Word instruction automatically loads the 27th word, etc. This permits a single index register to be used to access the kth element of an array, regardless of the type of elements in the array, without the need to perform complex index register calculations.

Protection Modes

The 560 system makes available, when required by an application, the entire instruction set including context, interrupt, input/output, and memory management control. Programs permitted full access to instructions operate in the Master Mode. Since program security is extremely important in multi-use environments, programs alternatively may be limited to one of two progressively more restricted instruction subsets, using either the Master-Protected or the Slave Mode. These modes prohibit programs from executing classes of instructions which may alter the overall operation of the Basic Processor. In the Slave Mode, no instruction may be performed which alters Basic Processor context.

Program Status Words

When the Basic Processor switches from one program to another or responds to

Basic Processor Specifications

Data Formats

A short floating-point number with a 24-bit fraction plus sign and a 6-bit hexadecimal exponent plus sign. A long floating-point number with a 56-bit fraction plus sign and a 6-bit hexadecimal exponent plus sign. A signed 16-bit integer. A signed 32-bit integer. A signed 64-bit integer. A variable-length string of 8-bit bytes. An immediate operand, 20 bits including sign. A packed decimal number of from 1 to 31 digits plus sign. **Operand Addressing Modes** Direct Direct Indexed Indirect Indirect Indexed Immediate Memory Access Modes Mapped (Virtual addressing) Unmapped (Real addressing) Arithmetic Modes **Fixed Point Floating Point** Decimal General Register Blocks Quantity — 4 blocks Number of registers per block - 16 Number of indexable registers per block -7Register size - 32 bits **Basic Processor Operation Modes** Master Master-Protected Slave

Instruction Compatibility Compatible with the Xerox 550 as well as the Sigma 5,6,7,8,9 and 9/3. an external interrupt, the current context of the Basic Processor is assembled into two Program Status Words (Psws), which may be stored anywhere in main memory. From another memory location, the new Psws are obtained. A single instruction performs the entire exchange. The Psws also indicate the general register block to be used. When new Psws are loaded, the 560 will automatically select the proper register block.

Internal Interrupts and Traps

All interrupts input to the System Control Processor. External interrupts are reserved for use by the application programmers. The 560 internal interrupts include processor fault, input/output, and console interrupts as well as four independent, programmable real-time clocks.

The 560 trap system is a powerful extension to the interrupts. Traps permit automatic detection and recovery from most programming errors without requiring alteration of the current execution priority. Four special traps, the CALL instructions, permit programs to request 560 control software services.

Input/Output Capabilities

Multiplexer Input/Output Processor

Each MIOP permits multiple peripheral devices to simultaneously access main memory. All MIOP data transfers occur independently of Basic Processor computation. The first MIOP with a Sigmaseries Adaptor is included as standard in the Basic Cluster. This MIOP shares the bandwidth of a common memory bus with the Basic Processor. However, the two processors function independently of each other. Additional MIOPS optionally may be added, three per Input/ Output Cluster. The Xerox 560 system may include up to 16 MIOPs, six of which optionally may interface to both Xerox 560 peripheral devices and Xerox Sigmaseries peripherals.

A maximum of 16 device controllers may be connected when using the Sigma 1/0 Adaptor. A maximum of eight 3000 series device controllers (utilizing up to 16 1/0 channels) are permitted. A mixed configuration of external device controllers is allowed. Data transmissions with device controllers may take place on a one or four-byte wide interface when using the Sigma-series Adaptor.

Rotating Memory Processor

The Rotating Memory Processor (RMP) is a specialized input/output processor which serves large storage, high transfer rate disk drives. The RMP operates independently of the Basic Processor and the MIOPS. One RMP may be attached to each Input/Output Cluster, permitting a maximum of five. The RMP features sophisticated error correction logic and order retry, angular position sensing and seek overlap, and automatic seek of alternate tracks.

External Interrupts

The external interrupts provide a highly responsive facility for synchronizing computation with external events. When an interrupt is triggered, testing for arm, enable, and inhibit conditions and queuing for execution are performed automatically by the hardware. A unique memory location is reserved for each interrupt. As a result, when an interrupt becomes active, additional identification processing is not required. External interrupts are input to the Xerox 560 System Control Processor.

Direct Input/Output Interface

The Direct Input/Output Interface (DO) provides a flexible and straightforward interface optimized for discrete data acquisition and control. DIO transfers are performed directly by programs. The Read Direct and Write Direct instructions permit 32-bit data word transfers between Basic Processor general registers and external devices via a bidirectional bus. An additional 16-bit address bus permits multiple devices to be attached to the DIO bus. The DIO Interface is an option which, when included in a system, resides in the System Control Processor.

Direct Memory Processor

When an application requires a specialized interface permitting extremely rapid transfers directly to memory, the Xerox Custom Systems organization can supply real-time interfaces which attach directly to an Input/Output Cluster. Such Direct Memory Processors offer the highest bandwidth available in a Xerox 560 system.

External Control Subsystem

Among the features of the Xerox 560 system are the Remote Assist and Centralized System Control facilities, which together comprise the External Control Subsystem. Using Centralized System Control, the system operator may manage the full hardware and software capabilities of the system from a single operator's console which may be located anywhere in the vicinity of the computer system or linked to the system from a remote location via telecommunications lines. Redundant consoles, one for message logging and the other for system control, may be switched if desired to assure continuous system operation.

The Remote Assist facility offers a telecommunications path into the 560 system which may be used for both online and off-line maintenance service. On-line maintenance allows diagnosis of system elements without disturbing normal system operation. Off-line maintenance allows, through the centralized configuration controls, the remote console to operate in parallel with the system console. All of the powerful tools of the central system are then available to the remote console for intensive interaction with the system.



Input/Output Specifications

External Interrupts	
Maximum Number	48
Increment Quantity	12
Interrupt States	Armed
	Enabled
	Waiting
	Active
	Inhibited
Triggering Methods	External
	Internal
Direct Input/Output Interface	
Data Bus	32 bits bi-directiona
Address Bus	16 bits
Multiplexing Input/Output Processo	or
Maximum Number of Channels	16 multiplexed
	channels
	14 multiplexed
	channels for Basic
	Cluster MIOP
Maximum Nominal Bandwidth	1 megabyte/sec.
Rotating Memory Processor	
Maximum number of devices	15
Nominal bandwidth	806,000 bytes/sec.
Direct Memory Processor Capability	
Maximum number of processors	4 multiplexed
· · · · · · · · · · · · · · · · · · ·	processors
Maximum nominal bandwidth	1.35 megawords/
	sec.
External Control Subsystem	
Centralized System Control	2 consoles
Remote Assist	1 console
Local and remote diagnostic	Individual elements
modes	Complete system

Peripherals

The wide range of Xerox 560 peripherals permits a close match between specific peripheral device capabilities and application requirements. Most conventional low- and medium-speed peripherals are attached to an MIOP. Peripheral controllers communicate to the MIOP via a multiplexed 1/0 bus. Each MIOP is configured so that all peripheral controllers may concurrently access main memory. Controllers for the fixed-head disk drives, for the disk pack drives, and for the medium- and high-speed magnetic tape transports may optionally operate with dual access. The MIOP peripherals are:

Line Printers

700 LPM 1250 LPM 4000 LPM (Xerographic printer)

Card Equipment

400 СРМ Reader 1500 СРМ Reader 100 СРМ Punch 75 ips, 800 & 1600 bpi 125 ips, 800 & 1600 bpi

2.88 Megabyte head-per-track RAD (Rapid Access Device) 755 Kilobyte/sec. transfer 8.5 Millisec. av. total access time

49 Megabyte disk pack drive 312 Kilobyte/sec. transfer 47.5 Millisec. av. total access time

Message-Oriented Communication Equipment

Character-Oriented Communication Equipment

Large-Scale Disk Storage

The RMP is used exclusively for the Xerox 100 megabyte (unformatted) disk pack drive. Up to 15 drives may be connected to each RMP. Drives are serviced one at a time although simultaneous track seeks are performed. Dual access between two RMPs is optional. The drive specifications are:

100 Megabyte pack capacity (unformatted)

806 Kilobyte transfer rate 38.3 Millisec. av. total access time

Real-Time Interfaces

Most analog and digital interfacing requirements may be satisfied with standard, modular components. Devices are attached to either the MIOP, or the Direct Input/Output (DIO) Interface, and most are supplied with standard handlers and diagnostic software. Included are analog and digital input/output controllers, frequency controllers, and microprogrammable system control units.



Typical Xerox 560 System Configuration



Includes 4 register blocks, memory map, memory protection, 4 real-time clocks, priority interrupts, power fail safe, direct I/O interface, system control panel, configuration control panel, floating point, decimal, local and remote assist facility.

Software

Xerox Control Program-Five (CP-V) Operating System

Xerox CP-v is a comprehensive multi-use, virtual memory operating system for use with the Xerox 560 computer. CP-v offers a range of software elements integrated into a system that exploits the computer's multi-use design through an entire range of operating environments. The comprehensive software provides capabilities to five modes of operational requirements, meeting the needs of each mode without restricting of penalizing the other modes. These five modes are:

- Multiprogrammed batch Sixteen regions Dynamic resource management
- Remote batch
 HASP Multileaving protocol
 Slave/master status
- Timesharing 128 lines Batch compatible facilities
- Transaction processing Terminal device independence Task management
- Real-Time Responsive Memory management controls

Multiprogrammed Batch

CP-V Batch Processing Mode offers a powerful multiprogramming capability. A combination of up to 16 batch streams may be processed concurrently, depending on system management constraints, thus assuring maximum system utilization with efficient application throughput. All jobs form a priority-ordered queue and are processed according to that priority and available resources.

To most efficiently utilize the system, cP-v allows installation management to define, at system generation, up to 16 separate batch partitions. Each partition is described by a set of parameters which establish maximum and minimum partition limits such as: Total job

Xerox 560/CP-V System



time, non-sharable peripherals (e.g., tape units), and core memory range. This unique definition of each batch partition provides the installation with a method of optimizing the executing job mix by predetermining the mix of t/o and compute-bound jobs.

All batch jobs entering CP-v whether from local card readers, remote stations, or a time-sharing terminal, make up one input queue. Jobs are selected from this queue for execution in the batch partitions. Jobs are ordered in this queue in priority sequence and selection of a job for the execution state is based upon its priority and resource requirements.

With CP-v, the installation manager has complete control over all functions relating to the running of jobs including system and partition limits.

Maximum and minimum limits of each partition can be changed for many types of resources including time, tape units, and core memory. System limits, which establish maximum resources for batch and on-line users, may also be dynamically adjusted. These limits include resources such as core memory, tape units, and disk packs. There are other controls available which are used: (1) to control the maximum number of batch partitions that may be active; (2) to temporarily block a particular partition; or (3) to lock a partition in memory.

Remote Batch

Remote Batch processing provides flexible communication between CP-v and a variety of remote terminals. These terminals can range from a simple card reader, card punch and line printer combination, to another computer system with a wide variety of peripheral devices. CP-v can communicate with any number of terminals/computers at one or several sites and simultaneously act as a remote terminal to other computers. These remote processing capabilities offer considerable flexibility in the construction of communication networks. Two basic types of remote terminals are supported by CP-V: Remote Batch Terminals (RBTs) and Intelligent Remote Batch Terminals (IRBTs).

An RBT is a card reader, card punch, and line printer combination which is used primarily to allow batch processing I/o functions to be performed at remote sites. That is, a job is input to the system from the remote site card reader, the job is processed at the central site, and the output is sent to the remote site line printer or card punch. The output may optionally be directed to the central site or to another remote site.

An IRBT can be either a satellite processor like the Xerox 530 performing online scientific and engineering data acquisition or another large-scale computer system, e.g., Sigma 9. Any computer system supporting HASP protocol may act as an IRBT to CP-V.

A CP-V system can act as the master computer to many terminals, or act as a slave IRBT to any other computer acting as master and communicating with HASP protocol.

Time Sharing

CP-v is designed to handle a large number (up to 128) of remotely-connected on-line terminal users. A terminal executive language and processor (TEL) is available for the handling of requests from users.

The time-sharing user has available all of the tools required for creation, modification, debugging, and use of programs, as well as for creation, modification, examination, and deletion of files. Complete file security and program security are afforded the user. The online terminal user has a choice of two processing modes — conversational or deferred batch.

In the conversational mode each user is unaware other users are also sharing the computer. CP-V manages the computer so that as a program requires system resources, they are provided. If the user does not wish to sit at the terminal during the execution of a program, he may conveniently employ the terminal batch entry facility of CP-V to enter the job into the job stream via the terminal batch entry facility for execution when the batch processing service is activated.

CP-v allows users to initiate and access the on-line services via a variety of character-oriented terminal devices (teletypes, IBM 2741, etc.). Full- and halfduplex terminals can utilize switched or dedicated lines.

Transaction Processing

Transaction Processing (TP) brings the computer to the source of your business information. TP enables the user to move from a batch processing environment to a remote on-line environment where business transactions are entered and processed directly from their point of origin.

TP includes features designed for ease of use by a non-technical person as opposed to the computer programmer or operator. At the same time, it is designed to provide simple straightforward interfaces for use by the customer programmers who prepare the application-unique processing programs.

TP provides for the entry of transactions from a variety of input devices, both local and remote. A variety of communications network configurations will be supported. These include CRT and hardcopy devices.

Outputs generated by the system may be routed directly to the originating station, to alternate stations, or to the central site output devices. The terminal control facilities of TP provide a deviceindependent interface to the application programs such that those programs need not be aware of the specific devices involved.

TP is designed to provide a controlled interface with the database management facilities of the Xerox Extended Data Management System (EDMS). This enables TP application programs to utilize all of the power and flexibility of EDMS to manipulate a centralized database in response to the various transactions received. A common journal facility is provided and used by various components of TP and EDMS to provide a complete audit trail of the flow of transactions through the system. This journal file is available for use by the TP recovery facilities in the event of a system malfunction or other abnormal situation. In the event of a single transaction malfunction, any associated interaction with the EDMS database is automatically rolled back leaving the database in its previous condition.

TP also takes advantage of the CP-V enqueue/dequeue (ENQ/DEQ) capability. ENQ/DEQ permits the same EDMS database to be accessed simultaneously by multiple on-line users. Each user appears to have individual access to the database regardless of actual demands on the database. In this way users get their jobs done quickly and easily without having to do sophisticated systems programming.

TP provides non-programmer protocols in order to examine, search, modify and report on all aspects of a database from a remote location. In addition, the standard file management facilities of CP-V may be utilized by TP applications.

Real-Time

CP-v provides extensive resident and non-resident real-time capabilities. Realtime jobs (Tasks) may be either mapped and centrally connected, or unmapped and directly connected. Response to real-time interrupts will be less than 500 microseconds ninety-nine percent of the time. For especially critical response time requirements, facilities are provided to allow the user the ability to suspend all other processing, and later resume normal user activity at the point of interruption. Thus, cP-v will also satisfy the requirements for relatively infrequent and anticipated critical real-time activity requiring response times approaching hardware context switching times.

System Management

CP-V system management routines perform all of the functions associated with the running of batch and on-line programs, operations, and the scheduling of system resources. Hardware features such as Memory Map and high-speed swapping devices assure efficient utilization of the system — space is taken on an as-needed basis.

- Memory Management Virtual Memory Program Fragmentation
- Rapid Access Disk (RAD) Management Efficient Swapping Optimized Allocation
- Job Scheduling Priority Structure Event Transition

Memory Management

Individual programs do not have to execute in contiguous physical memory. They may be fragmented into sections or pages as small as 2048 bytes and loaded wherever memory space is available. CP-v, using the Memory Map manages the loading and any subsequent re-loading that may be necessary. The Memory Map translates all address references so that the physically fragmented program appears to operate in a contiguous or virtual memory.

There are two protection schemes for real and virtual memory. The basic purpose of real memory protection is to ensure the integrity of the operating system and user programs. The memory protection locks and keys are changed when the system is initialized but not changed during the running of different programs.

This is in contrast to virtual memory protection, which is changed each time

a different program is run. Access protection is used to protect one program from another and simultaneously protect the program from accidentally destroying its own instructions. Through a combination of real and virtual memory protection, CP-v is able to provide all the necessary forms of program security.



Demand Paging

Demand paging provides control of physical and virtual memory usage by the operating system to achieve maximum memory resource utilization. The user's virtual memory requirements are allowed to exceed the available physical memory resources, permitting execution of programs which could not otherwise be run. Demand paging is performed using the Xerox 560 memory protection trap mechanism and the Memory Map to associate physical pages with virtual page accesses. Only the user's job context, procedure, data, and the shared processor data associated with a user is demand paged. The operating system is not. Demand paging is confined within a user, that is, when physical pages are needed, they are obtained from the user or monitor, not from another user Parameters are provided at both the user and the system manager levels to control the demand paging environment. Job accounting and system displays provide demand paging performance information which may be used to tune the job or system.



RAD Management

A typical CP-v configuration will contain one or more high-speed RADS. RADS are head-per-track disks that act as an extension to memory. In addition to storing the operating system they are used to temporarily store inactive user programs that have been swapped out while waiting for requested services like terminal 1/0 to be completed. Swapping assures that memory is fully utilized by active programs as much as possible.

When a user requests service from the system, space is allocated to him on this RAD. As his memory requirements grow during his session, RAD area necessary to contain him grows where possible into consecutive sectors following his initial page, so that the individual user on the RAD is organized for swapping as efficiently as possible.

When multiple users are being swapped out, the I/o commands for each user are sorted and chained together, so that the end of one user's area is the shortest possible distance from the beginning of the next.

After this chaining is accomplished, a command issued to the RAD will assure that the maximum amount of swapping is accomplished in one revolution. This procedure effectively reduces latency well below the RAD's 8.3 millisecond average access time. This same kind of logic is applied to the swapping-in of multiple processors along with user programs.



Job Scheduling

Status queues form a single priority structure from which selections for swapping and execution are made. The status queues form an ordered list with one and only one entry for each user. The position in queue is an implied bid for the services of the computer. As events are signaled to the scheduler, individual users move up and down in the priority structure. When at the high end, they have a high priority for swapping into memory and for execution. When they are at the low end, they are prime candidates for removal to secondary storage. This latter feature — that of having a defined priority for removal of users to secondary storage - is an important aid to efficient swap management. It avoids extraneous swaps by making an intelligent choice about outgoing as well as incoming users.

System Services

CP-v provides a wide range of system services and facilities to aid both users and installation management in utilizing the system most effectively. These facilities include:

- RESOURCE ACCESS Adjustable Limits Privilege Levels
- FILE MANAGEMENT Multiple Type Files Operating Mode Compatibility
- FILE RECOVERY Automatic File Backup Selective File Restore
- SYMBIONTS Concurrent 1/0 1/0 Buffering
- USER AUTHORIZATION Supervisory Subsystem Supervisory Options
- ACCOUNTING Time Statistics Resource Statistics



- PERFORMANCE MONITORING Internal Data Gathering Performance Measures
- PERFORMANCE CONTROL Batch Partition Defined Parameter Tuning
- SYSTEM INTEGRITY Detection and Logging of Malfunctions Formatted Reports
- OPERATIONAL AIDS Job and System Control

Resource Access

In order to achieve a level of operation in which control may be extended to each job mode, CP-V provides for generalized resource management. Three types of limits are maintained by the system: a) resource limits (for physically allocated devices); b) service limits (consumable system service commodities); and c) authorization for peripheral usage. Additionally, associated privilege levels assure system security in conjunction with the hardware access registers.

File Management

CP-V File Management consists of a set of routines which manage the contents of and access to physical files of information. Included are the functions of indexing, blocking and deblocking, management of the pools of space on RADs and disk packs, labeling, label checking, positioning for magnetic tape, formatting for printer and card equipment, and controlling access to and simultaneous use of a hierarchy of files.

Three basic file organizations are supported: CONSECUTIVE, KEYED, and RAN-DOM. Consecutive files are those which are created and accessed in sequential order. Keyed files consist of a collection of related records, with each record identified by a key. Random files provide the user with a contiguous randomaccess storage space to be organized at his own discretion. The same file management routines serve all modes of operation. For example, files created in time-sharing and translation processing modes can be used when running in batch.

File Recovery

File recovery is handled automatically by a CP-v processor. Files are copied from disk to tape as a backup so that they may be restored whenever needed. Files are automatically backed up according to a schedule established by the system manager. The schedule may be modified by the computer operator when necessary. Individual files may also be backed up at any time at the request of an on-line user. Files may be restored from tape during system initiation, during recovery after a catastrophic system failure, and, on a selective basis, at any time.

Symbionts

The symbiont system provides for complete buffering between unit record devices and the user's program. Therefore, a user's program can operate independently of the speed of unit record equipment. Also, the current job may be running while the output of the previous job and the input job file for the following job are being processed by the symbiont operation.

User Authorization

It is important in a multi-use environment to properly authorize user access and accurately account for all computer activity. By controlling the degree of privilege assigned to users, CP-v provides the Installation Manager with supervisory facilities which guarantee system integrity. When first accessing CP-v, certain information such as name, account, and passwords are requested. These items are validated by reference to a system file that controls entry and the type of privileges extended to the user. An Installation Manager, using the supervisory program, can establish and change default values; create, modify, or remove user accounts; and authorize remote batch work-stations.

Accounting

CP-v satisfies installation requirements to properly account for resource usage in the dynamic multi-use environment. Cumulative records are maintained by user account number and name. CP-v takes care of the problem of variable charge rates dependent upon the class of user. All accounting processes use rate tables to generate actual accounting values. When installation management chooses to dynamically modify the charge structure because of the time of day, the rate tables are switched and the accounting is automatically modified to reflect the new rate.

Performance Monitoring

In a sophisticated multi-use environment, it is particularly important to be able to measure the operation and performance of the system. cp-v continuously gathers information of this type and can display the results via any user terminal or batch stream granted the privilege. The items and groups may be periodically reported at a requested time interval and stored in history files for deferred analysis. Overhead imposed by monitoring routines is negligible and transparent to system users.

Performance Control

The Xerox CP-V Operating System provides facilities which allow adjustment of critical parameters to achieve better machine utilization. These features are an invaluable aid to the System Manager. In addition to displaying current information, they answer the problem of optimizing the production output of his installation.

A special control processor gives the ability to modify the necessary parameters to "tune" the system. With statistical summaries provided by the per-



formance monitoring routines, control inputs may be ascertained which will tailor system operation to the ever changing demands of a multi-use environment.

System Integrity

One of the major requirements of a multi-use system is that it be highly reliable and available to its users at all times. To meet this critical need, a number of system-integrity facilities have been designed into CP-v and are aimed at four major objectives: (1) to provide the highest possible security for user files, even in the event of total system failure; (2) to take the necessary steps to detect and alleviate any fixable situation that could cause a total system failure; (3) to provide automatic high-speed restart in the event of a system failure; and (4) to record sufficient information to isolate errors and failures caused by either hardware or software.

The system-recovery function is provided to restore CP-v to operational status very quickly after an unrecoverable failure. This is done by cleaning up all appropriate tables and files (both userand system-oriented), and restarting the system at its initialization point.

Entry will be made automatically to the recovery routine by various hardware- and software-detected errors. A manual entry point is also provided for use when the system cannot automatically recover.

Operational Aids

The CP-v operator is provided an interface to the system via a keyboard console which displays computer activity. Through the use of various keyins and system tasks, he has complete overriding control on the type of activity, the use of peripherals, and the maintenance of the file system. In general, however, CP-v has been designed to operate with minimal operator attention.

CP-V Processor Systems

The performance and richness of the CP-V system services are matched by the quality of the CP-v processor systems. Each processor provides the most up-todate and most powerful version available in the industry. Most processor subsystems (including the FORTRAN run-time library) are reentrant and shared. enhancing system performance by using only one copy of the program for all users, both batch and time-sharing. This means less swapping and less storage requirements in core memory and on the swapping RAD. More users can be supported with better response time and throughput on an economical basis.

Language Processors

Because CP-V makes little distinction between batch and on-line processing, the user can reduce program development time by using the time-sharing capability of CP-V. These programs can then be run in the batch or on-line mode depending on the needs of the user.

- BASIC The BASIC language, which was specifically developed for simple, convenient on-line use by inexperienced personnel, has been further refined by Xerox to provide more power and efficiency as well as more interactive facilities.
- APL APL (A Programming Language) is a concise, interactive programming language widely used by universities, engineers, and statisticians. Because APL is easy to learn and easy to use, it is also suited for many other applications.
- EXTENDED XEROX FORTRAN IV A superset of most available FORTRAN languages, Extended Xerox FORTRAN IV consists of a comprehensive algebraic programming language, compiler, and library of subprograms. It is designed to produce efficient object code, reducing execution time and core requirements, and to generate extensive diagnostics, reducing debugging time.

- FLAG FLAG (FORTRAN Load and Go) is an in-core, high-speed FORTRAN compiler designed for use where the job stream consists of numerous small programs, many of which might be written by novice programmers. FLAG is a compatible superset of FORTRAN IV-H with many features of Extended Xerox FORTRAN IV.
- ANS COBOL A powerful and convenient programming language for implementation of business or commercial applications in both batch and on-line environments, ANS COBOL generates compact programs, making maximum use of the secondary storage file and overlay organization to minimize core residence requirements.
- TEXT TEXT is a text processing system that provides the capability to create, edit, and print documents through typewriter-like terminals.
- SORT/MERGE Provides the user with a fast, highly efficient, device-independent method of performing either or both of two fundamental data manipulation processes: (1) rearrangement or sorting of records in a file to a predetermined order, and (2) combining or merging records of many ordered files into one ordered file.
- META-SYMBOL A high-level, assembly language processor, META-SYMBOL permits parameters to be tested, macros and variable code to be generated during assembly, based on the results of the tests.
- RPG The Report Program Generator offers a powerful and convenient problem-oriented language for implementation of a wide variety of commercial processing applications. It is easy to learn and can be quickly mastered without detailed knowledge of programming.
- INTERACTIVE DATABASE PROCESSOR (IDP) IDP provides a convenient and powerful tool for accessing Extended Data Man-

agement System (EDMS) databases. It offers query and report generation capabilities for both on-line and batch users. The IDP language consists of a set of simple but powerful commands which result in the efficient retrieval of data and formatting of reports. Capability is also provided for sorting data for reports and the accumulation of counts and totals.

Application Processors

The following application processors allow users to solve problems on-line or in batch mode. The on-line capabilities of CP-v add a new dimension of convenience, response, and interactivity to these applications.

- EDMS EDMS (Extended Data Management System) is a generalized system for storage, maintenance and retrieval of management information. It provides various file organization schemes for quick data access and retrieval. The user has the capability to define complex data relationships to suit his specific requirements and to produce efficient solutions. The inherent flexibility of EDMS enables a user to structure his data retrieval so that it virtually parallels the information flow of his business. EDMS is designed to be used with COBOL, FORTRAN and META-SYMBOL Programs. EDMS provides an effective tool for implementing highly-responsive terminal-oriented inquiry/response applications as well as batch-oriented database systems.
- CIRC CIRC is an easy-to-use, highly sophisticated circuit design tool. It was developed to help engineers simulate, evaluate and modify their circuit designs quickly and accurately. As a result, CIRC significantly reduces the expense and time of breadboarding and helps to optimize circuit performance, cost and reliability. CIRC is a unique circuit analysis program in that it is a complete package including non-linear bc and transient analysis as well as AC analysis.

Utility and Service Processors

The utilities and service processors provide conveniences and essential services to the batch and on-line users as well as to systems management personnel.

- TEL TEL is the executive service subsystem which conveniently interfaces the user to a variety of cp-v monitor facilities as well as to other cp-v subsystems.
- EDIT EDIT is a conversational line-at-atime context editor designed for creating, modifying and searching source programs and data files.
- **EASY EASY is a subsystem which offers** the novice user an easy-to-use executive interface and editor to the system.
- FDP FDP (FORTRAN Debug Package) provides the conversational and batch FORTRAN user with many powerful features to reduce checkout time.
- COBOL INTERACTIVE DEBUG SYSTEM The COBOL Interactive Debug System is an on-line debugging tool which reduces time invested in debugging COBOL programs. The debugger provides the programmer with the ability to display program areas, alter program data, trace program execution, and make alterations in the logic flow of the program. Breakpoints can be set symbolically and can be made conditional upon the change of field contents.
- PCL PCL is a media conversion service for moving files of data in various forms from one type of peripheral device to another.
- DELTA DELTA is a powerful conversational debugging service for checking and modifying any program in its assembly language form.
- LINK LINK subsystem forms executable program-load modules from relocatable object modules.
- SUPER SUPER (Supervisory Subsystem) gives system management control over the entry of users and the privileges extended to them.

- CONTROL Extensive resource-control facilities are provided so that installation management can smoothly and effectively control system operation and optimize utilization of the hardware and software.
- RATES The RATES processor allows the system manager to set relative charge weights on the utilization of system services.
- SYMCON SYMCON is a convenient tool for program development tasks where common symbol definitions between two or more subprograms are necessary in order to form a larger process.

Reliability/Maintainability/Availability

Comprehensive Reliability, Maintainability, and Availability (RMA) capabilities are critically important to the success of multi-use systems. The Xerox 560 system incorporates comprehensive RMA capabilities which have been designed along system concepts. Contributing to the total RMA capability of the 560 system are:

- Hardware reliability features
- Redundant configuration capabilities
- On-line diagnostics by CP-V
- Diagnostic Programming System
- Remote Assist connection

The combination of the above features permits the 560 to have a high inherent reliability, to assist in diagnosing possible malfunctions, and to be rapidly repairable.

Hardware Reliability

High reliability is inherent in the Xerox 560 hardware. The 560 hardware is constructed using LSI, MSI, and microprogramming techniques which allow, for example, the entire Basic Processor to reside on only 12 circuit boards. As a result, the hardware has relatively few cables and interconnects, items which historically have caused the majority of CPU failures.

The Xerox 560 hardware incorporates a comprehensive error detection and reporting capability. Error detection is performed by all processors and memory units. The classes of error detection are:

- Data transmissions between units (processors, memory units, controllers, and peripherals) include parity information which is checked by the receiving unit.
- Memory units include error detection by various parity and operational checks.
- Register blocks include parity bits with the stored data. Parity is generated at the time the data is being writ-



ten into the register. Data is checked upon read out.

- Control memories include parity bits which are stored with the appropriate data. Parity error detection permits checking of much of the control logic in the system.
- Control sequence errors are detected for special situations. Mutually exclusive control terms simultaneously active, or undefined operations may be detected.
- Critical system failures are detected such as power failures or over-temperature.

The Basic Processor will automatically attempt instruction retry whenever possible after detecting an error. The input/ output processors detect errors in the processors themselves and in device controllers, adapters, and peripheral devices. Detected memory unit errors include data, address, and protection errors as well as hardware malfunctions. The Watchdog Timer detects instructions which exceed the maximum time allowed for their completion and allows corrective action to be taken. The cause of incomplete instruction execution may result from an error in the processor, memory, or DIO busses.

Each processor and memory unit contains a status register in which information about a detected error is stored. These registers may be read by the diagnostic programs. When errors are detected, the System Control Processor also is automatically notified using either an internal interrupt, a trap, or a condition code setting. Even if a reported error is recoverable and processing continues, the occurrence will be output to the CP-v error log.

Redundant Configuration Capabilities

For applications requiring computer system availabilities greater than those possible with a single computer, the Xerox 560 system may be configured





redundantly. Then, when one computer is unavailable during preventive maintenance or a malfunction, the other can continue the processing. Depending on the required total availability, a Xerox 560 system can include some or all of the following redundancy capabilities.

- Redundant Basic Processors
- Redundant Input/Output Processors
- Redundant System Control Processors
- Shared Main Memory
- Backup Operator's Console
- Pooled RAD, Disk and Magnetic Tape Peripherals
- Switched Unit-Record Peripherals
- Switched Digital and Analog Interfaces

The Configuration Control Panel (CCP) provides a central control for configuring and partitioning the system. Included are such services as memory starting address control, memory port disable, memory interleave control, and processor unit address control. When operating in a redundant environment, the CCP permits preserving the on-line system's integrity by electrical partitioning while making possible rapid reconfiguration of a back-up system should a malfunction occur. Because of the inherent power partitioning of the Xerox 560 system, isolated processors and memory units may be individually powered-down.

Diagnostic Programming System

The Diagnostic Programming System (DPS) is a comprehensive, off-line error detection and isolation facility. A stratified fault isolation strategy is used permitting identification of system, processor, unit, and module faults. Starting with the most basic level of operation, the DPS verifies each phase of system operation before proceeding to test the next. Operation of the DPS is controlled at the operator console or via the Remote Assist facility. Maintenance operations are augmented by the System Control Panel which provides additional status displays. The testing hierarchy of the DPS begins with three hardcore tests:

- MICRO-DIAGNOSTICS HARDCORE TEST A microprogrammed test sequence is incorporated into the Basic Processor control memory. Data registers, transfer paths, control logic, and access to main memory are tested. The test is automatically activated during the load sequence.
- ROM HARDCORE TEST After successful completion of the micro-diagnostic hardcore test, a read-only memory (ROM) hardcore test is automatically performed. A micro-sequence will cause the transfer to a diagnostic from the ROM in the Basic Processor to main memory. This program tests the instructions used by the Software Hardcore Diagnostic, the 1/0 data paths via the 1/0 turnaround feature (permitting input/output processors to be exercised in a closed-loop mode), and the instructions to be used by the hardware bootstrap loader.
- SOFTWARE HARDCORE TEST The Software Hardcore test is the first diagnostic program that is loaded via the 1/0 hardware. This diagnostic further checks out Basic Processor and memory operation.

Functional diagnostics that test all system elements are run under control of the Diagnostic Monitor and the Loadand-Go Software Processor. These programs execute after the successful completion of all hardcore tests and use only the facilities tested by the hardcore sequence.

After all the elements of the system have been tested individually, the System Exerciser program operates these elements simultaneously. An attempt is made to approach the system failure threshold. After validating system operation, peripheral diagnostics are selectively executed.

Remote Assist

The Remote Assist facility provides each Xerox 560 system with a special remote-troubleshooting communication link to a Xerox Field Engineering Center. This interface is independent of any other communication equipment. Using Remote Assist, a Xerox Customer Engineer can assist with operator problems; debug software; control the operation of CP-v; run verification programs; run off-line diagnostics; and operate the system exerciser - all without actually visiting the 560 system installation site. If replacement parts are required, the Customer Engineer can determine in advance which parts are required.

Applications

Hundreds of Xerox multi-use systems, at work in applications similar to those shown here, have established Xerox as the leader in multi-use, general-purpose computing. The Xerox 560 system offers the computer user the power and versatility required by these diverse applications.

General Business

Accounts Payable Accounts Receivable Payroll Sales Analysis General Ledger Budget Reporting Personnel Records Order Entry

Education

On-Line Student Registration Interactive Computer Instruction Student Records Alumni Records Administrative Modeling Library Automation Career Planning

Manufacturing

Requirements Planning Bill of Material Maintenance Standard Cost Maintenance Cost Accounting Shop Floor Control Inventory Control Work In Process

Scientific and Engineering Processing

Data Acquisition Circuit Design and Analysis Statistical Analysis Control Applications Graphics

Communications

Store and Forward Message Switching Remote Information Retrieval and Update Remote Data Display Data Concentration Order Entry Data Collection

Nuclear Physics

Reactor Monitoring Film Scanning Pulse Height Analysis Spark Chamber Data Analysis Instrument and Reactor Control

Analytical and Scientific Laboratories

Gas and Liquid Chromatography Mass Spectrometry X-Ray Diffractometry Nuclear Magnetic Resonance Spectroscopy

Industrial

Process Control Process Monitoring Automatic Testing and Checkout Environmental Control

Radar

Precision Tracking Target Identification Impact Prediction Coordinate Transformation Telemetry

Simulation

Aircraft and Missile Simulation Pilot Training Fire Control Officer Training Direct Digital Control Test Report Generation System Analysis and Parameter Optimization Hybrid Computation





Support Services

Custom Systems

The Xerox Technology Centers can assist both end-user, OEM and reseller customers in adapting standard Xerox products to specialized applications.

Successful real-time systems require more than a highly efficient systemsoriented computer; they need hardware and software capable of interfacing the computer with specialized input/output devices, and capable of dealing with many kinds of information formats. In developing such systems, the degree of Xerox Technology Center involvement is negotiable on any specific contract; however, there are definite advantages to the customer in allowing Xerox to take single-source, turnkey responsibility for the entire system. These advantages include highest performance standards, greater confidence in the implemented solution, lower operational and maintenance costs, maximum system availability, and prevention of premature obsolescence.

Application Services

Xerox Application Services has proved, with years of indepth experience, that conversion can be accomplished efficiently and cost-effectively in a prespecified length of time. Many of our customers have taken advantage of these services because Xerox:

- Provides off-site systems and computer support dedicated solely to conversions.
- Performs on-line programming and testing using highly effective and efficient language translators and media conversion aids.
- Commits to contract specifications on a fixed-task, fixed-price basis.
- Supports either complete or partial systems design.

Thus, the flexible approach, the efficiency gained from indepth experience, and predictable schedules and pricing make it possible for Xerox to reduce conversion and systems design to an easily controlled process that allows you to realize the full benefits of Xerox computers.

Other Services

All too frequently the computer vendor's extensive pre-sales support seemingly evaporates after the sale is made. It won't after a Xerox computer is delivered. Customer support and corporate maturity have become synonymous with the Xerox name. In addition to the services described above, support from Xerox includes:

- On-going application analyst services
- Field engineering support
- Field engineering software analyst services
- Complete documentation
- Software program library
- Software update distribution
- Customer hardware education
- Customer software education

The key member of the computer support team is the Xerox marketing representative. In addition to assisting in the selection of Xerox computer products and services, he is the customer's personal representative in all matters related to achieving maximum utilization from his computer systems.

EXCHANGE — The Xerox Computer Users' Group

The Xerox Computer Users' Group was formed for the purpose of affording representatives of companies that own or lease Xerox computers an opportunity to exchange technical knowledge and experience with their counterparts in other companies.

The organization today serves as a formal information exchange for representatives of many different companies. Membership in the group offers many benefits — most of which are inherent in the following major goals of the Xerox Computer Users' Group:

- To advance the science of information processing through mutual education and interchange of ideas
- To reduce redundant effort among machine users in the preparation of computer programs
- To establish standards and to provide channels to facilitate the exchange of relevant information
- To provide feedback to Xerox pertaining to equipment and programming needs

Benefits

Some of the benefits of this professional interchange, more specifically, are:

- USERS' GROUP PROGRAM LIBRARY Membership in the Users' Group allows a company to obtain programs from the program library at no charge.
- PUBLICATIONS As a part of the continuous effort to keep members well informed, Xerox publishes the USER NEWS every other month.
- GENERAL, SEMI-ANNUAL MEETINGS The international meetings are normally held in the spring and fall each year.
- EXECUTIVE BOARD In order to ensure that the Users' Group remains active between meetings, the Executive Board meets to determine policy and implement decisions of the Group.
- INTEREST GROUPS AND COMMITTEES Several general and special interest groups and committees assist the Executive Board in conducting the business and implementing the goals of the Users' Group.

Xerox 560 Specification Summary

Memory		Input/Output Capabilities	
Memory Capacity	16.584 to 262,144	Maximum number of miops	16
Memory Cycle Time Memory Word Size Maximum Number of Memory Units Number of Memory Ports	32-bit words 645 nanoseconds 32 bits plus 4 parity bits 8	Maximum number of RMPs Number of channels per MIOP Number of devices per RMP Nominal maximum MIOP bandwidth Nominal RMP bandwidth	5 16 15 1 megabyte/sec. 806 kilobytes/sec.
Basic Processor General Registers Data Formats	64 in 4 blocks of 16 Doubleword	Typical Instruction Execution 7 (microseconds) Load Immediate Load Word Store Word	imes 1.51 1.72-1.94 (min-max.) 2.37-2.80
Memory Access Modes Memory Map Page Size	Halfword Byte Unmapped (Real addressing) Mapped (Virtual addressing) 512 words	Branch (Yes) (No) Logical AND Add Immediate Add Word (Fixed) Multiply Word (Fixed) Add Word (Floating) Multiply Word (Floating)	1.29 1.72 1.72-1.94 1.51 1.72-1.94 6.23 6.13 (typical)
System Control Processor	256		
Internal Interrupts Maximum number of external interrupts Clocks	14 48 4		

XEROX

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