GA22-7001-7
File No. S370-00

Systems

IBM System/370 System Summary: Processors

IBM

GA22-7001-7
File No. S370-00

Systems

IBM System/370 System Summary: Processors

Eighth Edition (October 1978)
This major revision obsoletes GA22-7001-4, -5, and -6 and the following Technical Newsletters:

GN22-0496 (dated June 16, 1975)
GN22-0502 (dated December 1, 1975)
GN22-0517 (dated June 22, 1976)
GN22-0509 (dated July 15, 1976)
GN22-0520 (dated July 18, 1977)
GN22-0531 (dated September 20, 1977)
GN22-0550 (dated September 20, 1977)
GN22-0555 (dated November 22, 1977)
GN22-0574 (dated September 12, 1978)

The obsoleted publication (GA22-7001-6) is now divided into the following three manuals:

1. The *IBM System/370 System Summary: Processors,* GA22-7001-7, that contains Sections 1 through 4 and Section 6 which becomes Section 5. An appendix has been added for the glossary and abbreviations.

   This edition also adds information about the System/370 Extended Facility and deletes information about the System/370 Models 155 and 165. Changes or additions to the text and illustrations are indicated by a vertical line to the left of the changes.
2. The *IBM Data Communication Device Summary,* GA27-3185, that contains information from Sections 5 and 8 to form its two sections. An appendix has been added for the glossary and abbreviations.
3. The *IBM Input/Output Device Summary,* GA32-0039, that contains the information from Section 7 to form its two sections. An appendix has been added for glossary and abbreviations.

Changes are continually made to the specifications herein; before using this publication in connection with the operation of IBM systems, consult the latest *IBM System/370 Bibliography,* GC20-0001, for the editions that are applicable and current.

Publications are not stocked at the address given below; requests for IBM publications should be made to your IBM representative or to the IBM branch office serving your locality.

A form for reader's comments is provided at the back of this publication. If the form has been removed, comments may be addressed to IBM Corporation, Product Publications, Department B98, PO Box 390, Poughkeepsie, NY, U.S.A. 12602. IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation whatever. You may, of course, continue to use the information you supply.

Preface

This publication provides basic information about IBM System/370 to help readers achieve a general understanding of this data processing system and the interrelationships of its components. Included in the overview is a description of the system concepts, features, and individual models. Discussed in greater depth are the System/370 programming systems.

This publication is divided into five sections. Sections 1 through 3 discuss the system structure and features; Section 4 describes the programming systems; Section 5 presents summary information about individual models, including processor complexes.

Generally, the sections should be read in sequence, because information presented in one section often depends on an understanding of information in previous sections. Section 4, however, can be read independently of the other sections.

Where it is important in this publication to point out that the arithmetic, logical, and control functions of a processor are directly affected during an operation, the term *CPU* is used instead of *processor* because a processor may physically contain a CPU and storage, and sometimes channels. Also, where it is important to refer only to storage that is directly addressable, the term *main storage* is used instead of *processor storage* because in certain cases not all of processor storage is directly addressable.

A basic knowledge of data processing systems, such as that given in the *Introduction to IBM Data Processing Systems,* GC20-1684, is assumed. However, for the programming systems information (Section 4), the reader is assumed to have basic knowledge of IBM programming systems, such as that found in *IBM System/360 Operating System Introduction,* GC22-6534.

Appendix A is a list of abbreviations and a glossary of terms that do not appear in the *IBM Data Processing Glossary,* GC20-1699.

More detailed information about System/370 is available in *IBM System/370 Principles of Operation,* GA22-7000.

This publication is a companion to the *IBM Input/Output Device Summary,* GA32-0039, which describes input/output devices for local operation with System/370, and to the *IBM Data Communication Device Summary,* GA27-3185, which describes data communication devices for remote operation with System/370.

All three publications can be ordered together under order number GBOF 4550, or separately as follows:

- *IBM System/370 System Summary: Processors,* GA22-7001
- *IBM Input/Output Device Summary,* GA32-0039
- *IBM Data Communication Device Summary,* GA27-3185

Contents

Section 1. Introduction to IBM System/370

IBM System/370 (Figures 1-1 and 1-2) is a family of upward-compatible general-purpose computers that provides a wide range of performance levels and processor storage capacities for a variety of data processing applications. Each System/370 model configuration includes locally attached input/output devices. In addition, the system can communicate, through data communication facilities, with compatible remote input/output devices of other systems.

System/370 offers:

- Fast internal performance
- A choice of channel capabilities
- Processor storage capacities of up to 8,388,608 bytes (depending on the model)
- Virtual storage capability
- Data communications capability
- Integrated emulation of other IBM systems (depending on the System/370 model)
- Reliability, availability, and serviceability (RAS)

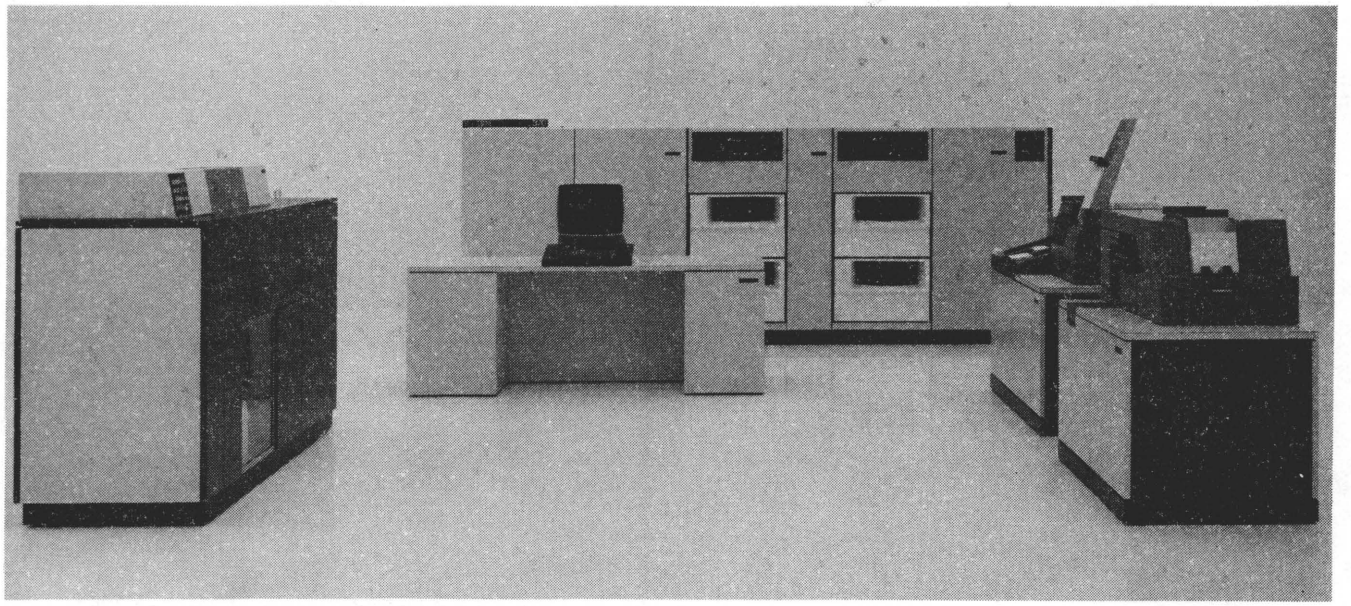


Figure 1-1. System/370 Model 125

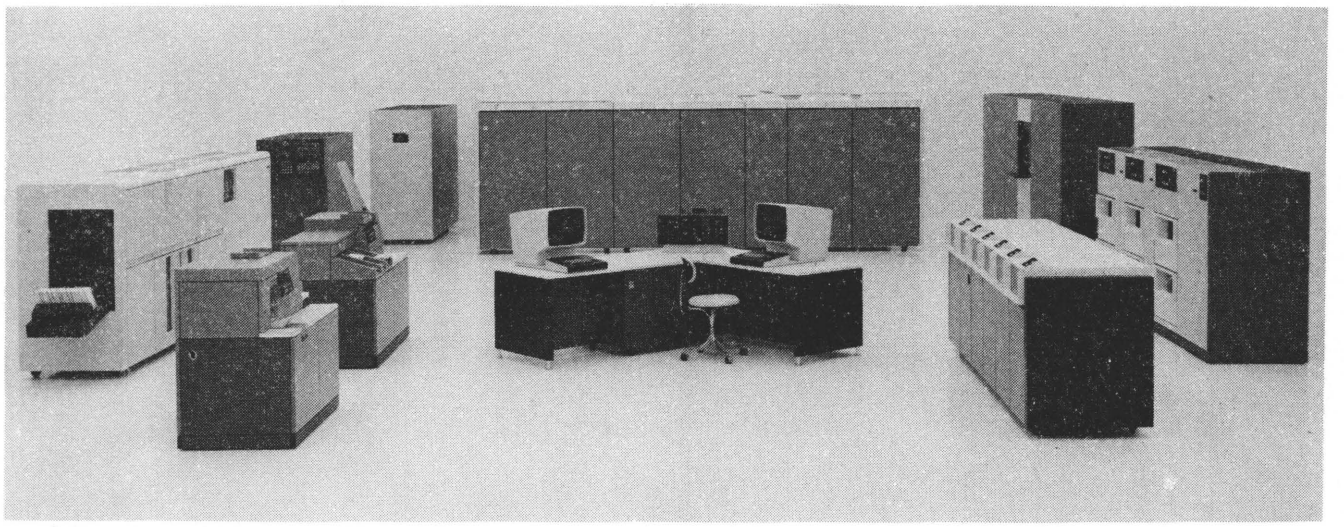


Figure 1-2. System/370 with the 3033 Processor

Logically, System/370 consists of a central processing unit (CPU), main storage, operator facilities, selector and multiplexer channels, and input/output devices that are generally connected to channels through control units.

The physical grouping of these logical parts may vary among System/370 models. In some models, the CPU and main storage are packaged together, and may be referred to as a *processing unit* in other models, the CPU, main storage, and channels are packaged together and may be referred to as a *processor.* When a processor is grouped with the appropriate operator facilities and power and cooling units, it is referred to as a *processor complex.* For convenience in discussion, a processor complex, together with its configured input/output devices, is referred to as a *model.*

Data Formats

The system transmits data in multiples of eight bits. Each eight-bit unit of data is called a *byte*, the basic building block of all formats in System/370. In CPU's and buffers, a ninth bit, the *parity* or *check* bit, is transmitted with each byte and carries odd parity in the byte. The parity bit cannot be affected by the program; its only purpose is to cause an interruption when a parity error is detected. In this manual, references to data exclude the mention of the associated parity bits.

A *field* is composed of one or more bytes. The *halfword*, *word*, and *doubleword* are fields of consecutive bytes; a halfword has two bytes, a word has four bytes, and a doubleword has eight bytes. These fields make up the basic fixed-length data formats (Figure 2-2).

Data formats are either fixed-length or variable-length. During processing, the field length is either implied by the operation to be performed, or it is stated explicitly as part of the instruction.

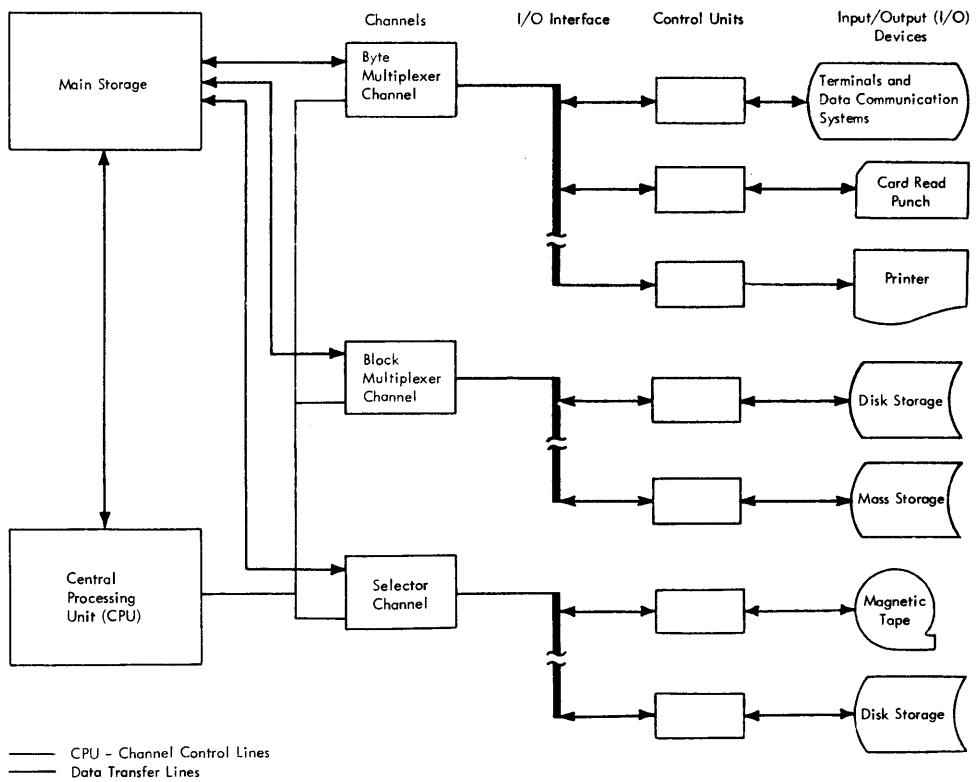


Figure 2-1. Organization of a Representative System/370 Model

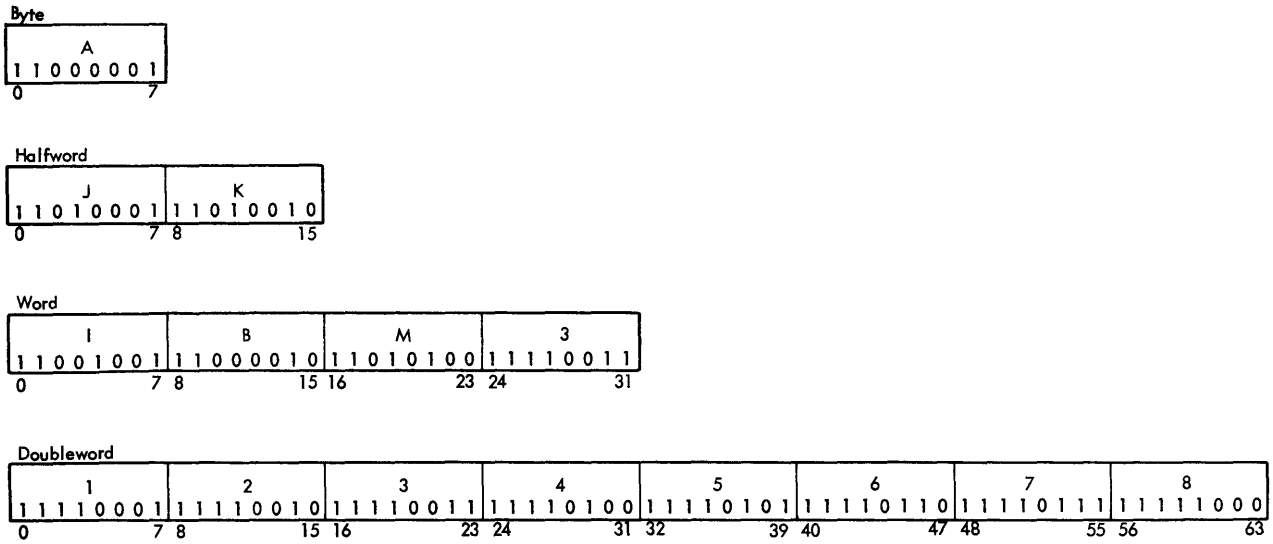


Figure 2-2. Basic Fixed-Length Data Formats (with EBCDIC-Coded Data)

Data Representation

In System/370, data (whether numeric, alphabetic, or alphameric) is processed in multiples of an eight-bit byte. The data may be in binary form (as numeric data for most scientific computations) or it may be in a binary *code*. Coding permits data to be represented by characters (for example, 1, 2, A, B, and *) on devices such as card readers, visual display units, and printers. These devices are code-dependent; that is, their operation depends on the code used to represent the characters.

The eight-bit byte provides for as many as 256 characters, which allows for future code expansion and permits System/370 to accept most present and future codes. The character code used internally in System/370 processing is the extended binary-coded-decimal interchange code (EBCDIC). The bit positions in EBCDIC (Figure 2-3) are numbered the same as those of bytes (left to right, 0-7).

MAIN STORAGE

Main storage provides the system with directly addressable fast-access storage of data. Both data and programs must be loaded into main storage (from input devices) before they can be processed. Some low-address locations are reserved for special purposes.

In some models of System/370, the physical packaging of main storage is referred to as ***processor storage,*** but in certain cases not all of processor storage is directly addressable. Therefore, where it is important to refer only to directly addressable storage, the term ***main storage*** is used.

Addressing

Byte locations in main storage are consecutively numbered starting with 0; each number is the address of a different byte location. A group of bytes in storage is addressed by the lowest-numbered byte location of the group. The number of bytes in the group is either implied by the instruction format or explicitly defined by the instruction itself. The addressing arrangement uses a 24-bit binary address, which gives System/370 the capability of addressing as many as 16,777,216 bytes of storage.

Data Positioning

Restrictions on data positioning in main storage depend on several factors, such as whether the data field is variable or fixed length. A variable-length field may be positioned on any byte boundary in usable main storage, but a fixed-length field (such as a halfword, word, or doubleword) may or may not, depending on what type of reference is made to the data field.

The *byte-oriented operand* feature, which is described in Section 3, allows some fixed-length fields to be positioned on byte boundaries rather than only on *integral boundaries*. A boundary is integral for a unit of data when its main storage address is a multiple of that unit's length in bytes. For example, halfwords (two bytes) should have main storage addresses that are multiples of 2. Figure 2-4 shows integral boundaries for the common units of data, with main storage addresses as four-digit decimal numbers (0000, 0001, 0002, etc.) rather than as the 24-digit binary numbers that are actually used. Sequential halfword addresses are shown in Figure 2-4 as 0000, 0002, 0004, etc. Words (four bytes) must have addresses that are multiples of 4 (shown in Figure 2-4 as 0000, 0004, 0008, etc.), and doublewords (eight bytes) must have addresses that are multiples of 8 (shown in Figure 2-4 as 0000, 0008, etc.).

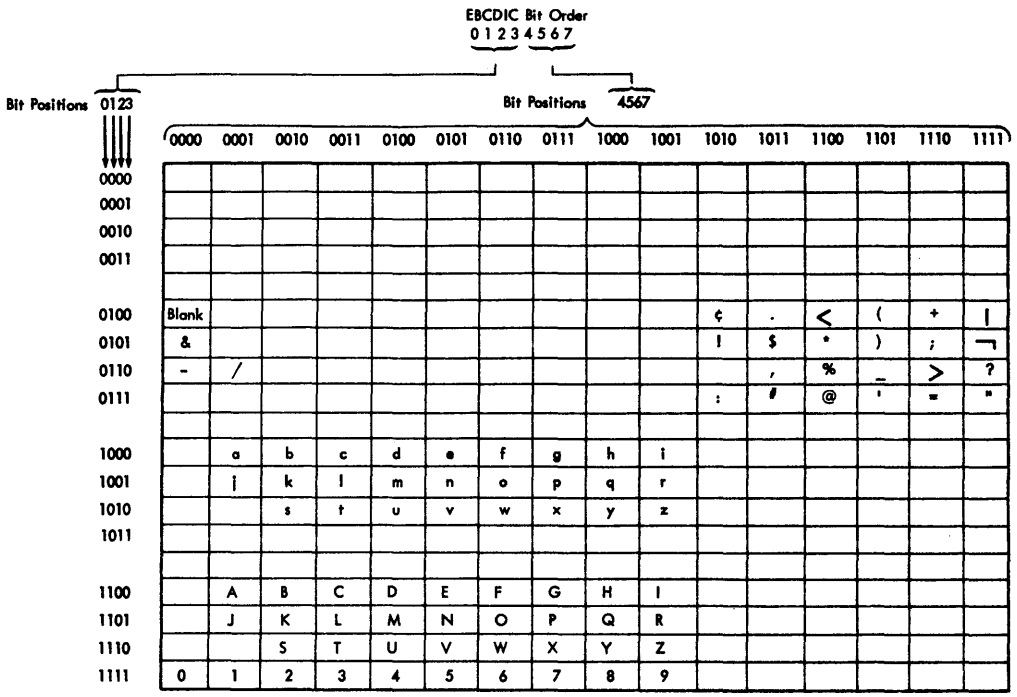


Figure 2-3. EBCDIC Character Codes (Excluding Control Characters)

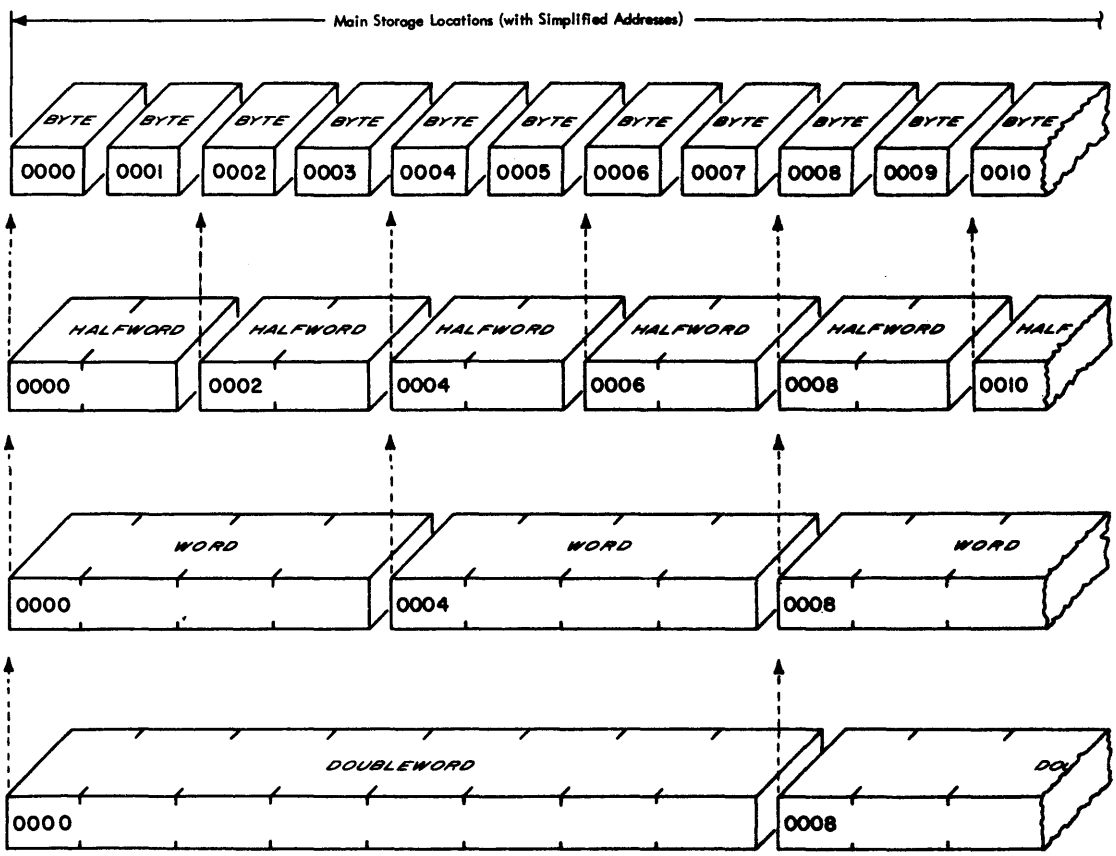


Figure 2-4. Representative Integral Boundaries for Halfwords, Words, and Doublewords in Main Storage

Performance Factors

The variety of main-storage sizes available for the System/370 models permits the system to be tailored to suit the individual needs of the user. Main storage differs in capacities, access widths, cycle times, and degrees of interleaving depending on the processor installed.

Depending on the model, storage capacities range from 64K (65,536 bytes) to 8M (8,388,608 bytes). (In this manual, 1K = 1,024, and 1M = 1,048,576 bytes.)

Storage Access Width is the number of bytes transferred to or from main storage in each access. As access width increases, the quantity of data that may be transferred per unit time increases. The width, which is model-dependent, ranges from 2 to 16 bytes.

Storage Cycle Time is a measure of storage speed and is defined as the length of time that main storage is busy whenever a reference is made to it. Generally, the shorter the cycle time, the greater the number of operations that can be performed in any time interval. The storage cycle time is 2.07 microseconds or less, the exact value depending on the system model.

Storage Interleaving, a model-dependent capability, increases the number of main-storage accesses started in a storage cycle, thereby significantly increasing the amount of data accessed per unit time.

CENTRAL PROCESSING UNIT

The central processing unit (CPU) is the controlling center of System/370. It provides facilities for:

Addressing main storage.
Fetching and storing data.
Arithmetic and logical processing of data.
Executing instructions in a desired sequence.
Initiating communication between main storage and input/output (I/O) devices.

Three types of programmable registers are provided by the processing unit: general, floating-point, and control. The 16 *general registers* and 4 *floating-point registers* are accessible to the problem programmer and are capable of receiving data, holding it, and permitting it to be operated on. The general registers are used primarily for fixed-point, logical, and addressing operations. The floating-point registers are used only for floating-point arithmetic. The control registers provide for the handling of information used to control some system operations. These registers are accessible to the control program by way of specific instructions. The number of registers and register positions available with any system model depends on which installed functions require control registers.

Arithmetic and Logical Operations

The arithmetic and logical operations fall into four classes:

Decimal arithmetic
Fixed-point arithmetic
Floating-point arithmetic
Logical operations

These classes differ in the data formats and field lengths used, the registers involved, and the operations provided.

Decimal Arithmetic

Decimal arithmetic, used principally for commercial applications, is performed on signed decimal data. Generally, decimal data entering and leaving the system via devices such as card reader-punches and printers is in *zoned* format (Figure 2-5). But for processing and for storage in direct-access and magnetic-tape devices, decimal data is in *packed* format (Figure 2-6). Packing fits two decimal digits (or one digit and sign) per byte. Because only four binary digits are needed to express one decimal digit, packing permits more efficient handling of decimal data.

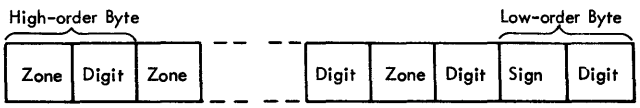


Figure 2-5. Zoned Decimal Number Format

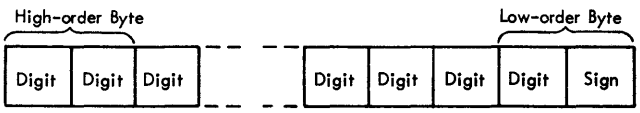


Figure 2-6. Packed Decimal Number Format

Packed data is taken from main storage, processed, and returned to storage without the data passing through any general registers; this is called *storage-to-storage* processing. The decimal field length, specified by the instruction, can be expanded to as many as 31 digits plus sign, all packed in up to 16 bytes.

Fixed-Point Arithmetic

Fixed-point arithmetic is used to perform arithmetic operations on both data and storage addresses.

The fixed-point binary word (Figure 2-7), the basic arithmetic operand in System/370, is a 32-bit signed integer (a 31-bit integer with a high-order sign bit). Halfword operands can be specified in many operations where a fullword is not needed, thus improving both performance and use of storage.

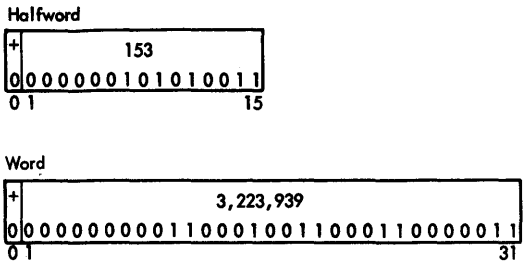


Figure 2-7. Fixed-Point Number Formats (with Signed Binary Data)

The 16 general registers, each four bytes (32 bits) wide, are used for fixed-point operations. For fixed-point product and dividend precision, two adjacent registers can be coupled, effectively doubling the register width.

Floating-Point Arithmetic

Floating-point arithmetic, used primarily in scientific applications, greatly increases the speed, precision, and efficiency of computations. In System/370, this form of numeric representation can express positive or negative decimal values from about 10^{-78} to about 10^{76}.

Floating-point numbers may be short (24-bit fractions, with about seven-decimal-place precision), long (56-bit fractions, with about 17-decimal-place precision), or extended (112-bit fractions, with about 34-decimal-place precision). Floating-point fractions are made up of hexadecimal (base 16) digits, each consisting of four binary digits and having equivalent decimal (base 10) values of 0-15. The short format (Figure 2-8) usually reduces execution times and increases the number of operands that can be stored, the long format (Figure 2-9) provides greater precision, and the extended format (Figure 2-10) provides about twice the precision of the long format. (See "Extended-Precision Floating-Point Feature," Section 3.)

Four floating-point registers, each eight bytes wide, are provided. The availability of these registers eliminates much fetching and storing of intermediate results. The 16 general registers are also used, primarily for indexing and address arithmetic.

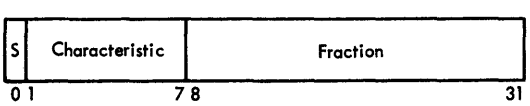


Figure 2-8. Short Floating-Point Number Format

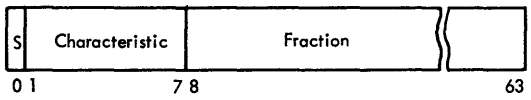


Figure 2-9. Long Floating-Point Number Format

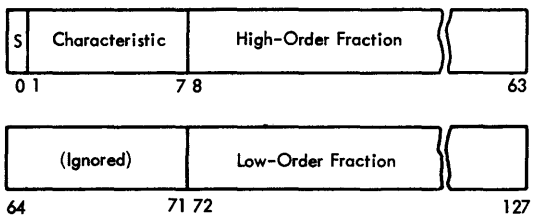


Figure 2-10. Extended Floating-Point Number Format

Logical Operations

The logical operations provide System/370 with the ability to manipulate logical quantities. The manipulations include: comparing, testing, translating (character for character), editing (sign and punctuation control), and moving logical data. The data may have either a fixed- or variable-length format (Figures 2-11 and 2-12). Fixed-length data, processed through the general registers, may be one, four, or eight bytes long; variable-length data, processed storage to storage, can extend to 256 bytes.

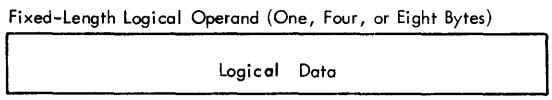


Figure 2-11. Fixed-Length Logical Format

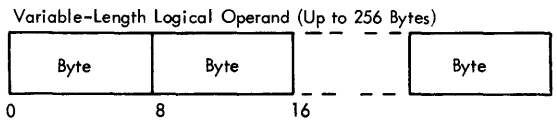


Figure 2-12. Variable-Length Logical Format

Instruction Formats

Main storage addressing and the execution of processing programs are directed by the CPU. The instructions that make up these programs may be of several different formats, identified by the format codes RR, RRE, RX, RS, S, SI, SS, and SSE (Figure 2-13).

RR denotes a register-to-register operation. The operands are in general registers, and the result replaces the first operand.

RX denotes a register-and-indexed-storage operation. The first operand is in a general register, and the second operand is in a main storage location. This format includes a

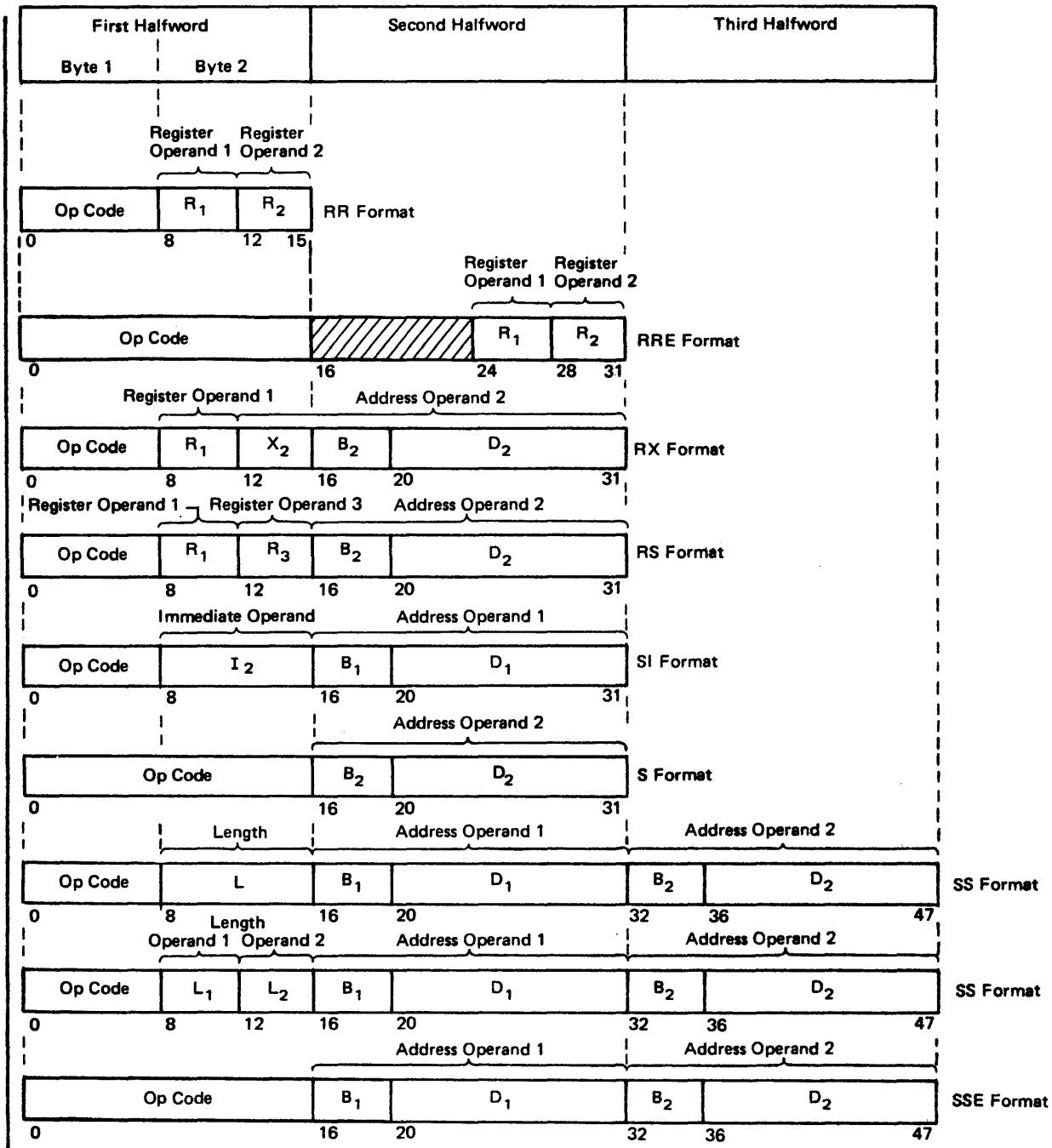


Figure 2-13. Basic Instruction Formats

quantity for indexing the main storage address; the quantity is contained within a general register, which is used as an index register and specified by the instruction. The result of an RX operation may replace the first operand depending on the instruction.

RS denotes a register-and-storage operation. The first operand is in a general register, the second operand is in main storage, and a third may be specified by another general register.

S denotes an operation using an implied operand and storage.

SI denotes an immediate-operand-and-storage operation. The first operand is one byte of data carried in the instruction itself (the immediate operand), and the second operand is in main storage.

SS denotes a storage-to-storage operation. Both operands are in main storage.

Generally, the first byte of each of these formats gives the operation code (the "op code"), which identifies the operation to be performed; for S-format instructions, however, the first *two* bytes are used for the op code.

Operator Facilities

The operator facilities provide for manual operation and control of the system. They include operator-to-machine communication, indication of machine status, control over the setting of the time-of-day clock, initial program loading, resets, and other manual controls for operator intervention in normal machine operation.

The need for operator manipulation of manual controls is minimized by the system design and by the governing control program, reducing the number and seriousness of operator errors.

A large-system capability permits certain operator controls to also be mounted on a separate console, such as the IBM 3036 Console.

INPUT/OUTPUT

An input/output operation transfers data between main storage and an I/O device. An I/O operation is initiated by a program instruction that generates a command to a *channel.* A *control unit* receives the command via the I/O *interface,* decodes it, and starts the I/O device.

Channels

Channels are the direct controllers of I/O devices and control units. They provide System/370 with the ability to read, write, and compute, all at the same time, by relieving the CPU of the task of communicating directly with the I/O devices.

Depending on the System/370 model, channels may be separate units, complete with the necessary logical and storage capabilities, or they may be physically integrated in the processor. The type available to any system model depends on the system model itself. In either case, the channel functions are identical, but may be implemented in such a way as to have different data transfer rates.

Functionally, the channel data path is divided into *subchannels.* To a programmer, each subchannel is a separate channel, and can be programmed as such.

Some subchannels can control several I/O devices, whereas others can control only one; these are called *shared* and *nonshared* subchannels, respectively.

System/370 has three types of channels: byte multiplexer, selector, and block multiplexer.

Byte Multiplexer Channels

Byte multiplexer channels separate the operations of high-speed devices from those of lower-speed devices. Channel operations are in either of two modes: ***byte*** mode for lower data rates, and ***burst*** mode for higher data rates.

In byte mode, the single data path of the channel can be shared by a large number of lower-speed I/O devices (such as card readers, printers, and terminals) operating concurrently; the channel receives and sends data to the I/O devices on demand.

Burst mode is forced by devices such as magnetic tape units or disks and is not under the control of the programmer. Such high-speed devices, having established a logical connection with a channel, usually stay connected to it for the duration of data transfer and thereby force the channel into burst-mode state.

The IBM 2870 Multiplexer Channel (Figure 2-14), the separate unit used with Model 168, houses one byte multiplexer channel. Like the integrated byte multiplexer channels, 2870's have *byte multiplexer subchannels;* additionally, 2870's can have *selector subchannels.*

Byte multiplexer subchannels may operate in either byte or burst mode, and may be of either the shared or nonshared type. In byte mode, each can operate one low- or medium-speed I/O device concurrently, if the total load on the channel does not exceed the channel capacity. In burst mode, one byte multiplexer subchannel monopolizes the byte multiplexer channel and operates one higher-speed I/O device.

Selector subchannels, which are of the shared type only, operate only in burst mode; each can operate one I/O device concurrently with the byte multiplexer subchannels but can control as many as 16 I/O devices.

Selector Channels

Selector channels transmit data to or from a single I/O device at a time. They can handle both high- and lower-speed I/O devices, but their burst-mode operation makes them especially suitable for high-speed devices. Each selector channel attaches up to eight I/O control

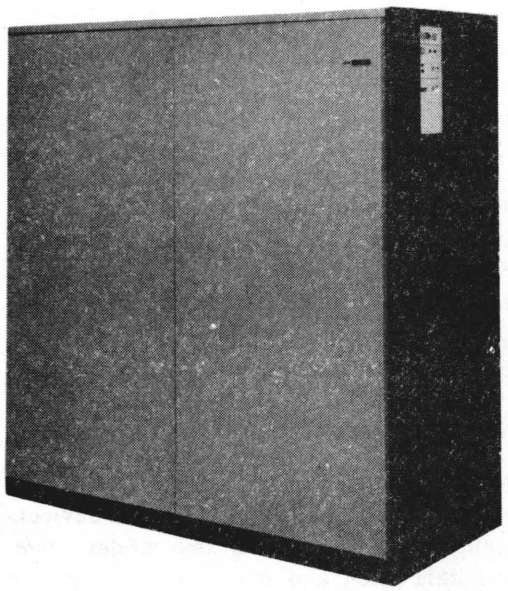


Figure 2-14. IBM 2870 Multiplexer Channel

units and can address as many as 256 I/O devices. One I/O device per selector channel can be transmitting data at any given time; no other I/O device on the channel can transmit data until all data is handled for the selected device.

In general, I/O operations on a selector channel are overlapped with processing, and all channels can operate simultaneously, provided that the processing unit's data rate capabilities are not exceeded. The maximum data rates for the selector channels vary with the System/370 models and the channel options available, and range from 1.3 to 1.85 million bytes per second.

The IBM 2860 Selector Channel, the separate unit used with Model 168, is similar in appearance to the 2870 Multiplexer Channel (Figure 2-14), and can house one, two, or three selector channels.

Block Multiplexer Channels

Block multiplexer channels have advantages of both byte multiplexer and selector channels in that they can concurrently operate many high-speed I/O devices on a single data path.

Block multiplexer channels operate in either of two modes: selector or block multiplex. *Selector mode* is functionally equivalent to selector channel operation, permitting attachment of all the I/O devices which can attach to selector channels. In *block multiplex mode*, these channels permit interleaving (multiplexing) of channel programs for high-speed devices in such a way that channel programs can be initiated sooner and channels can be freed earlier than would be possible with selector channels. The byte and block multiplexer channels differ primarily in that the block multiplexer channels can operate with much faster I/O devices, and they transfer larger quantities of data per transmission. These quantities are referred to as *blocks*, and may include a number of records.

Block multiplexer channels provide a number of subchannels of the shared or nonshared type. The maximum data rates for block multiplexer channels vary with the System/370 models and channel options available, and range from 1.2 to 3.0 million bytes per second.

The IBM 2880 Block Multiplexer Channel, the separate unit used with Model 168, is similar in appearance to the 2870 (Figure 2-14), and houses either one or two block multiplexer channels.

I/O Devices

I/O devices fall into a number of categories, some of which overlap. They are used in and for:

- Auxiliary storage
- Machine and manual (keyed) input, both local and remote
- Data Communications
- Reading (or output) of external documents and displays
- Process control
- Data acquisition

Many I/O devices function with an external document, such as a punched card or a reel of magnetic tape. Others handle only electrical signals, such as those in process-control and data acquisition systems.

Control Unit Function

The control unit function provides the logic circuitry and the storage areas (buffers) needed to operate the attached I/O devices. Yet, to the user, most control unit functions cannot be distinguished from I/O device functions.

The control unit function may be part of the I/O device or the processor (integrated attachments), or it can physically be a separate unit.

I/O Interface

The I/O interface provides a uniform method of attaching various I/O devices (through control units) to a channel. The information format and the control signal sequences provided by the interface are independent of the type of control unit and channel. Certain I/O devices that do not use the I/O interface do use the same programming information format and sequences.

INTERRUPTION SYSTEM

The interruption system permits System/370 to dynamically respond to equipment and programming errors, and greatly aids the efficient use of I/O equipment. To make

the interruption procedure as short and simple as possible, switching between the interrupted program and the control program (the program that services interruptions) must be efficient.

The interruption system uses *program status words* (PSW's) to hold status and control information. Additionally, System/370 uses control registers to regulate the interruption system.

As soon as an interruption occurs, all current status information, together with an identification of the cause of the interruption, is put into a PSW. This "old" PSW is stored at a fixed location. The system then automatically fetches a "new" PSW from a different fixed location. Each class of interruption uses two fixed locations in main storage: one to receive the old PSW when the interruption occurs, and the other to supply the new PSW that governs the servicing of that class of interruption.

After the interruption has been serviced, the CPU is restored by the control program to the status it had before the interruption.

Classes of Interruptions

The interruption system separates interruptions into six classes:

Program interruptions are caused by various kinds of programming errors; the exact type of condition is identified in the program old PSW.

Supervisor Call interruptions are caused when the program issues an instruction to pass control to the part of the control program, called the *supervisor*, which performs the supervisory functions associated with a task.

External interruptions are caused by an external device that requires attention, by the interval timer (an internal clocking device) going past zero, or by the operator pressing the interrupt key.

I/O interruptions are caused by an I/O device ending an operation or otherwise needing attention. Identification of the device and channel causing the interruption is stored in the I/O old PSW; in addition, the status of the device and channel is stored in a fixed location.

Machine Check interruptions are caused by the machine-checking circuits detecting an error.

Restart interruptions are caused by the operator activating the restart key or by another processor specifying restart.

Disallowing of Interruptions

Most interruptions may be either allowed or temporarily disallowed. When an interruption is disallowed, it is either delayed or does not take place, the outcome depending mainly on the class of interruption. The following interruptions can be disallowed:

All I/O interruptions
All external interruptions
Some program interruptions
All machine-check interruptions

Priority of Interruptions

During the execution of an instruction, several interruptive events may occur simultaneously. When this occurs, the competing interruption requests are serviced in a fixed order of priority.

VIRTUAL STORAGE CAPABILITY

System/370 virtual storage extends and enhances system capabilities by permitting users to program as though the system had use of as much as 16,384K (16,777,216 bytes) of storage. This storage capability is provided by way of dynamic address translation, channel indirect data addressing, and associated programming support. The contents of virtual storage are usually maintained on an external storage medium called ***external page storage*** (Figure 4-1).

Virtual storage is divided into ***segments*** of either 64K (65,536 bytes) or 1,024K (1,048,576 bytes). Each segment is divided into ***pages*** of 2K or 4K bytes. A segment is a block of sequential logical addresses spanning 64K or 1,024K bytes in virtual storage. A page is a block of sequential logical addresses spanning 2K or 4K bytes in virtual storage. A page may contain instructions, data or both. A page is transferable between real storage and external page storage. When a program is executed, the addresses specified by the program are translated, via dynamic address translation, into real addresses in main storage.

As pages of virtual storage are addressed, if they are not already in main storage they are brought in from external page storage to replace pages in real main storage that are not needed. The swapping of pages of storage is performed by the operating system.

MULTIPROCESSING

Multiprocessing is possible in a system that uses appropriate models (see Section 5 of the IBM 3158 or 3158-3 Processing Unit (System/370 Model 158), the IBM 3168 or 3168-3 Processing Unit (System/370 Model 168), or the IBM 3033 Processor (IBM 3033 Multiprocessor Complex). In each multiprocessing operation, the two processors operate under a single system control program.

The term ***multiprocessing*** applies to a system with two

CPUs such as a system with two MP-series or M-series processors, or a system with one A-series or AP-series processor and one attached processor.

In a multiprocessing system that uses the Model 158 or 168, shared processor storage is allocated from a configuration control panel located between the two processors. In a 3033 Multiprocessor Complex, shared processor storage is allocated from either of the IBM 3036 Consoles attached to the processors.

Multiprocessing in a system with two MP- or M-series processors offers:

1. Improved workload balance between the processors by the sharing of processor storage and I/O devices.
2. Increased availability through maintenance that is concurrent with job activity. Job processing can continue while a maintenance subsystem (processor, processor storage, and I/O devices) is used to complete a particular maintenance task.
3. Increased system flexibility because each system can operate independently, with its own system control program, assigned processor storage, and I/O devices.

Basic models of the 3158, 3158-3, 3168, 3168-3, and 3033 can be converted to multiprocessor models. In addition, the features and I/O devices available are the same for the basic and the multiprocessor models.

Multiprocessing in a system with one A-series or AP-series processor and one attached processor offers an increase of combined system instruction execution rates over those of a system with a single processor.

Section 3. System/370 Features

This section describes the more prominent standard and optional features of System/370. The features discussed are listed under the name of that part of the basic system structure with which they are usually associated.

Features may be standard, optional, or available only on certain System/370 models. (See Section 5 for further information.)

MAIN STORAGE FEATURES

Main (or processor) storage includes all storage that is directly addressable.

Main Storage Capacities

Main storage capacities offer a wide latitude in choosing the amount of storage required. The capacities vary from 64K (65,536 bytes) to 8,192K (8,388,608 bytes), depending on the System/370 model. Each System/370 model is available in a choice of several storage capacities.

Low-Address Protection

Low-address protection, which is active whenever bit 3 of control register 0 is one, prohibits the storing of instructions into locations 0 through 511. Because these locations contain information critical to proper operation of the entire system, the use of low-address protection can prevent system failures caused by inadvertent modifications in this area by the CPU program.

Low-address protection is not applied to accesses made by the CPU or channel for interruptions, updating the interval timer, logout, storing the CSW by an I/O instruction or interruption, storing channel identification during execution of Store Channel ID (STIDC), and the initial-program-loading and store-status functions, nor is it applied to data stores by a channel during I/O data transfer.

If storing is attempted to a location protected by low-address protection, the protected area is unchanged, and a program interruption for protection occurs, with suppression or termination of the operation.

This feature is available on certain System/370 models and is considered part of the extended facility.

Key-Controlled Storage Protection

Key-controlled storage protection, consisting of store and fetch protection, prevents the unauthorized changing or use of the contents of main storage. *Store protection* prevents the contents of main storage from being altered by storage addressing errors in programs or input from I/O devices. *Fetch protection* prevents the unauthorized fetching of data and instructions from main storage. As many as 15 programs (with associated main storage areas) can be protected at one time. Key-controlled protection is standard on all System/370 models.

Protection is achieved by dividing main storage into 2,048-byte blocks and by associating a five-bit *storage key* (Figure 3-1) with each block. Each storage key may be thought of as a lock. Each block of storage, then, has its own "lock." Two instructions are provided for assigning and inspecting the key, which contains a four-bit *code*. The same code may be used by many blocks, using binary codes 0001-1111.

A user's right of access to storage is identified by a four-bit *access key* (Figure 3-1), located in the program status word (PSW key) or in a special word used in channel operations (subchannel key). The access key may be thought of as the key for the "lock." During a main-storage reference (storing or fetching), the storage key is compared with the access key associated with the reference. Access to the location is granted only when the four leftmost bits of the storage key match the access key, or when the access key is zero (0000). The rightmost bit of the storage key determines whether fetch protection is operative for the storage block associated with that key. If the bit is 1, fetch protection is operative; if it is 0, it is inoperative.

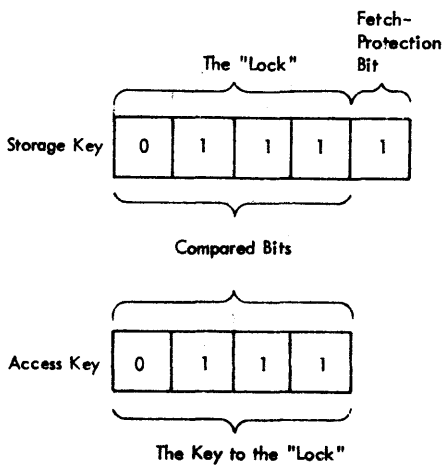


Figure 3-1. Storage Key and Access Key Showing Matching Keys

HIGH-SPEED BUFFER STORAGE

Buffer storage can sharply reduce the time required for fetching currently used sections of main storage. On the Model 168, for example, the CPU can obtain eight bytes from the buffer in two cycles (160 nanoseconds), and a request can be initiated every cycle. This compares with five cycles (400 nanoseconds) required to obtain eight bytes directly from main storage.

Buffer operation is handled entirely by hardware and is transparent to the programmer, who does not need to adhere to any particular program structure to achieve close-to-optimum use of the buffer.

CPU FEATURES

Instruction Sets

System/370 has three instruction sets: the standard, commercial, and universal (Figure 3-2).

The *System/370 standard instruction set* is a facility that includes all instructions that are not part of any separately defined grouping. These instructions provide the basic processing capability of the system.

The *System/370 commercial instruction set* includes the System/370 standard instruction set and the System/370 decimal instructions. It is standard on all System/370 models.

The *System/370 universal instruction set* includes the System/370 commercial instruction set and the System/370 floating-point feature instructions.

The System/370 instruction sets are fully described in the *IBM System/370 Principles of Operation,* GA22-7000.

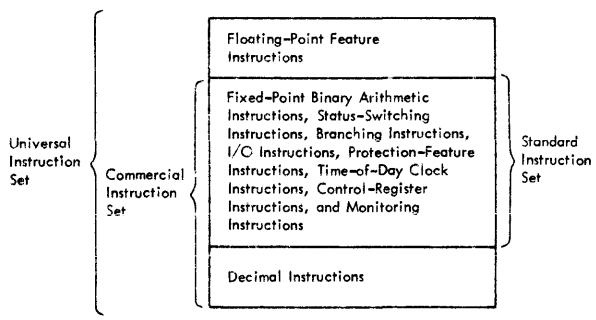


Figure 3-2. System/370 Instruction Sets

Decimal

This feature, especially useful in commercial operations, permits storage-to-storage decimal arithmetic operations and includes two instructions to assist in editing output.

Floating Point

This feature, used primarily in scientific operations, permits calculations on data with a wide range of magnitude. Included with this feature are four 64-bit floating-point registers, which are used to perform these calculations. Operands can be selected for either 24-bit fractions (short precision) or 56-bit fractions (long precision).

Extended-Precision Floating Point

This feature permits floating-point operands to have 112-bit fractions (extended precision) compared to the 56-bit fractions available with long-precision floating-point arithmetic. It also permits results to be rounded from extended to long precision or from long to short precision.

Direct Control

Direct control provides for exchanging control signals between two System/370 processors, between a System/370 processor and a System/360 processor, or between a System/370 and some specialized device, such as an analog-to-digital converter.

Direct control bypasses the channel by using the direct control instructions and an external-signal facility, consisting of six external interruption lines, each of which, when pulsed, sets up the conditions for an external interruption.

Some System/370 models provide the external-signal facility as a separate feature (that is, minus the instructions).

Interval Timer

This timer provides program interruptions on a program-controlled basis. The timer, which is updated by timing circuits, has a time resolution of 3.333 milliseconds, and a total clock cycle of 15.5 hours.

Time-of-Day Clock

This feature provides a precise measure of time suitable for accurate elapsed time measurements and time-of-day indication. The clock's binary value, updated each microsecond in bit position 51, can be interrogated or set by provided instructions. The total clock cycle is approximately 142 years.

Byte-Oriented Operand

The byte-oriented operand feature removes the integral-boundary restriction from fixed-length fields referenced by most *unprivileged* instructions, permitting the fields

to be located in main storage on byte boundaries. For optimum performance, however, these fixed-length fields should be located on integral boundaries, because significant performance degradation may result from the use of this feature.

Essentially, *privileged* instructions are those used solely with control programs, whereas *unprivileged* instructions are used in problem programs, as well as in control programs.

Translation

The System/370 translation feature includes the translation feature instructions, dynamic address translation, extended control mode, program event recording, and store status and program reset.

Dynamic Address Translation

This feature translates program-specified addresses into real addresses in main storage. With appropriate programming support, it can be used to move data and programs to an external storage device, and later return them to main storage for completion of execution.

Address translation uses a lookup procedure employing tables in main storage. A special buffer is used to store as many as 128 address translations, the number depending on the system model. All storage references are first compared with the buffer to determine if a current translation exists. If one does exist, it is used; if not, translation proceeds and the result is put into the buffer.

Extended Control Mode

This feature provides for an expanded PSW format and for a CPU mode in which certain System/370 features (such as dynamic address translation) can operate. When the system is not in extended control mode, it is in basic control mode.

Program Event Recording

Program event recording provides a means for debugging programs, and permits a programmer to be alerted to the following events:
A successful branch
Alteration of a selected general register
Instruction fetching from a selected main storage area
Alteration of a selected main storage area.

Store Status and Program Reset

The store status and program reset facilities include a reset function that does not destroy the contents of the progammable registers and a store status function that places the contents of the programmable registers into main storage.

Clock Comparator and CPU Timer

Expanded CPU timing functions are provided by this feature. The clock comparator causes an external interruption when the time-of-day clock reaches a value specified by the user. The CPU timer measures elapsed time and causes an external interruption when a prespecified interval of time has elapsed. The CPU timer can also be used as a high-resolution timer.

CHANNEL FEATURES

Channel Indirect Data Addressing

This feature provides the means for applying address translation to I/O operations.

Channel-to-Channel Adapter

This adapter provides a path for data transfers between two channels and synchronizes such transfers, providing systems with interchannel communication.

The channels are usually on separate systems. Connecting a channel of one system to a channel of another has the effect of interconnecting two processors.

The adapter uses one or two control-unit positions on each of the two connected channels, but only one channel need have the adapter.

Two-Channel Switch

This feature attaches a path to a second channel. The two channels may be on the same processor or different processors. Switching is under program control.

Command Retry

Command retry, a control-unit-dependent feature, can cause a failing channel command to be retried without requiring an I/O interruption. The number of retries is device-dependent.

SYSTEM FEATURES

Compatibility Features for Other IBM Systems

A number of features are available that permit operation of certain models of System/370 by the use of programs written for other IBM systems. These compatibility features are combinations of circuitry and programming that allow the System/370 to read programs written for the other system and to function like that system. In many cases, the program runs much faster on System/370 than on the system for which it was written.

Compatibility features are also called *emulators*, but not simulators. The latter, although they may perform the same function, do so with programming alone and thus run slower.

A compatibility feature is particularly useful when the user needs time to convert his present programs to System/370 code but, at the same time, wants the advantages offered by System/370. In addition, using such a feature may eliminate the need for converting programs that are seldom used.

Sufficient storage and appropriate or equivalent I/O devices must be available for the use of a compatibility feature. Furthermore, the use of one compatibility feature may preclude the use of another. Under unusual conditions, a feature may not be able to maintain exact compatibility; for example, programs that are time-dependent may not yield identical results, and the handling of error conditions may differ.

In general, the lower end models of System/370 offer 1401/1440/1460 and System/360 Model 20 compatibility. The upper end models offer 7070/7074, 7080, and 7090/7094 compatibility.

OS/DOS Compatibility

This feature provides a System/370 model with the ability to execute DOS programs under OS control.

The programming systems information as presented in this section assumes that the reader has a basic knowledge of IBM programming systems, such as that found in *IBM System/360 Operating System Introduction,* GC28-6534.

The IBM-supplied programming systems that support the System/370 include:

- DOS/VS (Disk Operating System/Virtual Storage)
- OS/VS1 (Operating System/Virtual Storage 1)
- OS/VS2 (Operating System/Virtual Storage 2)
- VM/370 (Virtual Machine Facility/370)

This section describes OS/VS1, OS/VS2, and VM/370. For information about DOS/VS, see *Introduction to DOS/VS,* GC33-5370. Also, more detailed descriptions of OS/VS2 and VM/370 can be found in *Introduction to OS/VS2 Release 2,* GC28-0661, and *IBM Virtual Machine Facility/370: Introduction,* GC20-1800, respectively.

OS/VS1 (Operating System/Virtual Storage 1)

OS/VS1 is one of the IBM-supplied programming systems that support the System/370. This support is comparable to that provided by OS/MFT (System/360 Operating System Multiprogramming with a Fixed Number of Tasks). Many enhancements as well as significant new features, however, are provided in VS1. Because OS/VS1 is a growth version of OS/MFT, this section assumes a basic knowledge of operating systems. For further information about OS/VS1 and OS/VS1 publications, see these publications:

- *Introduction to Virtual Storage in System/370,* GR20-4260
- *OS/VS1 Planning and Use Guide,* GC24-5090
- *IBM System/370 Bibliography,* GC20-0001
- *IBM System/370 Bibliography of Industry Systems and Application Programs,* GC20-0370

INTRODUCTION TO OS/VS1

OS/VS1 is a system control program (SCP) that makes possible the concurrent execution of as many as 15 separate jobs within a single computing system having only one central processor, while continuing to provide all other applicable services of the IBM System/370 Operating System.

Externally, OS/VS1 has the same functional characteristics as the current release of OS/MFT; internally, it includes several enhancements that make it a more effective and versatile operating system. The most significant enhancements are:

- VS (Virtual Storage)
- JES (Job Entry Subsystem)
- VSAM (Virtual Storage Access Method)
- VTAM (Virtual Telecommunications Access Method)

VSAM and VTAM are described under "Methods of Storing and Retrieving Data" and "Data Communications," respectively.

Virtual Storage

OS/VS1 uses the System/370 hardware feature called *Dynamic Address Translation (DAT)* that provides an expanded address space of up to 16,777,216 bytes. This enlarged storage is called *virtual storage,* which the user shares with the system control program.

Virtual storage is the address space that appears to the user as real (main) storage and from which instructions and data are mapped into real storage locations. In MFT, processor storage is referred to as main storage. VS1 uses the term *real storage* to designate the main storage of System/370, whereas *virtual storage* refers to its complete addressing range.

Figure 4-1 illustrates how VS1 implements virtual storage through a combination of the DAT hardware feature and the *paging* function of the system control program.

Programs are actually stored on auxiliary storage, called *external page storage,* which is divided into 2K blocks called *slots;* similarly, programs themselves are divided into 2K blocks called *pages* and real storage is divided into 2K blocks called *page frames.* The system transfers pages of programs from external page storage to real storage as they are required for execution, automatically translating the program's virtual storage addresses to actual addresses in real storage. The pages are not necessarily contiguous in real storage. This process is called *paging* and is transparent to the user. Page-in obtains a page from auxiliary storage and page-out returns a page to auxiliary storage. To accomplish the paging function, the page supervisor must:

- Recognize the need for page transfer to real storage.
- Select an appropriate real storage block for the page.
- Maintain an available supply of real storage blocks.
- Save the contents of pages by moving them to auxiliary storage, if necessary.
- Recognize the need to fix (or lock) a page in real storage.

Although VS1 is primarily a paging-environment system, the system control program enables the execution of

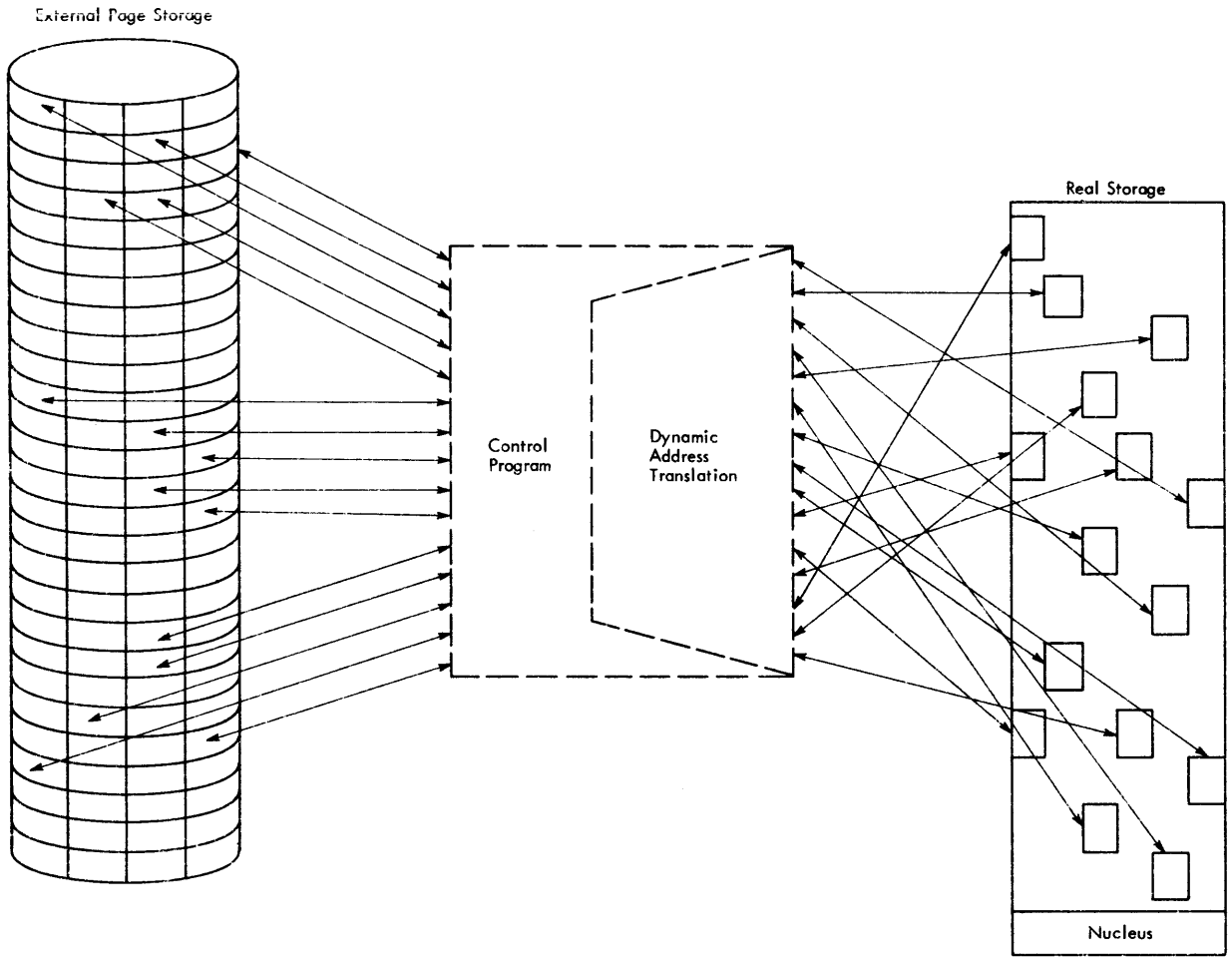


Figure 4-1. Virtual Storage Implementation

programs that cannot be paged between auxiliary storage and real storage. These programs, therefore, must run via the 'virtual = real' facility. This facility gives you real storage for any of your programs that do not run in the normally paged environment of VS1. It allocates real storage if it is available, at job execution time, with real storage addresses equivalent to virtual storage addresses on a byte basis, for the amount of storage you have specified for the job involved. Multiple virtual = real jobs execute concurrently if the system has enough real storage to accommodate the jobs. The classes of programs that do not run in a paged environment are:

1. Programs that modify the channel program while it is active.
2. Programs that are highly time dependent, such as some magnetic ink character recognition (MICR) programs.
3. Programs that use the execute channel program (EXCP) with user-written appendages.

Advantages of VS1 Virtual Storage

- Most jobs requiring more address space than the available real storage can execute in a VS1 environment.
- VS1 dynamically allocates real storage on an as-used or as-required basis.
- Real storage that was unused, by partitions, in an OS/MFT system can be recovered with VS1 and used by other partitions, because virtual address space in a partition does not require real storage until it is addressed.
- The small partition scheduling requirements of OS/MFT do not exist in VS1 because virtual address space sufficient for scheduler requirements is provided for all partitions. Thus, no partition forces another to wait for scheduling.
- You can test most programs with large design points on machines with smaller real storage. The performance of these programs is directly related to their storage requirements versus real storage availability.
- You can write future processors for VS1 with few storage restrictions.
- Infrequently executed system tasks do not require real storage to be permanently reserved for their use. You can page-in these programs on demand.

- You can reserve virtual storage for unscheduled top-priority jobs.
- Partition redefinition requirement is reduced.

JES (Job Entry Subsystem)

JES is a control-program facility that provides streamlined job processing in VS1. It spools and schedules primary input and output streams.

JES performs two spooling functions:

1. It reads all primary input streams, including JCL and data, from the input device, and stores them on a direct access storage device in a format convenient for later processing by the system and by the user's programs.
2. It similarly stores system (and selected user) print and punch output on a direct access storage device until a convenient time for printing or punching.

Spooling provides the following advantages:

- Nonsharable devices, generally unit record devices, are used at full rated speed if enough buffers are available.
- Nonsharable devices are used only for the time required to read, print, or punch the data.

Without spooling, the device is occupied for the entire time that a job is reading input or writing output. Thus, the device runs only as fast as the job can accept or generate data.

If system resources are the objects of contention (for example, buffer assignment), JES schedules the contending activities to assure the highest degree of system availability. Because data is stored on a direct access storage device, jobs or their output can be processed in a different order from that in which they were submitted. This ability to control system work is called *job queuing*. Jobs can be scheduled by class, and by priority within class.

OS/MFT–OS/VS1 Differences

In general, all major OS/MFT features are available in VS1. Listed below, however, are some of the more significant differences, which VS1 does not support. For a more complete list of differences between OS/MFT and OS/VS1, refer to the *OS/VS1 Planning and Use Guide,* GC24-5090.

- Main storage hierarchies: Large core storage (LCS) is not attachable to the System/370. (In programs where hierarchy values are specified, these values are added together.)
- TESTRAN: A low-usage component of MFT.
- Graphic Job Processor (GJP): A low-usage component of MFT.
- Satellite Graphic Job Processor (SGJP): A low-usage component of MFT.
- Queued Telecommunications Access Method (QTAM): Superseded by Telecommunications Access Method (TCAM).
- HASP: Superseded by JES.
- Remote Job Entry (RJE): Superseded by Remote Entry Services (RES).
- Rollout/Rollin: Not required because paging gives real storage to tasks as they need it. In programs that specify rollout/rollin, it is ignored.
- IEBUPDAT utility program: Superseded in VS1 by the IEBUPDTE utility program.
- IBCRCVRP (independent) utility program: Superseded in VS1 by the IEHATLAS (system) utility program.
- IHGUAP utility program: A low-usage component of MFT.
- IMAPTFLE service aid: Replaced by HMAPTFLE in VS1.
- IMASMP service aid: Replaced by HMASMP in VS1.
- IMDMDMAP service aid: Replaced by HMBLIST in VS1.
- SER0 and SER1: Their functions are provided in VS1 by the machine check handler (MCH) and the channel check handler (CCH).

Compatibility

In general, most object programs written for MFT execute in VS1. Existing programs that do not operate under VS1 without modification include:

1. Time-dependent programs (such as MICR).
2. Programs written to deliberately cause program exceptions.
3. Programs using machine-dependent data.
4. Programs using the program status word (PSW) bit 12 (the ASCII bit).
5. Programs reserving low-address storage for special purposes.
6. Programs dependent on devices or facilities not supported or available in System/370 or VS1.
7. Programs that require model-dependent System/360 functions.
8. Programs attempting to read or write SYSIN or SYSOUT data by other than SAM (sequential access method) (that is, EXCP will not work on these data sets).
9. Programs that depend on a valid UCB pointer in the TIOT for SYSIN/SYSOUT data sets.
10. Programs that include TCAM object decks. TCAM message control programs and TCAM message processing programs using the ICOPY, TCOPY, QCOPY, and TCHNG macro instructions must be reassembled and link-edited. TCAM message processing programs not using any of these macro instructions need only to be relink-edited.
11. Programs using TCAM II.

In addition, some MFT programs that do execute in VS1 may require virtual = real execution and do not use demand

paging. Current OS data sets process in the VS1 system without modification or conversion.

For compatibility, the JCL (job control language) statements of VS1 remain basically unchanged from MFT. The differences between the MFT JCL and the VS1 JCL are an additional parameter that permits the execution of programs in the virtual = real mode, a parameter that permits the printing of multiple copies of a data set, and two profile-type parameters that enable an installation to establish an automated scheduling algorithm. Additionally, VS1 processes VSAM (virtual storage access method) JCL parameters and ignores the HIERARCHY and ROLLOUT/ROLLIN parameters.

VS1 is upward compatible to VS2. This compatibility includes source program code, object program code, job control language, and conventions and standards.

Minimum System Requirements

The minimum system required for VS1 includes:

- A System/370 with at least 144K of real storage.
- DAT (dynamic address translation) feature.
- Standard multiplexer channel with associated input/output devices (one read/punch and one printer).
- One selector and/or block multiplexer channel with at least one of the system's direct access storage devices.
- These direct access storage devices are: at least three 2314/2319 devices, or two 3330/3333 devices, or two 3340 devices.
- Storage protection feature.
- Program event recording feature.
- Monitor call.
- One console device.

Note: System generation requires the addition of one tape unit and one 2314, 2319, 3330, 3333, or 3340 direct access storage device.

Devices Supported by VS1

OS/VS1 supports a variety of devices and control units, including:

- Direct access storage devices and control units
- Magnetic tape devices and control units
- MICR/OCR (magnetic ink character recognition/optical character recognition) devices
- Consoles and displays
- Communication terminals and control units
- Printers and printer control units
- Card readers and card punches
- Industry-oriented processing devices

For a complete list of OS/VS1 supported devices and control units, see *OS/VS1 Planning and Use Guide,* GC24-5090.

SYSTEM CONTROL PROGRAM COMPONENTS

The purpose of a data processing installation is to do work. VS1, as in MFT, enables the user to concentrate on this goal by performing many routine, and in some cases complicated, data processing operations. The programs that perform these operations are grouped and classified as a *system control program.* The system control program of VS1 has four major functions. They are:

1. *Job management*—To accept and schedule jobs in a continuous flow.
2. *Task management*—To supervise, on a sequential or priority basis, each unit of work to be done.
3. *Data management*—To simplify storage, retrieval, and maintenance of all data, regardless of the way it is organized and stored.
4. *Recovery management*—To reduce the damaging effects that a computer, channel, or I/O device malfunction might otherwise have on a program in process.

In addition to these management functions, certain programs are included to complete the family of functions performed by the system control program. These programs include utilities, a language processor, service programs (linkage editor and loader), and service aid programs.

Job Management

Job management, or job scheduling services, performs the same basic functions in VS1 as in MFT. These include:

1. Analysis of the input stream: scanning the input data to identify control statements; interpreting and analyzing the control statements; preparing the necessary control tables that describe each job to the system.
2. Allocation of I/O devices: ensuring that all necessary I/O devices are allocated; ensuring that direct access storage space is allocated as required; ensuring that the operator has mounted any required tape and direct access volumes.
3. Overall scheduling: selecting jobs for execution, by class and priority within a class.
4. Transcription of input data units, and user output from a direct access device.
5. Communication between the operator and the system.
6. System restart capabilities.

The changes made to job management in VS1 increase reliability, performance, and function. Improvements for VS1 include:

- Balancing the channel and device load.
- New time-of-day clock support.
- Preallocated external storage for system (spooled) data sets.

- Transparent buffering and spooling facilities.
- Scheduler work area data sets (SWADS) or the optional scheduler work area (SWA) in each partition separate the work areas and reduce contention for scheduler resources.
- Readers and writers are reenterable, and all programs use a single copy of each.
- Job control statements are interpreted by the initiators instead of the readers so that the unit-record input devices can run at near rated speeds.
- If system resources are in contention for a system data set, the job entry subsystem (JES) schedules the activities to assure the highest degree of system availability.

Job Flow

Before a job can execute, you must tell VS1 about the job and job steps through the job control language. The job control language supplies the system with job and program information, data characteristics, and device requirements before the program executes.

A job flows through the VS1 system by passing through two functional areas:

1. JES (job entry subsystem) where it is under VS1 control when it is read into the system until it is written out.
2. The partition where the program instructions are executed.

The JES reader reads jobs and data into the system. The reader is a part of the JES component called JEPS (job entry peripheral services). The job next enters JECS (job entry central services) which spools it on a data set and places records relative to its processing requirements on a job queue to await execution.

The initiator selects each job for execution. JECS transfers the data between the spooled data sets and virtual storage.

Before a job enters a partition, the intepreter subroutine of the initiator converts job control statements into system control tables based on job control information. At the same time, the allocation routines fill the device requirements. Once the initiator has completed its preparation activities, the program begins execution by calling for the necessary access method and supervisor services for data and program management.

When a VS1 program completes the execution phase, it performs the necessary termination and device deallocation and notifies the initiator that execution of the next job or job step (program) can begin. After each job is completed, the writer assumes control to perform the necessary output operations.

Job Initiation

The initiator for VS1 is pageable. When a command is entered from the console specifying an initiator procedure, the initiating task is established in the partition to schedule job execution. The initiator job selection routine attempts to dequeue the highest-priority job within a class from the first job input queue associated with its partition.

When the final step of the job is terminated or bypassed, any reserved data sets are returned to the system, and the initiator is ready to select another job.

Interpreter: The interpreter analyzes the contents of job control statements and builds tables that are used during the initiation and execution of job steps. The VS1 interpreter operates as a subroutine of the initiator.

Allocation: Allocation is a subroutine of the initiator. It analyzes the I/O device requirements of job steps, allocates devices to them, issues volume mounting instructions, and verifies that the volumes are mounted on the correct device. In VS1, the selection of a device is based on an I/O load-balancing algorithm.

Job Termination

When a problem program completes execution, the VS1 termination routines free (deallocate) all resources used by the program and perform the necessary cleanup to enable the system to continue functioning for other problem programs.

Command Processing

Some commands enter the system via the console or the input job stream. Others can enter only through the console. Most MFT commands are compatible with VS1. One enhancement is the ability for the operator to manipulate printer output.

You can enter this new VS1 command facility from the console only, enabling you to:

- Obtain multiple copies of job output on a data set or job basis.
- Immediately stop the job output stream and start writing again from the beginning.
- Forward space or backward space the output data.
- Single-, double-, or triple-space the output.
- Go to the next data set, or restart the output writing of the current data set.
- Suspend the writing of a job's output data, and replace it on the output hold queue to be written out later.
- Checkpoint SYSOUT data sets at specified intervals.
- Display outstanding requests of users running under remote entry services (RES).
- Dump selected areas of virtual storage to the SYS1.DUMP data set.

VS1 command facilities that are compatible with MFT include:

- Flexibility to manipulate jobs by displaying the class, priority, and the number of jobs to be processed; suspending the execution of certain jobs or classes of jobs; releasing jobs that have been suspended; direct canceling of a particular job; and changing the priority or class of a particular job.
- Redefining the size of a partition. In a virtual storage environment, the partitions actually are allocated in virtual storage so that the change in partition size is made in virtual storage and not in real storage as in MFT.
- Preparing for shutting down the system at the end of the day by enabling the user to save important statistics and data records.
- Modifying certain processing characteristics such as: changing output writer classes and conditions under which the output writer pauses for servicing; changing job classes associated with each system initiator; changing the job classes and output classes associated with direct system output processing (DSO); changing programmer-specified values providing the programmer has set the proper indicators in his program to allow such revisions.
- Starting a job called (via the console) from a procedure library to override the normal selection of jobs entered via the input job stream.
- Establishing the device to be used as the input work queue and whether this queue is to be formatted, as well as specifying the location of the library containing certain program procedures (procedure library), and specifying which automatic commands the user wishes to override.
- Allocating an I/O device to all job steps that require a particular volume, without intervening demountings and remountings of that volume. (The volume must be removable.)
- Placing I/O devices (other than a communications line) into online or offline status.

When commands within a VS1 job are entered in an input stream, they are executed when that job is selected for execution. When commands are entered via the console, or between jobs in an input stream, they are executed immediately.

Task Management

Task management controls the allocation and use of the CPU, virtual storage, real storage, and programming resources. The major change between task management for MFT and task management for VS1 is the addition of the page supervisor facility to manage virtual storage (see "Virtual Storage" in this section). Task management has seven major functions or routines. The routines are collectively referred to as the supervisor:

- Interruption supervisor analyzes interruptions to determine what supervisor processing is required.
- Task supervisor records which tasks are currently in the system, their status, priorities, the programs they require, and the order in which these tasks are to be performed.
- Virtual storage supervisor allocates and frees virtual storage, and records what use is being made of any portion of virtual storage. All requests made to main storage in MFT are made to virtual storage in VS1 (for example, FREEMAIN and GETMAIN).
- Contents supervisor loads programs into virtual storage, and records what programs are currently in virtual storage and what characteristics these programs possess.
- Timer supervisor sets and maintains the timers from information provided in timer macro instructions.
- Input/output supervisor controls the reading of data from, and the writing of data to, physical devices. The I/O supervisor also provides the necessary translation for channel programs requiring a change from their virtual to real storage addresses for execution. During this translation, the I/O supervisor takes into account noncontiguous pages in real storage and fixes all required pages in real storage for the duration of the I/O operation.
- Page supervisor allocates and releases real storage space for pages, and transfers pages between real storage and external page storage.

Data Management

Data management's objective is to achieve maximum efficiency in managing the mass of data associated with the many programs that are processed at an installation. Data management routines control all operations associated with input/output devices: allocating space on volumes, channel scheduling, storing, naming, and cataloging data sets, moving data between real and auxiliary storage, and handling errors that occur during input/output operations.

The data management routines include access methods, catalog management, DADSM (direct access device space management), and open/close/end-of-volume support. Figure 4-2 illustrates the relationship between a job and the services necessary for the management of data as well as the management of the job in execution.

Access Methods

The access methods, which communicate with the I/O supervisor, are primarily responsible for moving information between virtual storage and external storage and maintaining it in external storage. The data management

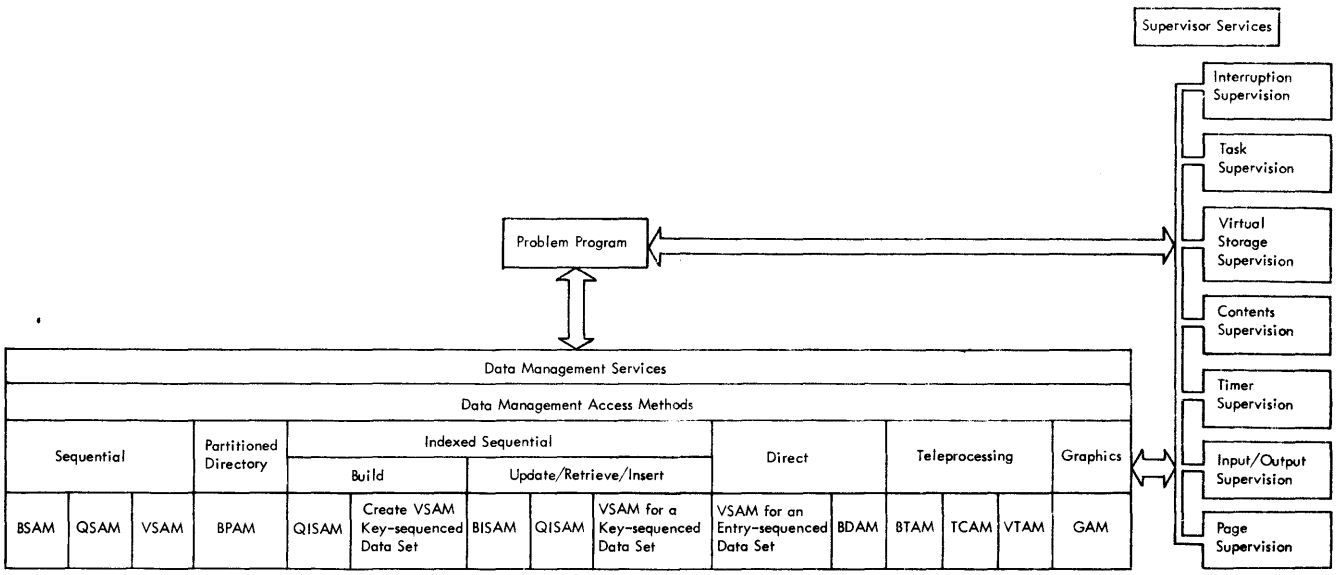


Figure 4-2. Data Management and Supervisor Services

routines that service problem programs require information about the data. This information is supplied when data is first recorded, some through the job control statements, and some at execution time. For a complete description of access methods, see "Methods of Storing and Retrieving Data" in this section.

Catalog Management

Catalog management routines maintain the collection of data set indexes (the catalog) that is used by the control program to locate volumes. The catalog management routines also locate the cataloged data sets. The catalog, itself a data set (SYSCTLG), resides on one or more direct access volumes. It contains indexes that relate data set names to the serial numbers and device types of the volumes containing the data sets. In maintaining the catalog, the catalog management routines create and delete indexes, and add or remove entries. To locate a data set, catalog management routines search through the indexes for the index entry containing the last part of the qualified name of the data set. (*Note:* VSAM (virtual storage access method) creates and maintains separate catalogs. See "VSAM" under "Methods of Storing and Retrieving Data" in this section.)

DADSM (Direct Access Device Space Management)

DADSM consists of routines that allocate space on direct access volumes to data sets. The routines are used primarily by job management routines during the initiation of job steps when space is obtained for output data sets. They also are used by other data management routines for increasing the space already assigned to a data set, and for releasing space no longer needed.

When space is needed on a volume, the DADSM routines check the volume table of contents (VTOC) for enough available contiguous tracks to satisfy the request. If there are not enough contiguous tracks, the request is filled using as many as five noncontiguous groups of free tracks.

O/C/EOV (Open/Close/End-of-Volume)

O/C/EOV support routines:

- Open a data control block before a data set is read or written.
- Close a data control block after a data set has been read or written.
- Process end-of-volume (EOV) conditions when an end-of-volume or end-of-data (EOD) set condition occurs during an I/O operation.

Open Processing: Before accessing a data set, an OPEN macro instruction must open the DCB (data control block) for that data set. When a processing program issues an OPEN macro instruction, the open routine of the control program:

- Verifies the mounting of volumes.
- Merges data set attributes from the data definition (DD) statement into the control blocks.
- Determines access method routines.

Close Processing: After processing has been completed for a data set, a CLOSE macro instruction must close the DCB for that data set. When a processing program issues a CLOSE macro instruction, the close routine of the control program:

- Processes input and output labels.

- Disposes of volumes.
- Restores the DCB to its original condition by removing the information that was merged from the DD statement.

End-of-Volume Processing: EOV (end-of-volume) processing is performed when end-of-data set or end-of-volume conditions occur during I/O operations on sequentially organized data sets. When a routine of a sequential access method encounters a tape or file mark (end-of-data set) or an end-of-volume condition, the routine issues a supervisor call instruction to pass control to the EOV routine.

Recovery Management

A failure of the system, whether during the development of new programs or while processing jobs, can result in a loss of productivity. To protect against, or at least to diminish the effects of, a failure, RAS (reliability, availability, and serviceability) facilities interact with the control program. RAS facilities attempt to retry or bypass machine malfunctions that result in system failure.

Recovery management is a RAS service in VS1 that reduces the damaging effects that a computer, channel, or I/O device malfunction might otherwise have on a program in process.

These programs provide recovery management services:

MCH (Machine-Check Handler) processes machine-check interruptions. Depending on the severity of the malfunction, MCH:

1. Restores the system to normal operation, or
2. Terminates tasks associated with the malfunction so the system can resume processing, or
3. Places the system in the wait state.

In all cases, MCH writes diagnostic messages and error records. These records are placed in the SYS1.LOGREC data set.

CCH (Channel-Check Handler) receives control after the detection of a channel data check, channel control check, or interface control check. For channel control checks and interface control checks, CCH:

1. Indicates the results of the analysis of the error for later use by the error recovery procedures when they set up for a retry of the I/O operation.
2. Constructs a record of the error environment. When this record is later recorded, a message is issued to inform the operator that a channel-detected error has been recorded on SYS1.LOGREC.

For channel data checks, CCH constructs a record of the error. The error recovery procedures do not require information from CCH to retry I/O operations on which channel data checks occurred.

APR (Alternate Path Retry) permits an I/O operation that has developed an error on one channel path to be retried on another channel path (if another channel path is assigned to the device performing the I/O operation). APR also provides the capability to vary a path to a device online or offline.

DDR (Dynamic Device Reconfiguration), upon receiving a request from the operating system or from the operator, permits a demountable volume to be moved from one device to another and repositioned, if necessary. This method is used to bypass various I/O errors, and is done without abnormally terminating the affected job or reperforming an IPL (initial program load).

MIC (Missing Interruption Checker) polls active I/O operations to determine if a channel end and/or device end interruption has been pending for more than an installation-specified period of time. Also, it provides a reminder message for mount requests.

Other RAS components available with VS1 to enhance the continuous operation of a system include OLTEP (online test executive program), DSS (dynamic support system), PWF (power warning feature), checkpoint/restart, and TOLTEP (teleprocessing online test executive program). For a description of these components, see "VS1 Standard and Optional Features" in this section.

Service Aids

A variety of programs that diagnose system or application program failures is available with VS1. The service aids described below are standard features.

GTF (Generalized Trace Facility)

GTF is a debugging tool that can be used to trace software behavior (system or problem program). GTF uses a hardware instruction (monitor call) to detect system events and to create trace records. Problem programs may also use a GTF macro instruction (GTRACE) to record problem program data in the trace data set.

GTF lets the user single out those programming activities he wishes traced within the system, including such things as I/O interrupts for all or specific devices, all program interrupts or only specific program interrupts, and all or only specific supervisor call interrupts.

The output from GTF is a trace data set that can be used with a data reduction program to edit the data set. The data reduction program enables the system to format specific trace activities. It operates as a problem program that can be called via the job control language.

HMBLIST Program

This service aid is a problem program that assists in problem determination by printing:

- A formatted listing of linkage editor/loader input and output (that is, object and load modules).

- A cross-reference listing of symbolic references within a load module without reprocessing that module through the linkage editor.
- A formatted listing of information in a module's CSECT (control section) IDR (identification record).
- A formatted listing of all program modifications for a load module or library.
- A map of a system's nucleus.

HMASPZAP Program

This service aid is a problem program that allows the user to inspect and modify data at the time a problem is diagnosed. Various combinations of the control statements for this service aid enable the user to:

- Inspect and modify instructions and data in any load module that exists as a member of a partitioned data set.
- Inspect and modify data in a specific data record that exists in a data set residing on a DASD (direct access storage device).
- Dump an entire data set, a specific member of a partitioned data set, or any portion of a data set residing on a DASD (direct access storage device).
- Update the system status index (SSI) in the directory entry for a load module.

HMDSADMP Program

The standalone dump service aid provides the user with a flexible, installation-tailored dump facility. It generates one of the following types of dump programs:

- The low-speed dump program dumps the contents of real storage to a printer or tape. The dump output is translated and unblocked. Output that is directed to tape can be printed by the print dump service aid or the IEBPTPCH utility program.
- The high-speed dump program dumps the contents of real storage to tape. Optionally, it can also produce dumps of page data sets. The dump output is in large, untranslated hexadecimal blocks. The HMDPRDMP service aid must be used to format, translate, and print the output.

HMDPRDMP Program

The print dump service aid is a problem program that formats and prints the contents of the standalone dump output data set, the SYS1.DUMP data set, and the GTF output data set. The user can supply control statements that control print dump output. Some of the areas and traces that can be printed are:

- Queue control block (QCB) trace
- System control blocks for all active tasks
- Allocated virtual storage
- Virtual storage ranges
- Real storage ranges
- Page data set records
- System nucleus

HMAPTFLE Program

This service aid is a problem program used to apply program temporary fixes (PTF). It generates control statements and applies PTFs in one operation. It produces the JCL and control statements needed to apply PTFs. The JCL must be executed in a later, separate step.

IMCJOBQD and IMCOSJQD Programs

The job queue dump service aid programs produce a formatted copy of the resident job list, system job queue data set, system scheduler work area data set, and scheduler work area data sets. The user can dump each of these control areas in its entirety or can specify certain sections to be dumped.

The two job queue dump programs are a standalone program and a system-assisted program. IMCJOBQD, the standalone program, provides a dump facility after system failure, and it also preserves the status of system queues at the time of system failure. IMCOSJQD, the system-assisted program, can run concurrently with other jobs, and it enables you to re-IPL using different volumes for SYS1.SYSJOBQE and SYS1.SYSWADS, while dumping the previous queues.

HMASMP Program

The SMP (system modification program) service aid enables you to either apply to or remove from a VS1 system IBM-issued modifications or your own modifications. You can apply or remove the modifications either selectively or in a group.

SMP performs these major functions:

- Checking the modification input for accuracy and determining whether a particular modification applies to your system.
- Putting IBM or user modifications into the operating system, distribution, or user library.
- Removing IBM or user modifications from the system.
- Maintaining records of the content and status of your system by creating a record of all the modules and macros in your system. As you make modifications, SMP adds records of these changes.
- Maintaining an audit trail of system modifications by means of time-stamped and date-stamped records kept in a history log.

Additionally, SMP can print the contents of the input data (modifications) or any of the SMP primary data sets.

Methods of Storing and Retrieving Data

The variety of techniques for gaining access to a data set is derived from two variables: data access technique and data set organization.

Access Techniques

The data management programs provide two general techniques for moving data: the queued technique and the basic technique. The queued technique offers you the maximum amount of automatic I/O facilities. The basic technique places some of the responsibility for data handling on the programmer, but gives him more direct control of I/O operations.

Queued Access Technique: When using the queued access technique, you can concentrate on data processing alone; the data management routines handle most I/O considerations. For example, I/O is automatically synchronized with processing. When you issue a GET macro instruction, the desired record is already in an input buffer, so processing can continue without delay. When a buffer is empty, the data management routines automatically refill it. The same principle applies for output records (PUT macro). They are collected in an output buffer and written when the buffer is full. When operating under a priority scheduling system, and if output is directed to a system output class (a class of system output units shared by all jobs), data is first written on a direct access device. When scheduling permits, the writer transfers the data to the proper device.

Because the queued access technique brings records into virtual storage before they are actually needed, the data management programs need a method of anticipating the user's demands. Therefore, the queued access technique can be used to retrieve only records in a sequential order, for example, records on magnetic tape.

Basic Access Technique provides the READ and WRITE macro instructions for input and output. These instructions move blocks, not records. As with the queued access technique, actual transmission to a specified device may be deferred and done by the writer when working under a priority system and output is going to a system output class.

Unlike the queued technique, the basic technique does not provide automatic synchronization of program processing and I/O. When issuing a READ, you cannot assume that the record is in virtual storage as you can assume with GET. You must determine that the I/O operation has been completed before attempting to use the desired record. Data management provides macro instruction facilities to check for successful completion of I/O operations and, if necessary, to wait for their completion.

Access Methods

The basic access methods are used for all data organizations while the queued access methods apply only to sequential and indexed sequential data sets as shown in Figure 4-3. The new access method, VSAM, employs a modified basic and queued access technique and applies to direct and sequential data sets.

Data Set Organization	Access Technique	
	Basic	Queued
Sequential	BSAM	QSAM
VSAM	VSAM	VSAM
Partitioned	BPAM	----
Indexed Sequential	BISAM	QISAM
VSAM Key - Sequenced	VSAM	VSAM
Direct	BDAM	----
VSAM Entry - Sequenced	VSAM	VSAM
Graphics	GAM	----

Figure 4-3. Data Management Access Methods

VSAM (Virtual Storage Access Method) is used with direct access storage devices on the IBM System/370 with VS1. It creates and maintains two types of data sets. One is sequenced by a key field within each record and is called a key-sequenced data set. Data records are located by using the key field and an index that records key fields and the address of the associated data, similar to ISAM (indexed sequential access method). The other is sequenced by the time of arrival of each record into the data set and is called an entry-sequenced data set. Data records are located by using the record's displacement from the beginning of the data set. The displacement is called the RBA (relative byte address). The RBA is similar to the relative block address used with BDAM (basic direct access method).

VSAM stores, retrieves, and updates user data records in these types of device independent data sets. VSAM stores data records in a new data format designed for long-term data stability and for data base applications. Data in both types of data sets can be accessed either sequentially or directly.

VSAM enhances many ISAM capabilities, including device independence, concurrent processing, data portability, and kinds of accessing supported. VSAM provides multiple

levels of password security protection. It creates and maintains separate VSAM catalogs that contain specialized information about each VSAM data set and link data sets with their indexes.

VSAM provides a multifunction service program that defines, deletes, prints, copies, and provides backup and portability of VSAM data sets and maintains separate catalogs. An interface routine, ISAM interface, which allows most existing ISAM programs access to VSAM data sets, is also provided.

Note: To use ISAM interface, you must convert both the ISAM JCL to VSAM JCL and the ISAM data set to VSAM.

For further information about VSAM, see the publication *OS/VS Virtual Storage Access Method (VSAM) Planning Guide,* GC26-3799.

Basic Access Methods: The basic access methods and their functions are:

- BSAM (basic sequential access method) sequentially organizes data and stores or retrieves physical blocks of data. The READ/WRITE macro instructions cause the initiation of an I/O operation. The completion of these operations is tested by using synchronization macro instructions. Automatic translation between EBCDIC and ASCII codes is provided for magnetic tape labels and record formats.
- BDAM (basic direct access method) organizes records within a data set on direct access volumes in any manner the programmer selects. Storage or retrieval of a record is by actual or relative address within the data set. This address can be that of the desired record, or a starting point within the data set, where a search for the record based on a key furnished by a programmer begins. BDAM also uses addresses as starting points for searching for available space for new records.
- BISAM (basic indexed sequential access method) stores and retrieves records randomly from an indexed sequential data set. It reads selectively by using the READ macro instruction and specifying the key of the logical record to be retrieved. You can replace individual records or add new records randomly.
- BPAM (basic partitioned access method), when used in conjunction with BSAM, can efficiently store and retrieve discrete sequences of data (members) belonging to the same data set on a direct access device. Each member has a simple name. The data set includes a directory that relates the member name with the address where the sequence begins. You can add members to a partitioned data set as long as space is available. (BPAM is usually used to store or retrieve programs.)

Queued Access Methods: The queued access methods and their functions are:

- QSAM (queued sequential access method) organizes data sequentially. It retrieves and stores logical records as requested. QSAM anticipates the need for records based on their sequential order, and normally has the desired record in virtual storage, ready for use, before the request for retrieval. When writing data, the program normally continues as if the record had been written immediately, although QSAM's routines may block it with other logical records, and defer the actual writing until the output buffer has been filled. Automatic translation between EBCDIC and ASCII codes is provided for magnetic tape labels and record formats.
- QISAM (queued indexed sequential access method) creates an indexed sequential data set and retrieves and updates records sequentially from such a data set. Synchronization of the program with the completion of I/O transfer and record blocking/deblocking are automatic. With QISAM you can also reorganize an existing data set.

Data Communication Access Methods: The data communication (teleprocessing) access methods are described in this section under "Data Communications."

Data Communications

Data communications (teleprocessing) refers to a large variety of data processing applications in which data is received from or sent to a central data processing system over communication lines, including ordinary telephone lines. Usually the source or destination of the data is remote from the central processing system, although it can be in the same building. In any event, the source or destination points of the data are often called terminals or (for some applications) workstations.

A terminal, or workstation, can have one I/O device or a combination of I/O devices. A large variety of such devices is available for use at remote terminals. These include special keyboards, graphic display devices, printers, and card read-punch units. In addition, a remote terminal may be represented by another data processing system.

A data communication program for most applications is normally divided along functional lines into two parts: a message control program and a message processing program. Message is the traditional name for a unit of information that is transferred to or from a remote terminal via data communication lines.

Users of TCAM (telecommunications access method) message control programs and message processing programs under MFT must reassemble/recompile their programs before they can run under VS1.

Message Control Programs

The main function of a message control program is to control the transmission of information between a message processing program in the central computing system and I/O devices at remote terminals. In this respect it performs much the same function as access method routines that control the transmission of information between an ordinary processing program and local I/O devices. For this reason, routines that IBM provides for use in creating a message control program are also called access method routines.

The three sets of such routines are:

- VTAM (virtual telecommunications access method)
- TCAM (telecommunications access method)
- BTAM (basic telecommunications access method)

VTAM (Virtual Telecommunications Access Method) is a direct-control access method that enables application programs to control VTAM terminals without concern for intermediate connections, such as control units and telecommunication lines. It is designed to use advanced hardware and software including System/370 virtual storage, the IBM 3704 and 3705 Communications Controllers, the OS/VS1 operating system, and the teleprocessing subsystems that use the SDLC (synchronous data link control) line discipline.

With VSAM (virtual storage access method), VTAM can be used to provide a complementary data base/data communication facility. In addition to its primary role of data transmission, VTAM has features that establish it as a base for building small to large data communication systems. These features are:

- Sharing of network resources, which reduces line costs and makes more efficient use of the network.
- Concurrent execution of TCAM and VTAM application programs using the same data communication network.
- Services required for interactive applications such as online inquiries and updates.
- Operation with the IBM 3704 and 3705 Communications Controllers to reduce the number of functions performed in the host computer for remote devices.
- Generation options for tailoring the data communication system to the user's needs.
- Support for industry-oriented data processing subsystems such as the IBM 3600 Finance Communication System.
- RAS (reliability, availability, and serviceability) aids to assist in reducing both the incidence of errors in the data communication system and the impact of errors that do occur, and in maintaining the data communication system.

TCAM (Telecommunications Access Method) is a generalized IOCS (input/output control system) that extends the techniques of logical IOCS to the data communication environment. Data sets accessed by the problem program are queues of messages coming in from, or going out to, remote terminals via communication lines.

TCAM furnishes far more than the control for I/O operations. In addition to supporting the transfer of messages between the terminal and user-written application programs, TCAM provides a high-level, flexible, message control language. (Data enters a data communication system in the form of messages.) You can use TCAM macro instructions to construct an installation-oriented message control program that controls the flow of message traffic from one remote terminal to another (message switching application), and between remote terminals and any application programs (message processing applications).

A data communication control system created through the use of the TCAM message control language:

- Establishes contact and controls message traffic between the computer and terminals.
- Deletes and inserts line-control characters automatically, thereby removing line control from the user's domain.
- Dynamically assigns and uses buffers as required.
- Edits incoming and outgoing messages (for example, code translation and insertion of new fields in message headers).
- Forwards messages to destination terminals and application programs.
- Takes corrective action and provides special handling for messages containing errors.
- Maintains statistical information about message traffic and system components.

BTAM (Basic Telecommunications Access Method) is for limited applications that do not require the extensive TCAM message control facilities, and for applications that require special user facilities.

The BTAM facilities provide the means to design and construct almost any data communication processing application. These include facilities for creating terminal lists and performing the following operations:

- Polling terminals
- Answering and initiating calls
- Receiving and transmitting messages

- Translating line codes
- Addressing terminals
- Online testing
- Changing the status of terminal lists
- Error recording and handling

Message Processing Programs

A program that processes or otherwise responds to messages received from remote terminals must be designed for a specific application. In designing the program, all of the facilities of VS1 are available. The program processes messages sequentially by a single task, or it processes more than one message concurrently by separate tasks. In many applications, a message processing program requires access to data or routines stored in local direct access storage. In such applications it is possible for separate tasks to process several messages concurrently. As the processing of one message is delayed while access is being gained to direct access storage, another message can be processed.

Specific Data Communication Applications Provided by IBM

A number of specific data communication applications have been designed by IBM and are available as optional VS1 features. These include:

- RES (remote entry services)
- CRJE (conversational remote job entry)
- Graphic programming services
- Industry-oriented data communication systems

RES (Remote Entry Services) extends the functions of JES (job entry subsystem) so that the batch computing facilities of VS1 can be made available to users at remote terminal (workstation) devices. RES allows jobs to be submitted from these remote workstations and the output from these jobs to be routed back to the originating location and/or to other workstations. Transmissions are made via communication lines. More users, therefore, would have direct access to a central computing system for job processing.

In a RES environment, you can submit jobs (one or more at a time) from a remote workstation directly into the central computer, thus bypassing the usual procedure of submitting jobs through the computing center to the computer via the system operator.

The only data communication access method used by RES is RTAM (remote terminal access method). RTAM must be specifically included by a separate RTAM generation.

CRJE (Conversational Remote Job Entry) is an optional VS1 facility that enables remote users to enter jobs for batch processing using keyboard terminals. You can enter jobs conversationally by carrying on a dialogue with the central computing system.

Remote job input consists of programs and data that you create at the terminal. Typed lines of program source statements, data, and job control statements are collected within the system; there is thus no need for keypunching, and there is no wait for operator handling or card reading. Simple error-correction procedures enable you to enter data correctly and easily.

Job turnaround time is greatly reduced because data is transmitted directly between the central processor and the terminal. To submit a job for execution, you select the program, data, and job control statements that are to be entered in the job stream. When the job is completed, you can examine the output at your terminal or have it directed to a system output device.

Graphic Programming Services handle graphic input and output and include macro instructions and problem-oriented routines to be used as building blocks in the construction of graphic processing programs. It also includes the graphic access method (GAM) that supports the IBM 2250 and 2260 Display Units.

You can create a display on one or more 2250 Display Units (Models 1 and 3) through the services of the graphic subroutine package (GSP). The displays produced consist of any figure that can be constructed with points, lines, arcs, and characters.

Industry-Oriented Data Communication Systems have been developed to perform the data processing requirements for specific industries, such as banking and food distribution. These systems, when attached to a central computing system, have data communication capabilities. Among these specialized systems are:

- 3600 Finance Communication System
- 3650 Retail Store System
- 3660 Supermarket System

VS1 STANDARD AND OPTIONAL FEATURES

Some of the standard and optional features available with VS1 are listed alphabetically in Figure 4-4.

A feature is standard if it is automatically resident in the system after system generation. That is, no special user-system interaction is required to make the feature operational. An optional feature, on the other hand, is a feature that requires a user-supplied triggering device (such as specifying a certain parameter in a macro instruction) to make it available or operational in the system.

A brief functional description of some of the more significant features available with VS1 follows Figure 4-4.

APF (Authorized Program Facility)

The authorized program facility (APF) allows your installation to control access to restricted system functions and (optionally) user functions by maintaining an authorization list that identifies the modules that are permitted to use

VS1 Features	Status	
	Standard	Optional
Alternate Path Retry (APR)	X	
Attach Function	X	
Attach Function Made Resident	X	
Authorized Program Facility (APF)	X	
Automated System Initialization (ASI)	X	
Automatic Partition Redefinition	X	
Automatic Volume Recognition (AVR)		X
Basic Direct Access Method (BDAM)	X	
Basic Indexed Sequential Access Method (BISAM)		X
Basic Partitioned Access Method (BPAM)	X	
Basic Sequential Access Method (BSAM)	X	
BLDL Table		X
Channel Check Handler (CCH)	X	
Checkpoint/Restart Facility		X
Consoles - Alternate and Composite Consoles Options		X
Consoles - Multiple Consoles Support (MCS)		X
Conversational Remote Job Entry (CRJE) Facility		X
DEB Validity Checking	X	
Device Independent Display Operator Console Support (DIDOCS)		X
Direct Access Volume Serial Number Verification	X	
Distributed Intelligence System		X
Dynamic Device Reconfiguration (DDR)	X	
Dynamic Dispatching		X
Dynamic Support System (DSS)	X	
Extended Fixed List	X	
Extended Timer Option		X
Extract Function Made Resident	X	
Fetch Protection		X
Graphic Programming Services		X
Greenwich Mean Time (GMT)	X	
IBM 3600 Finance Communication System Support		X
Identify Function Made Resident	X	
Indexed Sequential Access Method (ISAM)		X
I/O Load Balancing		X
Job Log Facility		X
Job Step Timing	X	
Machine Check Handler (MCH)	X	
Missing Interruption Checker	X	
Multiple Wait Option	X	
Online Test Executive Program (OLTEP)	X	
PAGETUNE Command	X	
Partition Deactivation/Reactivation		X
Power Warning Feature (PWF)		X
Program Controlled Interrupt (PCI) Fetch		X
Queued Indexed Sequential Access Method (QISAM)		X
Queued Sequential Access Method (QSAM)	X	
Reenterable Load Modules Made Resident	X	
Resident Access Method Routines	X	
Resident Job List	X	
Remote Entry Services (RES)	X	
Remote Terminal Access Method (RTAM)		X
Scheduler Work Area (SWA)	X	
Selective Posting	X	
Shared DASD		X
SPIE Routines Made Resident	X	
Storage Protection Option	X	
System Log		X
System Management Facilities (SMF)		X
System Modification Program (SMP)	X	
Telecommunications Option (BTAM, TCAM, VTAM)		X
Teleprocessing Online Test Executive Program (TOLTEP)		X
Time-Slicing Facility		X
Trace Option		X
Transient SVC Table		X
Types 3 and 4 SVC Routines Made Resident		X
User Modify Logical Cylinder Facility		X
User-Added SVC Routines		X
Validity Check Option	X	
Virtual Storage Access Method (VSAM)		X
Volume Statistics Facility		X

Figure 4-4. VS1 Standard and Optional Features

restricted functions. This feature improves system integrity by ensuring the preservation of programs for their intended use.

AVR (Automatic Volume Recognition)

The automatic volume recognition (AVR) feature issues volume-mounting instructions to the operator to minimize the time lost in performing job setups. The operator can premount labeled volumes on any available tape or disk device. AVR automatically records in a table the identification of the volume and the device used.

When a particular volume is needed for job setup, AVR searches the table containing the volume information. If the required volume is already mounted, the usual procedure of issuing a volume-mounting message is bypassed. This feature is advantageous in installations where work schedules are normally set in advance and follow a repeated pattern.

Automated System Initialization

The automated system initialization standard feature makes the system initialization process faster and more flexible and rapid. It significantly reduces the operator's role in the initialization process. Flexibility comes from the use of a data set (SYS1.PARMLIB), or card reader, to hold control statements that contain the system initialization parameters. By defining the proper set of parameters, each initialization tailors the system to better meet the needs of the anticipated job mixture.

System initialization is faster when this automated feature is used because the operator simply enters a reference (via the console) to the appropriate list in SYS1.PARMLIB or the card reader. Automated system initialization can also be invoked automatically by specifying the AUTO parameter at SYSGEN time. Formerly, the operator manually entered all of the needed parameters via the console.

BLDL Table

The BLDL Table is a list of the track addresses of user-specified module names in SYS1.LINKLIB and/or SYS1.SVCLIB. The table reduces the time required to find the listed modules on these libraries. The user has the option of making the BLDL Table fixed in real storage.

Checkpoint/Restart

The checkpoint/restart facility provides an opportunity to restart a job that terminates abnormally due to a hardware, programming, or system error. The restart is permitted either at the beginning of a job step or at a checkpoint within a job step. In either case the restart can be automatic or you can defer it until the job is resubmitted.

Consoles—MCS (Multiple Console Support)

MCS enables an installation to use one primary (or master) console and multiple secondary consoles. These secondary consoles can be dedicated to one or more system functions such as a tape library, disk library, or teleprocessing control. MCS services all consoles concurrently, creating an environment for operator-system interaction that gives each console the appearance of being the only console on the system. Each console operator receives only those messages from the system that are related to the commands that he enters and to his assigned functions. MCS:

- Routes messages to selected functional areas.
- Allows a user-written exit routine to modify the message's routing and description codes before the message is issued.
- Switches to an alternate console if a primary console should fail.
- Allows automatic message deletion on devices such as display tubes (graphics).
- Supports a hard-copy log for the recording of routed messages, operator commands, and system responses.

Distributed Intelligence System

Distributed Intelligence System is a separately ordered feature that permits several System/7 processors to be combined into a network with a System/370 operating system. The network offers the computing power and bulk storage of a System/370 linked with the rapid response and the sensor attachments of one or more System/7 processors. Up to 64 System/7 processors can be connected to the System/370 through one IBM 5098-N5 sensor-based control unit. The number of 5098-N5's that can be attached to a System/370 depends on the storage, processing, and physical attachment capabilities of the System/370.

All the processors within the Distributed Intelligence System network function together as one single processor. An event at either a System/7 or at the System/370 can trigger one or more of these actions at any computer in the network:

- Loading and executing programs in any computer attached to the network.
- Moving data from one computer to another or from one location to another within a computer.
- Reading data from a System/370 storage device to any computer within the network.
- Writing data to a System/370 storage device from any computer within the network.
- Communicating with a console printer from any computer within the network.

DIDOCS (Device Independent Display Operator Console Support) and SDS (Status Display Support)

DIDOCS provides uniform operator console support for a range of display devices. DIDOCS may be included in a system only when a display console and multiple console support (MCS) are specified.

DIDOCS enables you to:

- Display messages from the VS1 control program and problem program on the display console device.
- Enter commands from the display console to the control program via the alphameric keyboard and/or light pen, when available.
- Display out-of-line status displays as requested by the status display support.

SDS (status display support) provides for the presentation of information to a system operator clearly and understandably. It also provides the ability for messages sent to a display device to be displayed out of line in a special area of the screen. This allows related messages to be grouped together and easily read by the operator.

Dynamic Dispatching

Dynamic dispatching helps provide optimum use of CPU and I/O resources by altering the dispatching priorities of selected tasks while they are executing, so they can more efficiently use the system's resources.

The dispatching priorities for selected tasks indicates the task's requirements for I/O and CPU time. These dispatching priorities are calculated by an algorithm that distinguishes between I/O bound tasks (higher priority) so that the CPU is available to perform other tasks. Not all tasks must execute under dynamic dispatching. Thus you can specify dynamic dispatching for only some of your partitions.

DSS (Dynamic Support System)

DSS (dynamic support system) is a debugging program that assists the IBM program support representative and user-authorized maintenance personnel to identify and correct causes of programming failures. DSS requires the program event recording (PER) hardware feature of the System/370.

DSS has its own I/O capability and has access to both real and virtual storage. When executing, DSS has control of the system. It can gain control from, and return control to, VS1 via its own monitoring functions.

Because DSS takes control of the system on each activation, time dependencies cannot be maintained. Therefore, DSS should not be used while a time-dependent program, such as teleprocessing, is running.

Although DSS can make changes, the changes are not permanent. Any modifications made to the system are not carried over to the next IPL. Also, DSS cannot modify itself, IPL, or NIP.

Extended Timer Option

The extended timer option offers more extensive interval timing services than are available with the standard interval timer. It can be used to establish multiple time intervals that can be active at the same time.

The feature is restricted to System/370 models having the CPU timer and clock comparator.

Fetch Protection

Fetch protection provides security for user data by preventing unauthorized or unintentional access to a user's area of storage by other than the intended user. This protection includes the entire dynamic storage area (virtual storage partitions assigned to job steps and system tasks) and all nonkey-0 subpools.

IBM 3600 Finance Communication System Support

The 3600 is a data communication system developed specifically for the finance industry to help perform the varied data processing transactions in a financial institution. The 3600 system is made up of financial products and general-purpose data processing products, which together form a data processing system with three parts:

1. Controller and terminals.
2. Communication link.
3. Central computing system.

The controller in the 3600 system is the IBM 3601 Finance Communication Controller. The 3600 system terminals are the IBM 3604 Keyboard Display, the IBM 3610 Document Printer, the IBM 3612 Passbook and Document Printer, the IBM 3618 Administrative Line Printer, and the IBM 3614 Consumer Transaction Facility.

The communication link in the 3600 system allows data transmission between the 3601 Finance Communication Controller or the 3614 Consumer Transaction Facility and the central computing system. The communication link is made up of a data communication line, a pair of modems, and an IBM 3704 or 3705 Communications Controller. The 3704 (or 3705) is a programmable transmission control unit that directs data communications between the 3601 controller or the 3614 terminal and the central computing system.

The host computing system processes financial transactions in coordination with the 3601 Finance Communication Controller, with which it exchanges data over the communication link, or in conjunction with the 3614 Consumer Transaction Facility attached directly to the communication link. The CPU of the host computer operates under appropriate virtual storage system control programs and must have the relocate feature and at least 256K bytes of real storage.

I/O Load Balancing

I/O load balancing allocates data sets to devices in such a way as to attempt to equalize the amount of I/O contention on each device. The devices are selected for allocation of data sets by considering many variables. By monitoring the speed of the device, counting the number of I/O events to each device, and comparing the different characteristics of different devices, I/O load balancing selects the best device available. If space is not available on that volume, load balancing selects the next best choice.

I/O load balancing can be used only for nonspecific requests (that is, where no volume serial number or device address is specified).

Job Log Facility

Operating systems that have the job log feature specified collect WTO's (write-to-operator), WTOR's (write-to-operator-with-reply), replies to WTOR's, and WTL's (write-to-log) (if SYSLOG is inactive) for each job and include them in the job's printed output. When a multiple-line WTO is issued, only the first line is included in the job log.

OLTEP (Online Test Executive Program)

You can use OLTEP to:

- Diagnose I/O errors.
- Verify I/O device repairs.
- Verify engineering changes.
- Check the operation of devices periodically.
- Verify the integrity of customer data.

You can use OLTEP without relinquishing control of the system and with minimum interference to other jobs that are running.

PAGETUNE Command

The PAGETUNE command allows a knowledgeable system programmer to tune the paging algorithm to meet the changing demands of a multipartition system. A system programmer who understands the operation of the page supervisor should determine if, when, and how to use the PAGETUNE command. For example, if an installation is teleprocessing oriented during one shift but batch oriented during another, the installation may decide to alter the VS1 paging algorithm to smooth the online transition from one state to another.

The system programmer should select the PAGETUNE options necessary to meet the installation needs and give direction to the operator entering the command. The PAGETUNE command can also be automatically executed when the automated system initialization process is used. Briefly, the PAGETUNE command enables you to:

- Alter the page supervisor task deactivation mechanism.
- Alter the page supervisor page replacement algorithm.
- Suspend the task deactivation mechanism.
- Alter realtime intervals associated with the task reactivation function.
- Reset a modified paging algorithm being used by the VS1 paging algorithm.
- Display certain values or parameters being used by the VS1 paging algorithm.

Partition Deactivation/Reactivation

With this VS1 feature, the operator can control the deactivation and reactivation activity of the page supervisor. Task deactivation is necessary to prevent the phenomenon known as thrashing. The term thrashing can be defined as excessive overhead and severe performance degradation caused by nonproductive paging activity. Thrashing is induced when the amount of real storage available is insufficient to contain the space requirements of active tasks. To prevent thrashing, the page supervisor must be able to deactivate active tasks. Therefore, the operator must never define all active partitions ineligible for deactivation.

Declaring a partition ineligible for deactivation is useful whenever a partition is to run a critical job or online teleprocessing application. Operator-initiated task reactivation can be beneficial, for example, should a currently deactivated job have to meet a certain deadline. The operator can exercise one of a number of options available for deactivating or reactivating tasks.

The operator, at IPL time, can vary the time function of task reactivation from 0 to 9 seconds. This specified value is used by the page supervisor at system wait time in an attempt to reactivate the highest-priority partition currently deactivated. Task reactivation is executed whenever the specified time interval has elapsed, the paging rate has diminished to zero, and sufficient storage has become available to reinstate the deactivated task.

PWF (Power Warning Feature) Support

Power warning feature (PWF) support, with its associated hardware, prevents the loss of information that is in real storage when a utility power disturbance occurs. The hardware includes an uninterruptible power supply (UPS), which provides alternate power, and equipment to signal the PWF routines when a disturbance occurs.

PWF support, after receiving the signal of a power disturbance and determining the significance of the disturbance, can transfer the contents of real storage to disk storage. After utility power is restored, you can use the

power warning feature support restore routine to refresh the contents of real storage from disk.

PWF support requires that a system have the following features:

- The uninterruptible power supply (UPS), which supplies power to a critical subset of a system for a minimum of 1 second per 100K bytes of real storage.
- A power line disturbance detector, which, after detecting a disturbance, sends a signal to PWF.
- A power warning feature, a separately ordered IBM feature that causes a machine check (power warning interrupt) when signaled that a disturbance has occurred.
- Two data sets, called *warn data sets,* which are allocated, cataloged, and mounted on two disk drives of the same model.

SWA (Scheduler Work Area)

Scheduler work area (SWA) is an area in virtual storage that contains the scheduler tables (formerly written to SWADS) from DASD. The choice between the tables being on SWADS or in SWA is on an initiator basis and is controlled by the system programmer (via the initiator procedure EXEC statement PARM field) or by the operator (via overriding the PARM= field in the START command). There is one SWA for each initiator.

Shared DASD (Direct Access Storage Device)

The shared DASD option allows one or more direct access storage devices to be shared between two or more CPU's when the drives are connected to a control unit that has a path to each CPU. This feature allows access to the devices through separate channels connected to separate CPU's.

Systems can share common data and consolidate data when necessary; no change to existing records, data sets, or volumes is necessary.

Sharing is accomplished by a two-channel or four-channel switch that allows a shared control unit to be switched between two channels from different systems. The VS1 control program controls the use of a shared device so that data being used in one CPU is protected from modification by a program in another CPU, and so that access-arm contention between CPU's is minimized.

The shared DASD facility can be included in a system only at system generation time.

Storage Protection Option

Storage protection keys are assigned to 2K areas of storage that are designated for use by either the system (storage protection key of 0) or problem programs (storage protection keys of 1-15). This feature prohibits the modification, by a problem program, of areas of storage other than those identified with the problem program's storage protection key. The system has access to all allocated storage protection keys and may, on occasion, use non-key-0 areas.

System Log

The system log consists of two SYSOUT data sets on which the communications between the programmer and/or operator and the system are recorded.

Several kinds of information can be recorded in the system log:

1. Job time, step time, and data from the job and execute statements of a job that has ended can be written in the log. This information is entered in the log by the user's own accounting routine.
2. Operating data entered by problem programs using a write-to-log (WTL) macro instruction can be written in the log.
3. Operators can record in the log descriptions of unusual events that occur during processing.
4. Write-to-operator (WTO) and write-to-operator-with-reply (WTOR) may be recorded in the log on systems with the multiple console support option when the system log (SYSLOG) is specified as the hard-copy device. This includes the routing codes used to route the messages and the time the message was executed.
5. Commands issued through the operator's consoles and the input stream, and commands issued by VS1 and responses can be entered in the log in systems with multiple console support when the system log is specified as the hard-copy device.

When one of the system data sets is filled, VS1 writes it out. The operator, at any time, may also write out the system log.

SMF (System Management Facilities)

System management facilities (SMF) collects and, optionally, records system, job management, and data management information on a DASD file. It also provides control program exits to installation-supplied routines that can periodically monitor the operation of a job or job step.

SMF collects information such as:

- System configuration
- Job and job step identification
- CPU wait time
- CPU time used by each job and job step
- Virtual or real storage requested by each job step
- Virtual or real storage used for each job step
- Paging statistics on a job step and system basis
- I/O device use by each job step
- Temporary and nontemporary data set use by each job and job step

- Temporary and nontemporary data set status
- VSAM data space status
- Status of removable direct access volumes
- Input count by each job and job step
- Output count by each job
- Output writer records by each job
- Allocation recovery records by each job
- Vary online and offline records

It is possible to suppress the writing of all or selected SMF records at IPL time.

The SMF exits to installation-written routines allow certain parameters to be passed to them to identify the job and job step being processed and to provide accounting and operating information. These exit routines can cancel jobs, write records to the SMF data set, open and use their own data sets, and suppress the writing of certain SMF records.

Time-Slicing Facility

The time-slicing facility permits each task of a specified priority to have control of the CPU for a given time. Normally, a task maintains control either until it is complete, until a higher-priority task becomes ready, or until it must wait for some event (such as an I/O operation). With time-slicing, a group of tasks share the CPU, each for the same fixed time. As soon as one task has used its allotted time, control is passed to the next-ready task in the time-slice group. (This, of course, is contingent on no other task outside of the time-slice group having a higher priority and being ready for execution.)

When a time-sliced task loses control before the expiration of its time (either because it must wait or because a higher-priority task acquires the CPU), the remainder of the time is not saved. When control is returned to the time-slice group, the next task is dispatched, not the task that lost control.

TOLTEP (Teleprocessing Online Test Executive Program)

TOLTEP for VTAM is the interface between online test programs (OLT), the operating system, and devices allocated to VTAM. You can use TOLTEP to:

- Perform preventive maintenance.
- Perform problem determination.
- Diagnose I/O errors.
- Verify device repairs and engineering changes.

TOLTEP is included in the system when VTAM is generated. It runs as a task of VTAM and resides in the VTAM region. TOLTEP can run concurrently with OLTEP (online test executive program) and can be invoked by more than one user at the same time.

SUPPORT PROGRAMMING

A wide selection of support programs is available with VS1. The processing programs are designed to reduce the time, training, expense, and manpower required to design and code efficient problem-state programs.

System Assembler

The OS/VS1 System Assembler is the only language translator that is a standard SCP component of VS1. It is a macro assembler that enlarges the language now available under OS for System/360 Assembler F and provides improved messages to diagnose user errors. The language supported by the System Assembler is compatible with that supported by Assemblers E and F. In addition, it is a subset of, and compatible with, the language supported by the program product Assembler H.

You can use the OS/VS1 System Assembler to program any type of application. All services provided by the VS1 system control program are available when using the System Assembler.

Linkage Editor

The VS1 linkage editor provides new control statements to take advantage of virtual storage and the authorized program facility in addition to those functions provided by the MFT linkage editor. The linkage editor forms a single program that is ready to be loaded and executed. It enables changes to be made in a program without recompiling (or reassembling) the complete program; only those sections that are changed need to be recompiled.

Loader

The loader combines the basic editing functions of the linkage editor and the loading function of program fetch in one job step. It loads object modules produced by language translators and load modules produced by the linkage editor for execution. It is designed for high-performance loading of modules that do not require the specific facilities of the linkage editor and program fetch. The loader does not produce load modules for program libraries.

Utility Programs

The utility programs provided with VS are divided into three categories:

- Data set utility programs
- System utility programs
- Independent utility programs

Data Set Utility Programs are used chiefly by the programmer and operator. The list that follows describes the general function of each utility:

- IEBCOMPR compares two identically organized sequential or partitioned data sets at the logical record level.
- IEBCOPY copies, compresses, merges, loads, and unloads partitioned data sets.
- IEBDG provides a *pattern* of test data used as a programming debugging aid.
- IEBEDIT creates an edited input job stream data set from a master job stream data set.
- IEBGENER copies a sequential data set or a partitioned member, or produces a partitioned data set from sequential input.
- IEBISAM copies, reorganizes, and prints indexed sequential data sets.
- IEBPTPCH prints or punches all, or selected portions, of a sequential or partitioned data set.
- IEBUPDTE creates and updates symbolic libraries, incorporates changes to partitioned members or sequential data sets, and changes data set organization from sequential to partitioned or vice versa.

System Utility Programs are used chiefly by the system programmer to maintain collections of data and system control information. This list describes the general function of each program:

- IEHATLAS locates and assigns an alternate track to replace a defective track. It retrieves usable data records from the defective track and transfers them to the alternate track.
- IEHDASDR prepares direct access volumes for use and dumps data from, or restores data to, these volumes.
- IEHINITT writes IBM volume label sets in EBCDIC, BCD, or in ASCII on magnetic tapes.
- IEHIOSUP updates TTR entries in the transfer control tables of the SVC (supervisor call) library.
- IEHLIST lists entries in a catalog, entries in the directory of one or more partitioned data sets, or entries in a volume table of contents.
- IEHMOVE moves or copies logical collections of operating system data.
- IEHPROGM modifies system control data and maintains data sets at an organizational level.
- IFHSTATR formats and writes information from type 21 ESV (error statistics by volume) records.

Independent Utility Programs are used chiefly by the operator. These utility programs operate outside, and in support of, OS/VS1. The general function performed by each program is described in the following list:

- IBCDASDI initializes direct access volumes for use with OS/VS1 and assigns alternate tracks on direct access storage volumes.
- IBCDMPRS dumps or restores data between a direct access storage device and a transportable volume.
- ICAPRTBL loads the UCS (Universal Character Set) buffer and the FCB (forms control buffer) for an IBM 3211 Printer.

Emulator Programs

Integrated emulator programs, used with a compatibility feature, allow object programs written for one system to be executed on another system with little or no reprogramming. The compatibility feature consists of hardware and microprogrammed routines that aid emulation. The emulator programs are executed as problem programs under the VS1 system control program. Although the emulator programs are components of the system control program, the user must order them separately from IBM. The VS1-supported emulators are shown in Figure 4-5.

Emulators	System/370 Models			
	135	145	158	168
1401/1440/1460, 1410/7010		X	X	
1401/1440/1460	X	X		
7070/7074			X	X
7080				X
709/7090/7094 II				X
OS/DOS	X	X	X	

Figure 4-5. Emulators

VS1 STARTER SYSTEM

The IBM-supplied starter system is required to generate your first OS/VS1 system. Thereafter, you can use the generated system to create an alternate configuration.

IVP (INSTALLATION VERIFICATION PROCEDURE)

When OS/VS1 is installed at a customer location, an IBM representative performs installation verification procedure (IVP) to assure that the system is operational and supports the hardware configuration. This procedure is performed as part of IBM's system control program installation procedure for the initial installation of VS1 and for updates.

The jobs included in the IVP job stream are limited to the VS1 system control program. These jobs exercise the functions within the newly configured VS1 system, but no attempt is made to exercise any specific function. The job

stream consists of existing VS1 facilities (programs, commands, etc.) which, when executed, exercise the VS1 functions and provide identification and information about the devices in the system.

TYPE I AND TYPE II PROGRAMS

For specific information about the Type I functional programs and the Type II application programs that run under VS1, see your local IBM representative.

IBM PROGRAM PRODUCTS

VS1 is designed so that program products can operate in this new environment as part of the system's upward compatibility. Program products, available from IBM for a license fee, can be categorized as those that are system oriented and those that are industry oriented. For further information about these program products, see your local IBM representative.

OS/VS2 (Operating System/Virtual Storage 2)

OS/VS2 Release 2 (MVS–Multiple Virtual Storage) is a virtual storage operating system with multiprogramming, multiprocessing, time-sharing (TSO), and a job entry subsystem (JES2). MVS supports certain System/370 models and processor complexes. This support is discussed for the models and the processor complexes under "Programming Support" in Section 5.

The three most important features of MVS are:

1. Virtual storage
2. Multiprocessing
3. Time-sharing

Virtual Storage: MVS extends the concept of virtual storage to provide multiple address spaces; that is, each system user has his own private address space. (For additional information on virtual storage, see *Introduction to Virtual Storage in System/370,* GR20-4260.)

Multiprocessing: MVS directs the combined resources of both processors (in a tightly coupled environment) and schedules execution of simultaneous tasks to provide higher utilization of shared I/O and storage.

Time-Sharing: In MVS, time-sharing (TSO) is a standard feature. The user has access to the system through a command language from remote terminals.

FEATURES AND FACILITIES

Many features and facilities that were available in previous operating systems (OS/MVT and OS/VS2 Release 1) are also available (essentially unchanged) in MVS. A complete description of all MVS functions is contained in *Introduction to OS/VS2 Release 2,* GC28-0661. The following paragraphs summarize the major new and redesigned features of MVS such as:

- JES2, a new job entry subsystem
- SRM, a system resources manager
- MF/1, a system activity measurement facility
- VIO (Virtual I/O), a virtual I/O paging mechanism for temporary data set
- New data set handling facilities
- New recovery termination management functions
- New allocation design

Handling the Job Stream

Multiple virtual storage (MVS) offers new facilities to improve the management of jobs with the resources available in the system.

JES2 operates as the primary job entry subsystem in MVS and provides:

- An input/output spooling function
- A simplified job class scheduling structure
- A remote job entry capability

SWA (scheduler work area), a pageable portion of an address space, contains control blocks and tables created during JCL interpretation. The inclusion of SWA in MVS eliminates the need for the system job queue and reduces the requirements for preallocated auxiliary storage.

Allocation: The new allocation design allows an installation to assign names to subsets of devices and to define a precedence list for allocating device types. The intent is to reduce contention for devices (serialization) and to reduce allocation time by tailoring the allocation process.

Dynamic allocation of auxiliary storage is now available to both background and foreground jobs, and provides support for

- Multivolume or multiunit data sets
- Generation data groups
- Concatenation of data sets (except VSAM and ISAM data sets)
- Optional freeing of data sets (at CLOSE)
- Allocation of devices other than direct access devices

Handling Data Sets

Data management facilities in MVS are intended to provide systematic and effective means of organizing, identifying, storing, cataloging, and retrieving all data.

VSAM (virtual storage access method) operates with direct access devices and supports both sequential and

direct processing. VSAM creates and maintains two types of data sets:

- Key-sequenced: Organized by a key-field in each record
- Entry-sequenced: Organized chronologically

The VSAM Catalog: The master catalog in Multiple Virtual Storage (MVS) must be a VSAM master catalog. You can convert an existing catalog (OS or OS/VS2 Release 1) to the VSAM format by using a facility of Access Method Services. Also, you can use a utility program, IEHUCAT, to update an existing master catalog with changes made to the VSAM master catalog. (*Note:* MVS provides support for non-VSAM private catalogs through the CVOL processor.)

Access Method Services is a set of service routines intended for use with VSAM data sets. Some functions provided are:

- Defining, copying, and printing data sets
- Deleting VSAM entries from a catalog
- Providing data set portability between DOS/VS and OS/VS

VIO (virtual I/O) handles temporary data sets in MVS and provides the following advantages:

- Elimination of some of the usual I/O device allocation and data management overhead for temporary data sets
- Generally, more efficient use of direct access storage space
- Use of the I/O balancing capability of the paging mechanism

Operating the System

Operator Commands: The operator command language now supports:

- JES2 (job entry subsystem)
- SRM (system resources manager)
- Multiple private address spaces
- Multiprocessing

System Initialization: Multiple Virtual Storage (MVS) includes facilities that are aimed at increasing the speed and flexibility of system initialization. The increased flexibility in specifying parameters is an attempt to increase the speed of the process by decreasing the amount of required operator intervention.

Managing the System

As computer systems become more complex, the ability to control the use of the system and its resources becomes more important. MVS includes facilities to help an installation manage its system.

SRM (System Resources Manager) monitors a wide range of data about the condition of the system. It analyzes system-wide CPU and I/O load, monitors storage utilization, and requests that address spaces be swapped into or out of real storage in an attempt to keep the utilization of each of the resources within an acceptable range. In addition, SRM monitors the rate of usage of system resources by individual users, compares this rate to a target usage specified by the installation, and attempts to maintain this target resource usage rate by making the appropriate swapping decisions.

MF/1 (System Activity Measurement Facility) collects information about system activities and produces trace records and reports. MF/1 can monitor the following classes of system activity: CPU, paging, work load, channel and I/O device.

System Integrity is the ability of the system to protect itself against unauthorized user access; that is, an unauthorized program using any system interface should be unable to:

- Bypass store or fetch protection (read from or write into another user's area)
- Bypass password checking (access password protected data for which a password has not been supplied)
- Obtain control in an authorized state

In MVS, all known integrity exposures have been removed. IBM will accept as valid any authorized program analysis report (APAR) that describes an unauthorized program's use of any system interface (defined or undefined) to bypass store or fetch protection, to bypass password checking, or to obtain control in an authorized state.

Note: An authorized program in MVS is one that executes in a system key (Key 0-7), in supervisor state, or is authorized via the authorized program facility (APF).

Reliability, Availability, and Serviceability

Multiple Virtual Storage (MVS) provides improved reliability, availability, and serviceability (RAS) facilities that can be used to promote continuous system operation.

RTM (Recovery Termination Management) cleans up system resources when a task or address space terminates. Specifically, RTM:

- Performs normal and abnormal task termination
- Performs normal and abnormal address space termination
- Writes dumps and records errors
- Provides for recovery for supervisory routines by routing control to functional recovery routines (FRRs)

- Provides for recovery in a tightly coupled MP environment by routing control to alternate CPU recovery (ACR) when one CPU fails.

Software Error Recording: In MVS, records of software failure and recovery activity are written in the SYS1.LOGREC data set. The recorded data can be retrieved, formatted, and printed to provide assistance in isolating system failures and evaluating the effectiveness of program changes.

PWF (Power Warning Feature) support, along with the hardware that supports it, prevents the loss of information in real storage when a utility power disturbance occurs. PWF support, after receiving the signal of a power disturbance and determining the significance of the disturbance, can transfer the contents of real storage to disk storage. After utility power is restored, you can use PWF support to refresh the contents of real storage from disk storage.

SMP (System Modification Program) is a service aid that enables you to put IBM modifications or your own modifications into an MVS system. In addition, SMP maintains records of the contents and status of your operating system.

IBM PROGRAM PRODUCTS

Program products are available from IBM for a license fee. For further information about program products, see your local IBM representative.

BIBLIOGRAPHY

For additional information about multiple virtual storage (MVS), including the total scope of the system, and compatibilities and incompatibilities with MVT and OS/VS2 Release 1, see the following publications:

- *Introduction to OS/VS2 Release 2,* GC28-0661
- *OS/VS2 Planning Guide for Release 2,* GC28-0667
- *OS/VS2 Release 2 Guide,* GC28-0671
- *IBM System/370 Bibliography,* GC20-0001
- *IBM System/370 Bibliography of Industry Systems and Application Programs,* GC20-0370

Virtual Machine Facility/370 (VM/370)

VM/370 is a system control program (SCP) that manages a real computing system so that all of its resources–CPU, storage, and input/output devices–are available to many users at the same time. Each user has at his disposal the functional equivalent of a real, dedicated computing system. Because this functional equivalent is simulated for the user by VM/370 and does not really exist, it is called a virtual machine.

VM/370 is designed for IBM System/370 processors that have the dynamic address translation (DAT) feature, a hardware facility that translates virtual storage addresses to real storage addresses, and the system timing facility. Also, the processors must operate in extended control mode, a mode in which all the features of a System/370, including dynamic address translation, are operational.

VM/370 is the System/370 version of a control program called CP-67/CMS, which performs similar functions on a System/360 Model 67. Like its predecessor, VM/370 provides:

- Virtual machines and virtual storage
- The ability to run multiple operating systems concurrently
- A conversational, time-sharing system

A major difference between CP-67/CMS and VM/370 is that VM/370 provides a remote spooling communications subsystem (SCS). In addition, VM/370 supports such devices as the IBM 3330 Disk Storage, the IBM 3340 Direct Access Storage Facility, and the IBM 2305 Fixed Head Storage, and offers several performance options to optimize performance in the virtual machine environment.

ELEMENTS OF VM/370: CP, CMS, AND RSCS

VM/370 has three major elements:

1. The control program (CP), which controls the resources of the real computer to provide multiple virtual machines. Executing a program on a virtual machine produces exactly the same output as executing that program on a real machine.

   When a user logs onto VM/370, CP creates a virtual machine for him based on information stored in the VM/370 directory. The VM/370 directory contains one entry for each user identification. Each entry includes: the password associated with the userid; a description of the virtual input/output devices associated with this virtual machine; its normal and maximum virtual storage sizes; the user's CP command privilege class(es); and optional virtual machine characteristics, such as extended control mode.

   CP controls the resources of the real computer to provide multiple virtual machines. CP intercepts, translates, and schedules all real input/output operations of the virtual machine. All virtual machines execute in problem state, and the control program traps and processes all interrupts and privileged instructions. Only CP executes in supervisor state.

2. The conversational monitor system (CMS) is the major subsystem of VM/370. Together with the control program of VM/370, it provides a time-sharing system suitable for direct problem solving and program development. CMS is an operating system that runs only in a VM/370 virtual machine. (CMS uses the Diagnose interface for all of its disk and tape input/output operations and includes no error recovery routines.)

   CMS is a conversational, single-user system. The user's interface to CMS is the virtual operator's console, that is, the terminal used to gain access to VM/370.

   CMS has no multiprogramming capabilities, as it is designed to run in a VM/370 virtual machine. CP provides the time-sharing environment; CMS provides the conversational user interface. Using CMS, the user can write programs to run under CMS or under another virtual machine operating system.

   CMS is used to incorporate all VM/370 program releases and program fixes.
3. The VM/370 remote spooling communications subsystem (RSCS) provides the spooling of files between remote stations and virtual machines at the VM/370 installation. (Remote stations are configurations of I/O devices attached to the VM/370 computer by binary synchronous communications (BSC) switched or non-switched lines.)

   The VM/370 computer is the functional center of communications in the RSCS teleprocessing network. The operator of the RSCS virtual machine controls the network by issuing RSCS commands at the RSCS virtual machine console.

   The facilities of RSCS are selected and controlled by means of commands and control cards. Connections between geographically remote locations are made by the operator of the RSCS virtual machine.

   Each location in the RSCS network is assigned a location identifier, which RSCS uses to find a link, or path, to the remote location.

VIRTUAL MACHINE OPERATING SYSTEMS

While the control program of VM/370 manages the concurrent execution of the virtual machines, it is also necessary to have an operating system managing the work flow within each virtual machine. Because each virtual machine executes independently of other virtual machines, each one can use a different operating system, or different releases of the same operating system.

The operating systems that can run in virtual machines are shown in Figure 4-6. CP provides each of these with virtual device support and virtual storage. The operating systems themselves execute as though they were controlling real devices and real storage, but they must not violate any of the VM/370 restrictions.

Figure 4-7 shows six virtual machines running concurrently under control of CP on an IBM System/370

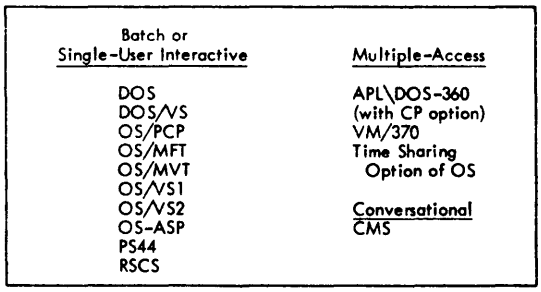


Figure 4-6. Virtual Machine Operating Systems

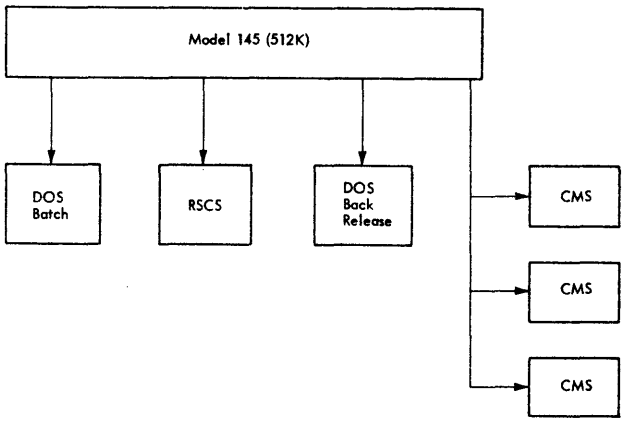


Figure 4-7. Multiple Virtual Machines

Model 145, with 512K bytes of real storage. One machine is doing batch production work under the present release of DOS; a second is executing programs that require a back release of DOS; and a third is controlling the RSCS network. The other three virtual machines are running CMS for three separate conversational users.

VIRTUAL MACHINE ASSIST FEATURE

The Virtual Machine Assist feature, which improves the performance of VM/370, is a combination of a CPU feature and VM/370 programming. Virtual storage operating systems (such as OS/VS1 and DOS/VS) that run in problem state under control of VM/370, use many privileged instructions and SVCs that cause interrupts that VM/370 must handle. When the Virtual Machine Assist feature is used, many of these interrupts are intercepted and handled by the CPU; consequently, VM/370 performance is improved.

Whenever VM/370 is loaded (via IPL) on a CPU that has the Virtual Machine Assist feature, the feature is enabled for all virtual machines on the system. The system operator can disable and enable the feature for the system.

When a user logs on, the assist feature is enabled for his virtual machine if it is enabled for the system. The general user can set the feature off for his virtual machine, and later

set it on again. He can also control whether SVC interrupts are handled by the Assist feature or by VM/370.

Under some conditions, the Virtual Machine Assist feature cannot be used. CP automatically turns the feature off if the user invokes certain trace functions, attaches a dedicated channel, or attempts to load a system containing a shared segment. CP automatically turns the feature on again when the user ends tracing, detaches the dedicated channel, or loads a system that does not contain a shared segment.

VM/370 APPLICATIONS

VM/370 assists an installation to perform its work more efficiently and easily. Virtual machine applications aid programmers, operations personnel, and interactive users.

Programming

Programming is facilitated in the following ways:

1. Programs being developed need not conform to the real storage size of the real computer.
2. Virtual machines make program testing more flexible. Subject to available resources, a virtual machine can be made active whenever needed, thus relaxing normally tight or inflexible testing schedules and allowing programmers more compilations and tests per day.
3. JCL (job control language) usually is not needed when compiling, assembling, and/or testing under CMS.
4. Users can test privileged code in their own virtual machines.
5. Programmers can use debugging aids at their terminal that parallel those of an operator at a system console: displaying and storing into the general or floating-point registers or into virtual storage, instruction address stopping, and altering the normal flow of execution. Which of these functions each user is allowed to perform are defined by the privilege class(es) assigned to him.
6. CMS simplifies the creation and manipulation of source programs on disk, and allows the user to examine selected portions of program listings and storage dumps at his terminal.
7. RSCS allows users to transmit files to, and receive files from, users at other remote locations.
8. The VM/370 data privacy, security, and user-isolation features protect each user's data, programs, and disk files from access or destruction by other users.
9. Many System/360 and System/370 programs can be compiled under control of CMS; within certain restrictions these programs can also be tested under CMS. DOS assembler language programs can be compiled under CMS if the installation adds the appropriate DOS macros to the CMS system. Problem programs using DOS macros can be conversationally developed under control of CMS; then control of the virtual machine is passed to DOS, and the programs are compiled and tested. The user specifies which operating system is to control his virtual machine by means of the IPL command of CP.

Operations

The virtual machine environment relieves certain problems of scheduling, updating programs and backup, and expedites production in the following ways:

1. System generation, updating, and system testing, as well as operating system conversion and testing, can be done without a dedicated real machine, concurrently with normal production work. This reduces errors that might otherwise be caused by using a system that has not been fully tested, and it also reduces the possibility of abnormal terminations of the system. For example, a program temporary fix (PTF) applied to a copy of an IBM operating system volume can be tested concurrently with the production execution of that same operating system in another virtual machine, provided sufficient direct-access storage resources are available. The virtual machine test will be analogous to one made on a real machine provided:
   - There are no timing dependencies.
   - The test is not measuring time.
   - Dynamically modified channel programs are not used except as allowed by VM/370.

   A possible combination of virtual machines in a VM/370 configuration is shown in Figure 4-8. Operating system testing is shown running concurrently with batch work and a variety of conversational applications.
2. VM/370 allows DOS and OS, including virtual storage (VS) versions, to run concurrently on the same System/370. Multiple copies of the same operating system can also run concurrently in separate virtual machines.
3. Many types of batch applications can be run, either in an individual user's virtual machine or in a virtual machine dedicated to running batch, with no change to the batch program.
4. New computer operators can get hands-on experience using a virtual machine terminal as a system console.
5. An installation using VM/370 has more flexibility in using another System/370 computing system for backup. The backup system need not be the same System/370 model nor have the same amount of real storage. Backup can be done in two ways:
   - The VM/370 system residence volume and the user and CMS volumes can run on another System/370 if the device addresses on both machines are the same. This is not unique to VM/370; the same procedure would be used to back up OS or DOS systems.
   - The second method is unique to VM/370. The user volumes alone can be carried over to another computing system that is using VM/370. The backup

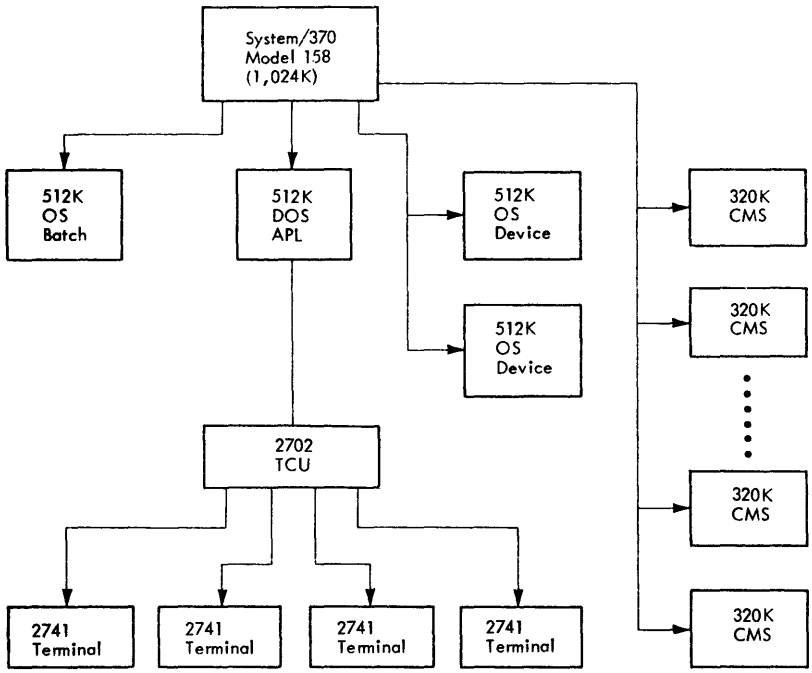


Figure 4-8. Virtual Machines for Concurrent Program Maintenance

system must include, but is not limited to, the same type and number of real devices as these user volumes require. Because the virtual devices defined in the user volumes are not assigned to specific real devices until execution time, the installations need not concern themselves with device addresses; VM/370 on the backup system assigns real devices just as it does for its own virtual machines. Thus, the production work of the system being backed up can run in virtual machines concurrently with the execution of the virtual machines of the backup system.

Interactive Use

Two kinds of interactive systems run under VM/370: multiple-access and single-user.

1. Multiple-access systems like APL\DOS-360 run in one virtual machine and directly service many interactive terminals. A user of a multiple-access system dials the system instead of logging on to connect his terminal with the virtual machine running the multiple-access system he wishes to use. Once his terminal is connected, the user issues statements in the command language associated with the multiple-access system only.

   For example, dialing APL could connect the user's terminal with an APL\DOS-360 system running in a virtual machine under VM/370. Once connected, the user communicates only with APL commands and cannot use any CP commands.

2. Systems that a single user can run interactively include the conversational monitor system (CMS) and any operating system that can run on a virtual machine. A time-sharing environment is created when VM/370 creates multiple virtual machines, each controlled by a copy of CMS. These systems operate concurrently with each other as well as with other conversational or batch systems. CMS is useful for program development and problem solving.

   The CMS command language provides each user with a wide range of capabilities at his remote terminal, such as:

   - Creating source programs, data, and text files directly on disk.
   - Adding, deleting, modifying, rearranging, extracting, or merging files and/or portions of files.
   - Compiling, testing, and debugging some types of OS problem programs under CMS.
   - Creating complete job streams to be passed to batch processing systems such as DOS or OS for compilation and/or execution. The resultant output can be printed on a high-speed printer or directed back to CMS for analysis and correction by the user.
   - Submitting jobs to a background CMS batch facility.
   - Extending CMS facilities to suit the user's requirements, such as creating additional commands or developing command procedures.

BIBLIOGRAPHY

For additional information about VM/370 and VM/370 publications, see these publications:

- *IBM Virtual Machine Facility/370: Introduction,* GC20-1800
- *IBM System/370 Bibliography,* GC20-0001
- *IBM System/370 Bibliography of Industry Systems and Application Programs,* GC20-0370

Section 5. System/370 Models

The individual System/370 models, including processor complexes, are briefly described and illustrated in this section. Figure 5-14 at the end of the section compares the prominent features and characteristics of each processor with those of the other processor.

System/370 Model 115

System/370 Model 115 (Figure 5-1), the smallest of the System/370 models, is a compact, versatile system with 64K (65,536 bytes) to 384K (393,216 bytes) of monolithic main (processor) storage. The Model 115, with either the IBM 3115-0 Processing Unit or the IBM 3115-2 Processing Unit that has extended performance, provides users with virtual storage capability. The Model 115 offers native (integrated) attachment of punched-card, tape, and disk devices; printers; and teleprocessing terminals. The Model 115 also offers channel attachment of a variety of I/O devices, including the IBM 3540 Diskette Input/Output Unit for cardless system operation.

Other prominent features contributing to performance are:

1. An integrated display/keyboard console, which provides the system control function and uses the display for better system-to-operator communications.
2. A console file, which provides the facility for loading control storage with microprograms or a system check-out program.
3. The alter/display function, which provides a means of displaying and altering main storage data at a printer-keyboard.

Standard Features

System/370 commercial instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Channel indirect data addressing
Error checking and correction
Direct disk attachment (3340)
Service processor (SVP)
Audible alarm

Optional Features

Floating point (3115-0)
Floating point, including extended precision
External signals
System/360 Model 20 compatibility
1052 compatibility
1401/1440/1460 compatibility
1403/3203 carriage control
2311-1/3340-series compatibility
2314/3340-series compatibility
Basic byte multiplexer channel (3115-0 and 3115-2)
Extended byte multiplexer channel (3115-2)
Integrated card I/O attachment
Magnetic tape adapter (for 3410/3411 or 3803-3/3420)
Integrated printer attachment
Integrated console printer attachment
Integrated communications adapter
3340 fixed head attachment capability
3340 string switching capability (3115-2)

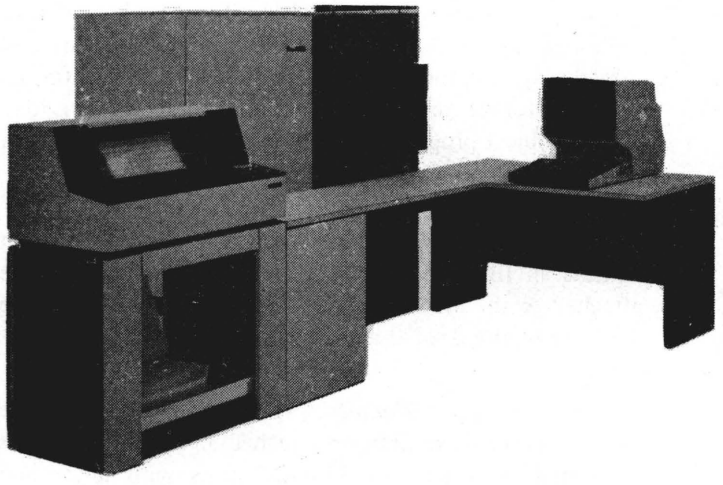


Figure 5-1. IBM System/370 Model 115 with IBM 3203 Printer

System Components

Processing Unit: IBM 3115-0 or 3115-2 Processing Unit

The 3115-0 or 3115-2 Processing Unit contains main storage, and also contains several subprocessors, which increase operating efficiency. These subprocessors include:

The *main storage controller,* which controls access to main storage, and also keeps and updates the address registers for the other subprocessors.

The *service processor,* which loads microprograms from a console file, handles maintenance support and the manual control of the system, and logs and evaluates errors.

The *machine instruction processor* (MIP) of the 3115-0, which fetches and executes program instructions, executes arithmetic/logical instructions, analyzes I/O instructions, calculates addresses, sets condition codes, updates the PSW, and controls the direct disk attachment.

The *instruction processing unit* (IPU) of the 3115-2, which performs the same functions as the MIP of the 3115-0 except for control of the direct disk attachment. This function is handled by a separate I/O processor. Because it does not have to control the direct disk attachment, the IPU has a higher instruction execution rate than the MIP.

The *input/output processors,* which execute I/O commands, and supervise data transfer between the I/O devices and the main storage controller.

Basic Machine Cycle Time: 480 nanoseconds (0.48 microsecond) for one byte on the machine instruction processor of the 3115-0; 480 nanoseconds for two bytes on the instruction processing unit of the 3115-2.

Instruction Sets: The System/370 commercial instruction set is standard with the Model 115. Adding the floating-point feature provides the Model 115 with the System/370 universal instruction set.

Error Checking and Correction: For data read from main storage, error checking and correction circuits automatically detect all single-bit and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Monitoring: This feature provides a means of selectively recording events in the execution of a program.

External Signals: Six lines from external devices to the CPU are provided by the external signals feature. When pulsed, the lines set up the conditions for an external interruption.

Audible Alarm: The audible alarm operates under program control to alert the operator about operator errors and messages.

Processor Storage: Part of IBM 3115-0 or 3115-2 Processing Unit

Processor Storage Capacities:

Capacity (Bytes)	*115 Model Designation*	
	If 3115-0 Used	*If 3115-2 Used*
65,536	F	F2
98,304	FE	FE2
131,072	G	G2
163,840	GE	GE2
196,608	GF	GF2
262,144	–	H2
393,216	–	HG2

Storage Cycle Time: 480 nanoseconds (0.48 microsecond).

Storage Access Width: Two bytes (one halfword).

Channels: Part of IBM 3115-0 or 3115-2 Processing Unit

Model 115 can have one byte multiplexer channel with 32 subchannels, up to eight of which can be shared.

The basic 3115-0 or 3115-2 channel data rate is 19 kilobytes per second in byte mode. The 3115-2 channel with the extended byte multiplexer feature has a data rate of 25 kilobytes per second in byte mode. The burst-mode data rate for either channel is 29 kilobytes per second.

System

Basic System: The minimum configuration for a Model 115 includes one 3115-0 or 3115-2 Processing Unit, one IBM 3340 Direct Access Storage Facility Model A2, one line printer, and either the 3540 Diskette Input/Output Unit or a card reader.

System Control: The system controls are located at the operator console, which consists of a display with a keyboard. The console enables the operator to start and stop the system and to display and alter selected information in storage areas. After initial microprogram load (IMPL), object programs can be loaded from I/O devices via the keyboard and display.

Direct Disk Attachment: The direct disk attachment permits an IBM 3340 Direct Access Storage Facility to be attached to the Model 115. As many as four drives can be attached to the 3115-0 and as many as eight to the 3115-2.

String Switching Capability: The string switch feature allows the 3115-2 to share an attached 3340-A2 unit and its associated 3340-B1 and 3340-B2 units with any other System/370 processor except the 3115-0 or the 3125-0.

Integrated Card I/O Attachment: The IBM 2560 Multi-function Card Machine Model A1 or A2 can be attached to the Model 115 with an integrated 2560 attachment; the IBM 5425 Multi-function Card Unit can be attached to the Model 115 with an integrated 5425 attachment.

Magnetic Tape Adapter: A magnetic tape subsystem can be attached to a Model 115 via the magnetic tape adapter. This subsystem can consist of an IBM 3411 Magnetic Tape Unit and Control, with up to five IBM 3410 Magnetic Tape Units (the 3411 and 3410 model numbers must correspond); or an IBM 3803 Tape Control Model 3, with up to eight IBM 3420 Magnetic Tape Units Model 3 or 5. The magnetic tape adapter allows attachment of the 3410/3411 subsystem to any 3115-0 model or a 3115-2 Model F2 through H2, or attachment of the 3803/3420 subsystem to any 3115-0 or 3115-2 model.

Integrated Printer Attachment: This attachment allows an IBM 3203 Printer Model 1 or 2 or an IBM 5203 Printer Model 3 to be attached to a Model 115 without requiring a separate control unit.

Integrated Console Printer Attachment: This attachment allows an IBM 5213 Printer Model 1 to be attached to a Model 115 to provide hard-copy output of messages displayed on the operator's console.

Integrated Communications Adapter: This adapter allows as many as four synchronous and eight asynchronous communication lines, or as many as five synchronous communication lines, to attach to a Model 115 without requiring a separate transmission control unit. Data rates range from 45.5 to 1200 bps for asynchronous lines and from 1200 to 50,000 bps for asynchronous lines.

Compatibility Features: The compatibility features available for the Model 115 include:

System/360 Model 20
1052
1401/1440/1460
1403/3203 carriage control
2311-1/3340-series
2314/3340-series

Programming Support

Model 115 is supported by DOS and DOS/VS. With the CPU in basic control mode, operation with System/360 programs is possible if the 1052 and 2311 (or 2314) compatibility features are installed and both the IBM 5213 Printer and IBM 3340 Direct Access Storage Facility Model A2 are attached.

System/370 Model 125

The System/370 Model 125 (Figure 5-2), with either the IBM 3125-0 Processing Unit or the IBM 3125-2 Processing Unit, which has improved performance, provides users with a compatible low-end System/370 having a storage capacity of from 96K (98,304 bytes) to 512K (524,288 bytes). Monolithic circuitry, used in both main (processor) storage and control storage, and virtual storage capability contribute to the high performance level of the Model 125.

Other prominent features contributing to performance are:

1. An integrated display/keyboard console, which provides the system control functions, replaces the conventional indicators and switches, and uses the display for better system/operator communication.
2. Native (integrated) attachment of a variety of I/O devices, which eliminates the need for external control units; or channel attachment of other I/O devices such as the IBM 3540 Diskette Input/Output Unit for cardless system operation.
3. A console file, which provides the facility for loading control storage with microprograms or a system check-out program.
4. The alter/display function, which provides a means of displaying and altering main storage data at the display/keyboard console.

Standard Features

System/370 commercial instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Channel indirect data addressing
Error checking and correction (in main storage)
Instruction retry
Direct disk attachment (3330/3333 or 3340)
Service processor (SVP)
Audible alarm

Optional Features

Floating point, including extended precision
External signals
System/360 Model 20 compatibility
1052 compatibility
1401/1440/1460 compatibility
1403/3203 carriage control compatibility
2311-1/3330-series compatibility
2311-1/3340-series compatibility
2314/3340-series compatibility
Byte multiplexer channel
Integrated card I/O attachments
Magnetic tape adapter (for 3410/3411 or 3803-3/3420)
Integrated printer attachment
Integrated console printer attachment
Integrated communications adapter
3340 fixed head attachment capability
3340 string switching capability (3125-2)

System Components

Processing Unit: IBM 3125-0 or 3125-2 Processing Unit

The IBM 3125-0 or 3125-2 Processing Unit contains main storage and several subprocessors for independent handling of programs, diagnostics, and input/output processing. These subprocessors include: a main storage controller (MSC), a service processor (SVP), an instruction processing unit (IPU), and input/output processors.

The *main storage controller* (MSC) can directly access main storage and control accessing of main storage by the other processors on a fixed-priority basis. The MSC has a logical storage area containing address registers assigned to each processor. The registers are maintained and updated by the MSC as it handles each request for access to main storage.

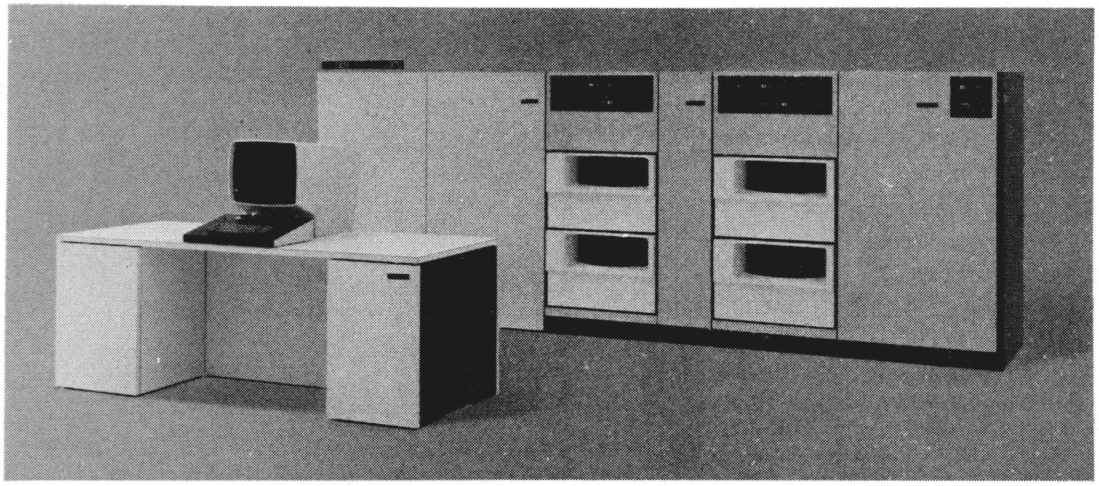


Figure 5-2. IBM System/370 Model 125 with IBM 3330 and 3333 Disk Storage

The *service processor* (SVP) loads microprograms from the console file into the processors, supervises the manual control of the system, and controls microinstruction retry by the IPU. When an error is detected, the SVP attempts recovery, and also logs and evaluates the error for maintenance support.

The *instruction processing unit* (IPU) processes instructions, selects input/output processors, and handles interrupts. It fetches instructions from main storage, analyzes them, fetches associated operands, processes them, and returns the results to main storage. Under identical operating conditions, the IPU of the 3125-2 is from 20% to 30% faster than the IPU of the 3125-0.

The *input/output processors* handle data transfer, control information, and sense information between the I/O devices and main storage. Once selected by the instruction processing unit, the input/output processor takes over the servicing of the I/O devices.

A system may have more than one input/output processor, and each processor may attach more than one I/O device.

Basic Machine Cycle Time: 480 nanoseconds (0.48 microsecond) for two bytes in the 3125-0; 320 nanoseconds (0.32 microsecond) for two bytes in the 3125-2.

Instruction Sets: The System/370 commercial instruction set is standard with the Model 125. Adding the floating-point feature provides the System/370 universal instruction set.

Error Checking and Correction: For data read from main storage, error-checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Monitoring: Events in the execution of a program can be selectively recorded by monitoring.

Instruction Retry: The ability to recover from many intermittent failures during program execution is provided by instruction retry. When an error is detected, a microprogram returns the IPU to the beginning of the operation or a point in the operation before which execution was correct, and the operation is continued.

External Signals: Six lines from external equipment to the CPU are provided by the external signals feature. When pulsed, the lines set up the conditions for an external interruption.

Audible Alarm: The audible alarm operates under program control to alert the operator to operator errors and messages.

Processor Storage: Part of IBM 3125-0 or 3125-2 Processing Unit

Processor Storage Capacities:

Capacity (Bytes)	*125 Model Designation*	
	If 3125-0 Used	*If 3125-2 Used*
98,304	FE	FE2
131,072	G	G2
163,840	GE	GE2
196,608	GF	GF2
262,144	H	H2
393,216	–	HG2
524,288	–	I2

Storage Cycle Time: 480 nanoseconds (0.48 microsecond).

Storage Access Width: Two bytes (one halfword).

Channels: Part of IBM 3125-0 or 3125-2 Processing Unit

The Model 125 can have one byte multiplexer channel with 32 subchannels, up to eight of which can be shared. The sustained data rate in byte mode is 25 kilobytes per second. The maximum data rate in burst mode is 29 kilobytes per second.

System

Basic System: The minimum configuration for a Model 125 includes: one 3125-0 or 3125-2 Processing Unit, one direct access storage device containing two drives, one line printer, and either the 3540 Diskette Input/Output Unit or a card reader.

System Control: The system controls are located at the operator console, which consists of a display with a keyboard. The console enables the operator to start and stop the system and to display and alter selected information in storage. After initial microprogram loading (IMPL), object programs can be loaded from I/O devices via the keyboard and display.

Direct Disk Attachment: This attachment allows one string of IBM 3340 Direct Access Storage Facility devices (up to eight drives) to be attached to the 3125-0, one or two strings of 3340 devices (up to 16 drives) to be attached to the 3125-2, or allows the IBM 3333 Disk Storage and Control and IBM 3330 Disk Storage (up to four drives per system) to be attached to either the 3125-0 or the 3125-2.

String Switching Capability: The string switch feature allows the 3125-2 to share one or two strings consisting of a 3340-A2 unit and its associated 3340-B1 and 3340-B2 units with any other System/370 processing unit except the 3115-0 or the 3125-0.

Integrated Card I/O Attachment: This feature permits the direct attachment of an appropriate model of one of the following to the Model 125:

2560 Multi-function Card Machine
3504 Card Reader
3525 Card Punch
5425 Multi-function Card Unit

Magnetic Tape Adapter: A magnetic tape subsystem can be attached directly to the Model 125 via the magnetic tape adapter. This subsystem can consist of an IBM 3411 Magnetic Tape Unit and Control, with up to five IBM 3410 Magnetic Tape Units (the 3411 and 3410 model numbers must correspond); or an IBM 3803 Tape Control Model 3, with up to eight 3420 Magnetic Tape Units Model 3 or 5.

Integrated Printer Attachment: The IBM 1403 Printer Model 2, 7, or N1, or the IBM 3203 Printer Model 1 or 2, can be attached directly to the Model 125 via the integrated 3203 printer attachment.

Integrated Console Printer Attachment: This feature allows the IBM 5213 Printer Model 1 to be attached as an integral part of the Model 125 operator console. The 5213 provides hard-copy output of operator messages that are displayed.

Integrated Communications Adapter and Extension: This feature allows as many as 16 asynchronous or 6 synchronous communication lines to be attached to the Model 125 without requiring a separate transmission control unit. Data rates range from 45.5 to 600 bps for asynchronous lines and from 600 to 50,000 bps for synchronous lines.

Compatibility Features: The compatibility features available for the Model 125 include:

System/360 Model 20
1052
1401/1440/1460
1403/3203 carriage control
2311-1/3330-series
2311-1/3340-series
2314/3340-series

Programming Support

Model 125 is supported by DOS and DOS/VS. With the CPU in basic control mode, operation with System/360 programs is possible if the 1052 and 2311 (or 2314) compatibility features are installed and both the IBM 5213 Printer and IBM 3340 Direct Access Storage Facility Model A2 are attached. If the IBM 3330 Disk Storage is attached, the 2311 (or 2314) compatibility feature is not required for operation with DOS Release 27.

System/370 Model 135

The System/370 Model 135 (Figure 5-3), with either the IBM 3135 Processing Unit or the IBM 3135-3 Processing Unit (with improved performance), offers processor storage capacities of up to 512K (524,288 bytes) and virtual storage capability with System/370 reliability and performance at relatively low cost. Features such as error checking and correction (ECC) circuits and instruction retry increase Model 135 reliability, and monolithic storage circuits contribute significantly to performance.

Further enhancing the Model 135 are:

1. The console file, which provides the facility for loading control storage with the System/370 microprogram, diagnostic microprograms, or a system checkout program.
2. The alter/display function, which provides a means of displaying and altering main storage data at a printer-keyboard.
3. The CPU-integrated I/O adapters, which eliminate the need for external control units for some commonly used I/O devices.

Standard Features

System/370 commercial instruction set (3135), } including:
System/370 universal instruction set (3135-3), }
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer (3135-3)
Clock comparator (3135-3)
Channel indirect data addressing
Error checking and correction (in main storage and control storage)
Instruction retry
High-speed buffer storage
Conditional swapping (3135-3)
PSW key handling (3135-3)
APL assist (3135-3)
Extended control-program support (3135-3)
Byte multiplexer channel (one: channel 0)
Channel retry information
Command retry
OS/DOS compatibility
Audible alarm

Optional Features

System/370 universal instruction set (3135)
Floating point (3135)
Extended-precision floating point (3135-3 prerequisite)
Direct control (with external interrupt)
Clock comparator and CPU timer (3135)
System/360 Model 20 compatibility
1401/1440/1460 compatibility
2314/3340 compatibility
Selector channels (first and second) (3135)
Block multiplexer channel (3135)
Block multiplexer channels (first and second) (3135-3)
Block multiplexer shared subchannel
Multiplexer subchannels, additional
2319 integrated file adapter (IFA)
3330/3340-series integrated file adapter (IFA)
IFA conversion
Universal character set adapter
Integrated printer adapter (IPA)
Integrated communications adapter (ICA)
Adapter for 3210-1 or 3215-1 Console Printer-Keyboard
Expanded control storage (3135)
Virtual machine assist (3135)
Emergency power-off control
APL assist (3135)

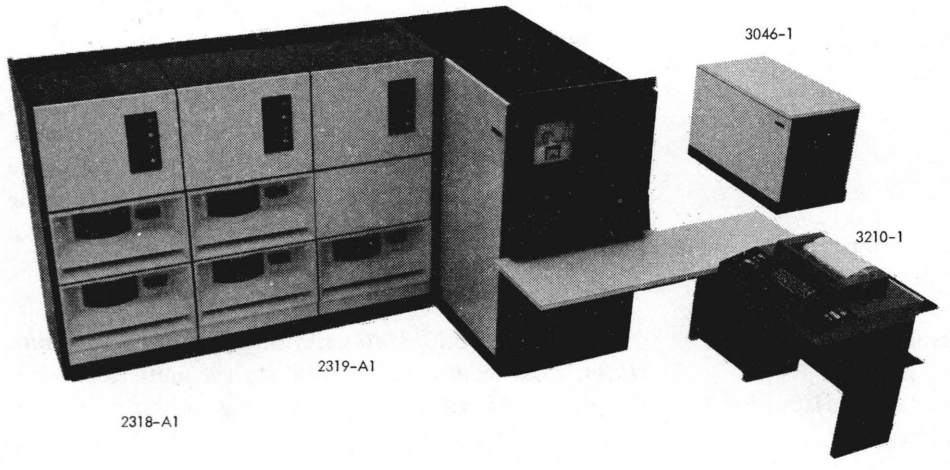


Figure 5-3. IBM System/370 Model 135 with IBM 2318 and 2319 Disk Storage, IBM 3210 Console Printer-Keyboard, and IBM 3046 Power Unit

Processing Unit: IBM 3135 or 3135-3 Processing Unit

The 3135 has seven models: FE, GD, GF, H, HF, HG, and I. The 3135-3 Models A1, A2, A3, and A4 are available as a miscellaneous-equipment specification (MES) to current 3135 Models H, HF, HG, and I.

Basic Machine Cycle Time: 275 to 1,485 nanoseconds (0.275 to 1.485 microseconds), depending on the type of instruction performed.

Instruction Sets: The System/370 commercial instruction set is standard with the 3135 Processing Unit. The System/370 universal instruction set is standard with the 3135-3 Processing Unit.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and in most cases reattempts its execution.

Error Checking and Correction: For data read from main storage and control storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Monitoring: This feature provides a means of selectively recording events in the execution of a program.

Processor Storage: Part of 3135 or 3135-3 Processing Unit

Processor Storage Capacities:

Capacity	*135 Model Designation*	
(Bytes)	*If 3135 Used*	*If 3135-3 Used*
98,304	FE	–
147,456	GD	–
196,608	GF	–
262,144	H	A1
327,680	HF	A2
393,216	HG	A3
524,288	I	A4

Storage Cycle Time: 0.770 microsecond (770 nanoseconds) for main storage read, 0.935 microsecond (935 nanoseconds) for main storage write. These storage cycle times include the fetch time for the next microinstruction.

Storage Access Width: Two bytes (one halfword), but four bytes (one word) in certain read operations.

Control Storage: Part of 3135 or 3135-3 Processing Unit

Control Storage Capacity: The control storage capacity of the 3135 Processing Unit is 24K (24,576 bytes), expandable to 36K (36,864 bytes) or 48K (49,152 bytes). The control storage capacity of the 3135-3 Processing Unit is 128K (131,072 bytes).

Channels: Part of 3135 or 3135-3 Processing Unit

The Model 135 can have as many as four channels, including the IFA, which is addressed as channel 1. One byte multiplexer channel is standard on both the 3135 and the 3135-3. The byte multiplexer channel for the 3135 has 16 subchannels as standard, which can be extended to 64, 128, or 256 subchannels by option. The byte multiplexer channel for the 3135-3 has 64 subchannels as standard, which can be extended to 128 or 256 subchannels by option.

The 3135 can have one or two additional selector channels that can have the optional block multiplexer channel feature to operate as block multiplexer channels.

The 3135-3 can have one or two additional block multiplexer channels.

Each block multiplexer channel for the Model 135 can have one of three subchannel combinations. Subchannels can be combined as 16 nonshared and 1 shared, 8 nonshared and 9 shared, or 8 nonshared and 5 shared.

System

The Model 135 system consists of the following:

IBM 3135 or 3135-3 Processing Unit
IBM 3210 or 3215 Console Printer-Keyboard Model 1
IBM 3046 Power Unit Model 1
Appropriate input/output devices for a minimum or larger system configuration

System Control: The Model 135 is operated, monitored, and controlled through a system control panel on the CPU, and through the console printer-keyboard.

Console File: The console file, located on the system control panel, is used to load into control storage the microprogram required for system operation. As part of the loading operation, diagnostic microprograms check out the CPU and adapters. Other disks for the console file carry a diagnostic program for system checkout.

2319 and/or 3330/3340-series Integrated File Adapter (IFA): Each feature permits disk storage units to attach to the Model 135 without a separate control unit or channel. The 2319 IFA controls as many as eight disk drives, and the

3330/3340-series IFA allows one or two 3333 units or 3340-A2 units to be attached directly to the Model 135. Each 3333 can attach up to three 3330 units. Each 3340-A2 can attach 3340-B1 or -B2 units, and one 3340-A2 can also attach 3344-B2 or -B2F units. The maximum number of drives per string is eight. A 3333/3330 string and a 3340 string (without 3344's) can be attached to the IFA if the optional intermix feature is installed. Both the 2319 IFA and the 3330/3340-series IFA can be attached to the same system if the system has the IFA conversion feature installed.

Integrated Printer Adapter (IPA): This feature allows an IBM 1403 Printer Model 2, 7, or N1 to be attached to the Model 135 without a separate control unit. The universal character set is available as a subfeature.

Integrated Communications Adapter (ICA): This feature allows direct attachment of eight communication lines.

Compatibility Features: The compatibility features available for the Model 135 are:

System/360 Model 20
1401/1440/1460
2314/3340
OS/DOS

Programming Support

The Model 135 is supported by DOS, DOS/VS, OS/MFT, OS/VS1, and VM/370.

System/370 Model 138

The IBM System/370 Model 138 (Figure 5-4) provides either 512K (524,288 bytes) or 1,024K (1,048,576 bytes) of processor storage and virtual storage capability at a level of performance between that of the Models 135 and 145.

Other characteristics that contribute significantly to the performance of the Model 138 include:

1. Control storage capacity that covers control storage requirements for the full line of Model 138 standard and optional features.
2. A display console with a keyboard that provides a visual communication link with the system.
3. Instruction retry facilities, and error checking and correction (ECC) circuits.
4. The CPU-integrated I/O adapters, which eliminate the need for external control units for several commonly used I/O devices.
5. Extended control-program support.

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Conditional swapping
PSW key handling
Channel indirect data addressing
Error checking and correction (in main storage and control storage)
Instruction retry
Extended-precision floating point
APL assist
Extended control-program support
Console file
Byte multiplexer channel (with 64 byte multiplexer subchannels)
Block multiplexer channels (two, each with 1 shared and 16 nonshared block multiplexer subchannels)
Channel retry information
Command retry
OS/DOS compatibility
Audible alarm

Optional Features

Direct control
Channel priority
System/360 Model 20 compatibility
1401/1440/1460 compatibility
2314/3340 compatibility
Block multiplexer shared subchannels (8 nonshared and 9 shared or 8 nonshared and 5 shared)
Multiplexer subchannels (128 or 256 subchannels)
Integrated communications adapter (ICA)
Integrated printer adapter (IPA) for 1403
3330/3340-series integrated file adapter (IFA)
- 3333 or 3340 string switching capability
- 3333/3340 intermix capability
- 3340 fixed-head attachment capability
- 3344 fixed-head attachment capability

Integrated 3203-4 Printer attachment

System Components

Processing Unit: IBM 3138 Processing Unit

Basic Machine Cycle Time: 275 to 1,485 nanoseconds (0.275 to 1.485 microseconds), depending on the type of instruction performed.

Figure 5-4. IBM System/370 Model 138 with Display Console and Keyboard

Instruction Set: The System/370 universal instruction set is standard with the Model 138.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and in most cases reattempts its execution.

Error Checking and Correction: For data read from main storage and control storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Extended Control-Program Support: This is a hardware assist that reduces the CPU time needed to execute certain supervisor functions in both VS1 and VM/370.

Monitoring: This feature provides a means of selectively recording events in the execution of a program.

Processor Storage: Part of 3138 Processing Unit

Processor Storage Capacities:

Capacity (Bytes)	*Model*
524,288	I
1,048,576	J

Storage Cycle Time:

Operation	*Time (Nanoseconds)*
Read byte or halfword	715
Read fullword	880
Write	935

Storage Access Width: Two bytes or four bytes, depending on the operation.

Control Storage: Part of 3138 Processing Unit

Control Storage Capacity: 128K (131,072 bytes).

Channels: Part of 3138 Processing Unit

The Model 138 can have as many as four channels, including the IFA, which is addressed as channel 1. One byte multiplexer and two block multiplexer channels are standard.

The byte multiplexer channel has 64 subchannels as standard, which can be extended to 128 or 256 subchannels by option.

Each block multiplexer channel can have one of three subchannel combinations. Subchannels can be combined as 16 nonshared and 1 shared, 8 nonshared and 9 shared, or 8 nonshared and 5 shared.

System

The Model 138 system consists of:

IBM 3138 Processing Unit with attached display console and keyboard
IBM 3046 Power Unit Model 1
Appropriate input/output devices for a minimum or larger system configuration

System Control: The Model 138 is operated, monitored, and controlled through the system control panel on the CPU, and through the display console. An IBM 3287 Printer Model 1 or 2 can be attached, as a console printer, to the Model 138.

Console File: The console file, located under the operator's console table, is used to load into control storage the microprogram required for system operation. As part of the loading operation, diagnostic microprograms check out the CPU and adapters. Other disks for the console file carry a diagnostic program for system checkout.

3330/3340-series Integrated File Adapter (IFA): This feature allows one or two 3333 units or 3340-A2 units to be attached directly to the Model 138. Each 3333 can attach up to three 3330 units. Each 3340-A2 can attach 3340-B1 or -B2 units, and one 3340-A2 can also attach 3344-B2 or -B2F units. The maximum number of drives per string is eight. A 3333/3330 string and a 3340 string (without 3344's) can be attached to the IFA if the optional intermix feature is installed.

Integrated Printer Adapter (IPA) for the 1403: This feature allows an IBM 1403 Printer Model 2, 7, or N1 to be attached to the Model 138 without a separate control unit. The universal character set is available as a subfeature.

Integrated 3203-4 Printer Attachment: This feature allows an IBM 3203 Printer Model 4 to be attached to the Model 138.

Integrated Communications Adapter (ICA): This feature allows direct attachment of eight communication lines.

Compatibility Features: The compatibility features available for the Model 138 are:

System/370 Model 20
1401/1440/1460
2314/3340
OS/DOS

Programming Support

The Model 138 is supported by DOS/VS, OS/VS1, and VM/370.

System/370 Model 145

The System/370 Model 145 (Figure 5-5), with either the IBM 3145 Processing Unit or the IBM 3145-3 Processing Unit (with improved performance), is a versatile data processing system for both commercial and scientific applications. It has virtual storage capability, provides efficient performance while preserving upward compatibility, and offers processor storage capacities as large as 2,048K (2,097,152 bytes).

The performance of the Model 145 is further enhanced by:

1. System/370's notable reliability and serviceability features, such as its retry capabilities, error-logging facilities, extensive internal checking circuits, and error checking and correction (ECC) circuits for main storage and control storage.
2. A console file, which provides a facility for loading control storage with either the System/370 microprogram, extensive microdiagnostics, or system tests.
3. An alter/display function, which provides a means of displaying and altering main storage without interfering with any concurrent I/O operations.
4. A control storage capacity of 128K (131,072 bytes) in the 3145-3 Processing Unit.

Standard Features

System/370 commercial instruction set (3145) } including:
System/370 universal instruction set (3145-3) }
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Conditional swapping
PSW key handling
Channel indirect data addressing
Error checking and correction (in main storage and control storage)
Instruction retry
Extended-precision floating point (3145-3)
APL assist (3145-3)
Extended control-program support (3145-3)
Advanced control program support (3145-3)
Console file
Byte multiplexer channel
Block multiplexer channel (3145-3)
Selector channel (3145)
Channel retry information
Command retry
OS/DOS compatibility
Audible alarm

Optional Features

System/370 universal instruction set (3145)
Floating point (includes extended precision) (3145)
Clock comparator and CPU timer (required for 3145-3)
Word buffer (required for 3145-3)
Direct control
1401/1440/1460 compatibility
1401/1440/1460, 1410/7010 compatibility
3345 Storage and Control Frame Model 1, 2, 3, 4, or 5 (3145)
Byte multiplexer subchannels, additional
Selector channels (second, third, and fourth) (3145)
Block multiplexer channel (3145)
Block multiplexer channels (second, third, and fourth) (3145-3)
Channel-to-channel adapter
Integrated file adapter (IFA) (3145)
Integrated storage control (ISC)
Virtual machine assist (3145)
APL assist (3145)
Adapter for a 3210-1 or 3215-1 Console Printer-Keyboard
Adapter for a 3210-2 Console Printer-Keyboard

System Components

Processing Unit: IBM 3145 or 3145-3 Processing Unit

The 3145 has 12 models: GE, GFD, H, HG, and I; and H2, HG2, I2, IH2, J2, JI2, and K2. The 3145-3 has seven improved-performance models (A1 through A7) available as a miscellaneous-equipment specification (MES) to current 3145 Models H2 through K2.

Basic Machine Cycle Time: 202.5 to 315.0 nanoseconds (0.2025 to 0.315 microsecond) for the 3145 and 180.0 to 270.0 nanoseconds (0.180 to 0.270 microsecond) for the 3145-3. The exact time for each CPU depends on internal CPU operations.

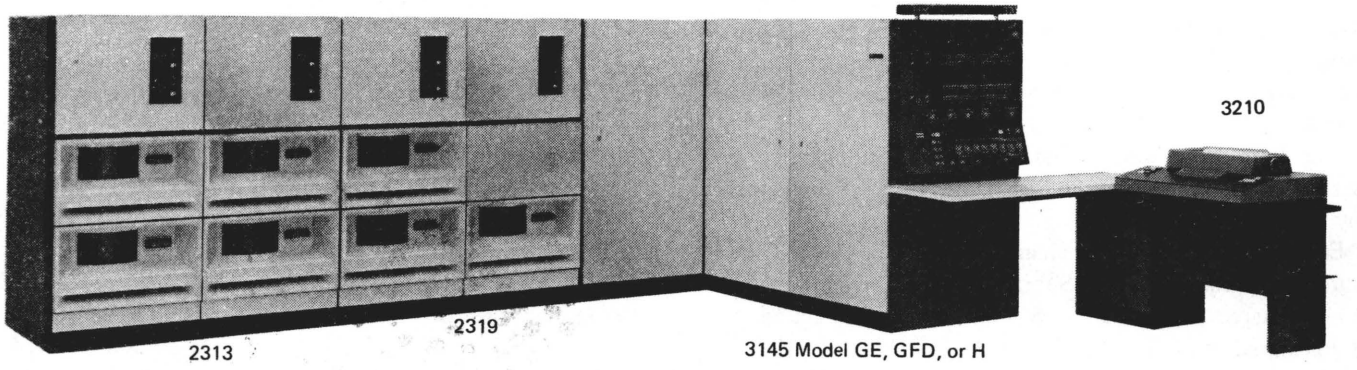


Figure 5-5. IBM System/370 Model 145 with IBM 2313 and 2319 Disk Storage and IBM 3210 Console Printer-Keyboard

Instruction Sets: The System/370 commercial instruction set is standard with the 3145 Processing Unit and becomes the System/370 universal instruction set by the addition of the floating-point feature. The System/370 universal instruction set is standard with the 3145-3 Processing Unit.

Instruction Retry: The ability to recover from many intermittent failures is provided through retry techniques performed by microprogram routines that save the source data before it is altered during an operation. When an error is detected, a microprogram returns the CPU to the beginning of the operation or to a point in the operation that was correctly executed, and the operation is continued.

Error Checking and Correction: For data read from main storage and control storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Processor Storage: Part of 3145 or 3145-3 Processing Unit: and on Certain Models of the 3145 Includes the IBM 3345 Storage and Control Frame Model 1, 2, 3, 4, or 5

Processor Storage Capacities:

Capacity (Bytes)	*145 Model Designation*	
	If 3145 Used	*If 3145-3 Used*
163,840	GE	–
196,608*	–	A1
212,992	GFD	–
262,144	H, H2	–
327,680*	–	A2
393,216	HG, HG2	–
458,752*	–	A3
524,288	I, I2	–
720,896*	–	A4
786,432	IH2	–
983,040*	–	A5
1,048,576	J2	–
1,507,328*	–	A6
1,572,864	JI2	–
2,031,616*	–	A7
2,097,152	K2	–

*Reflects the removal of 64K from 3145 model being converted.

Storage Cycle Time: 540.0 nanoseconds for a main storage read and 607.5 nanoseconds for a main storage write in the 3145; 405 nanoseconds for a main storage read and 540 nanoseconds for a main storage write in the 3145-3.

Storage Access Width: Eight bytes (one doubleword) on instruction fetches.

Control Storage: Part of 3145 or 3145-3 Processing Unit

Control Storage Access Time: 109 nanoseconds for the 3145 and 75 nanoseconds for the 3145-3.

Control Storage Capacity: The 3145 has a control storage capacity of 32K (32,768 bytes) that is expandable to 64K to cover control storage requirements for installed features. The additional control storage capacity is at the expense of main storage. The storage boundary is determined at the time that the microprogram is compiled by IBM.

The 3145-3 has a control storage capacity of 128K (131,072 bytes) that covers control storage requirements for the full line of 3145-3 features including extended control-program support. In converting from a 3145 to a 3145-3, all of the currently used control storage and up to 64K of main storage is removed and replaced with the new 128K control storage.

Channels: Part of 3145 or 3145-3 Processing Unit

The 3145 Processing Unit can have as many as five channels. One byte multiplexer channel and one selector channel are standard. Three additional selector channels are available as optional features. If the IFA feature is installed, only one additional selector channel can be attached. The block multiplexer channel feature provides block multiplexer capabilities for all system selector channels.

The 3145-3 Processing Unit can have as many as five channels. One byte multiplexer channel and one block multiplexer channel are standard. Three additional block multiplexer channels are available as special features.

The byte multiplexer channel for the 3145 has 16 subchannels as standard. Subchannels can be added for a total of 32, 64, 128, or 256. The byte multiplexer channel for the 3145-3 has 64 subchannels as standard. Subchannels can be added for a total of 128 or 256.

The block multiplexer channels for the 3145 have 16 nonshared subchannels as standard. Subchannels can be added, in increments of 16, for a system total of 512. Block multiplexer channels for the 3145-3 have 64 nonshared subchannels as standard. Subchannels can be added for a system total of 128, 256, or 512.

Word Buffer: This feature increases the efficiency of the system by permitting assembly of up to four bytes of data before requiring a share cycle to transfer the data, thereby greatly improving channel speeds and CPU throughput.

This feature applies to all selector channels (3145) and to all block multiplexer channels (3145 and 3145-3) attached to the system.

System

The Model 145 system consists of the following:

IBM 3145 or 3145-3 Processing Unit
IBM 3210 Console Printer-Keyboard Model 1 or IBM 3215 Console Printer-Keyboard Model 1
IBM 3345 Storage and Control Frame (3145 Models H, HG, and I)
IBM 3046 Power Unit Model 1 (3145 Models HG and I)
IBM 3047 Power Unit Model 1 (3145 Models H2, HG2, I2, IH2, J2, JI2, K2, and 3145-3 Models A1 through A7)
Appropriate input/output devices for a minimum or larger system configuration

Compatibility Features: The compatibility features available for the Model 145 are:

1401/1440/1460
1401/1440/1460, 1410/7010
OS/DOS

System Control: The Model 145 is operated, monitored, and controlled through the system control panel on the 3145 or 3145-3 Processing Unit, and through a 3210 or 3215 Console Printer-Keyboard Model 1.

Console File: The console file, located under the operator's console table, is the initial microprogram loading (IMPL) device for the system. The file provides all microcode, on removable diskettes, for the system. Diskettes supplied with the system provide the required microcode for system operation, emulators, diagnostics, and any other required microprogram material to be loaded into control storage.

Integrated File Adapter (for 3145 Models GE, GFD, H, HG, and I): This feature, assigned exclusive use of selector channels 1 and 4, incorporates a file control unit for controlling three to eight drives of natively attached disk storage. This control unit attaches the three-drive 2319 Disk Storage Model A1. Additionally attachable, to a maximum of five drives, are the single-drive 2312-A1, two-drive 2318-A1, three-drive 2319-A2, and four-drive 2313-A1.

Integrated Storage Control (for 3145 Models H, HG, and I through the 3345 Storage and Control Frame Models 3, 4, and 5, respectively; and for 3145 Models H2, HG2, I2, IH2, J2, JI2, K2, and All 3145-3 Models): This feature permits the attachment of one or two 3333 units with associated 3330's, one or two 3340-A2 units with associated 3340-B1 or -B2 units, or one or two 3350-A2 or -A2F units with associated 3350-B2, -B2F, -C2, or -C2F units, for a maximum of eight drives per string. Up to two additional 3333/3330, 3340, or 3350 strings can be attached. Attachment of one or two 3340-A2's with 3344's is mutually exclusive with attachment of either 3333's or 3350-A2's or -A2F's. A two-channel switch attaches the integrated storage control to a second channel, providing channel sharing ability.

Programming Support

The Model 145 is supported by DOS, DOS/VS, OS/MFT, OS/MVT, OS/VS1, OS/VS2, and VM/370.

System/370 Model 148

The IBM System/370 Model 148 (Figure 5-6) is a versatile data processing system for both commercial and scientific applications. It has virtual storage capability, provides efficient performance while preserving upward compatibility, and offers processor storage capacities of 1 megabyte (1,048,576 bytes) or 2 megabytes (2,097,152 bytes).

The performance of the Model 148 is further enhanced by:

1. System/370 reliability and serviceability features, such as retry capabilities, error-logging facilities, extensive internal checking circuits, and error checking and correction (ECC) circuits for main storage and control storage.
2. A console file, which provides a facility for loading control storage with either the System/370 microprogram, extensive microdiagnostics, or system tests.
3. An input/output display console and keyboard for operator communication with the system. The display console provides a fast means of displaying system status information and also provides the capability to select some aspects of the system environment at initial microprogram loading (IMPL) time.
4. Extended control-program support.
5. Control storage capacity that covers control storage requirements for the full line of Model 148 standard and optional features.

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day Clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode
- CPU timer
- Clock comparator
- Conditional swapping
- PSW key handling
- Channel indirect data addressing
- Error checking and correction (in main storage and control storage)
- Instruction retry
- Extended-precision floating point
- APL assist
- Extended control-program support
- Advanced control program support
- Console file
- Byte multiplexer channel (64 byte multiplexer subchannels)
- Block multiplexer channels (64 block multiplexer subchannels)
- Channel retry information
- Command retry
- Word buffer
- OS/DOS compatibility
- Audible alarm

Optional Features

- Direct control
- 1401/1440/1460 compatibility
- 1401/1440/1460, 1410/7010 compatibility
- Byte multiplexer subchannels (additional, for a total of 128 or 256)
- Block multiplexer subchannels (additional, for a total of 128, 256, or 512)
- Channel-to-channel adapter
- Emergency power-off control
- Integrated storage control with options
- Integrated 3203-4 Printer attachment

System Components

Processing Unit: IBM 3148 Processing Unit

Basic Machine Cycle Time: 180 to 270 nanoseconds (0.180 to 0.270 microsecond), depending on internal CPU operations.

Instruction Set: The System/370 universal instruction set and extended-precision floating-point feature are standard with the Model 148.

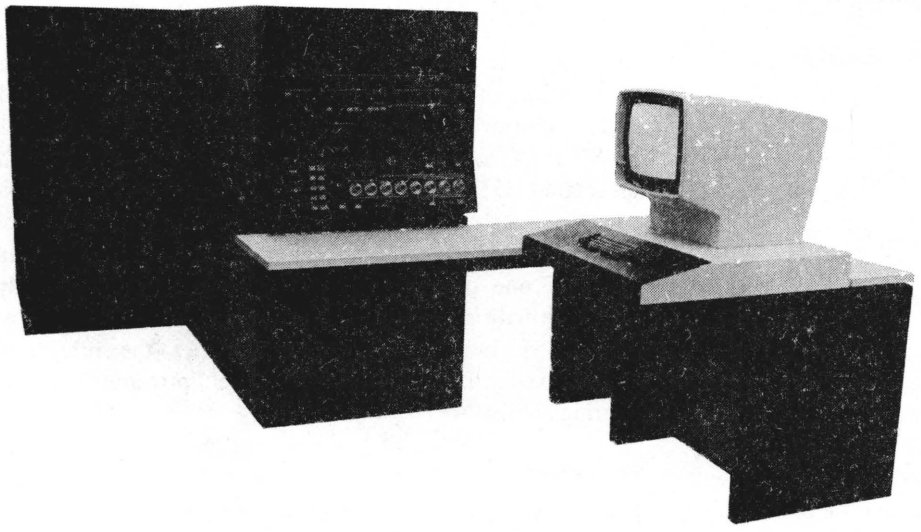


Figure 5-6. IBM System/370 Model 148 with Display Console and Keyboard

Instruction Retry: The ability to recover from many intermittent failures is provided through retry techniques performed by microprogram routines that save the source data before it is altered during an operation. When an error is detected, a microprogram returns the CPU to the beginning of the operation or to a point in the operation that was correctly executed, and the operation is continued.

Error Checking and Correction: For data read from main storage and control storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Advanced Control Program Support: This feature provides the following:

Compare and swap instructions
PSW key handling instructions
Clear I/O function

Extended Control-Program Support: This is a hardware assist that reduces the CPU time needed to execute certain supervisor functions in both VS1 and VM/370.

Monitoring: This feature provides a means of selectively recording events in the execution of a program.

Processor Storage: Part of 3148 Processing Unit

Processor Storage Capacities:

Capacity (Bytes)	*Model*
1,048,576	J
2,097,152	K

Storage Cycle Time: 405 nanoseconds for a main storage read and 540 nanoseconds for a main storage write.

Storage Access Width: Eight bytes (one doubleword) on instruction fetches.

Control Storage: Part of 3148 Processing Unit

Control Storage Access Time: 75 nanoseconds.

Control Storage Capacity: 128K (131,072 bytes).

Channels: Part of 3148 Processing Unit

One byte multiplexer channel and four block multiplexer channels are standard on the Model 148.

The byte multiplexer channel has 64 byte multiplexer subchannels, and additional subchannels can be added for a total of 128 or 256 subchannels.

The four block multiplexer channels have 64 nonshared subchannels as standard. Subchannels can be added for a system total of 128, 256, or 512. Each channel has the word buffer that increases channel data rate by allowing up to four bytes at a time to be transferred between the channel and processor storage.

System

The Model 148 system consists of:

IBM 3148 Processing Unit with attached display console and keyboard
IBM 3047 Power Unit Model 1
Appropriate input/output devices for a minimum or larger system configuration

System Control: The Model 148 is operated, monitored, and controlled through the system control panel on the CPU, and through the display console. An IBM 3287 Printer Model 1 or 2 can be attached, as a console printer, to the Model 148.

Console File: The console file, located under the operator's console table, is the initial microprogram loading (IMPL) device for the system. The file provides all microcode, on removable diskettes, for the system. Each diskette contains a full control storage load of system microcode. Diskettes supplied with the system provide the required microcode for system operation, emulators, diagnostics, and any other required microprogram material to be loaded into control storage.

Integrated 3203-4 Printer Attachment: This feature allows an IBM 3203 Printer Model 4 to be attached to the Model 148.

Compatibility Features: The compatibility features for the Model 148 are:

OS/DOS (standard)
1401/1440/1460
1401/1440/1460, 1410/7010

Integrated Storage Control: This feature permits the attachment of one or two 3333 units with associated 3330's, one or two 3340-A2 units with associated 3340-B1 or -B2 units, or one or two 3350-A2 or -A2F units with associated 3350-B2, -B2F, -C2, or -C2F units, for a maximum of eight drives per string. Up to two additional 3333/3330, 3340, or 3350 strings can be attached. Attachment of one or two 3340-A2's with 3344's is mutually exclusive with attachment of either 3333's or 3350-A2's or -A2F's. A two-channel switch attaches the integrated storage control to a second channel, providing channel sharing ability.

Programming Support

The Model 148 is supported by DOS/VS, OS/VS1, and VM/370.

System/370 Model 158

The System/370 Model 158 (Figure 5-7), with either the IBM 3158 Processing Unit or the extended-performance IBM 3158-3 Processing Unit, features monolithic processor storage and virtual storage capability, and provides both high performance and expanded capabilities for a variety of applications.

The Model 158 offers:

1. Processor storage, which uses compact, high-speed circuitry, and provides real storage capacities of 512K (524,288 bytes) to 6,144K (6,291,456 bytes).
2. Virtual storage capability, which permits users to program as though the system has use of up to 16.777,216 bytes of storage.
3. The System/370 extended feature, which is supported by the MVS/System Extensions program product, improves the execution of some of the functions of MVS, the operation of the translation lookaside buffer (TLB), and the protection of some of the storage locations used by the operating system.
4. High-speed buffer storage, which stores currently used sections of processor storage for faster accessing of data.
5. A display console, which provides a visual communication link with the system.
6. An attached processor capability, which, by means of the IBM 3052 Attached Processing Unit Model 1, increases the instruction execution rate of the system.
7. A multiprocessing capability, which increases flexibility and availability, permits the sharing of processor storage and I/O devices, and improves workload balance between the two processing units.
8. Retry facilities, which reattempt the execution of most failing instructions and channel commands.

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Channel indirect data addressing
Error checking and correction
Instruction retry
High-speed buffer storage
Reloadable control storage
Byte multiplexer channel (one)
Block multiplexer channels (two)
Channel retry information
Command retry
Asymmetric storage (most 3158-3 MP models)
Alternate power down (3158-3 MP models)
Service processor (SVP)
3056 Remote System Console (part of the SVP for the 3052 Attached Processing Unit Model 1)

Optional Features

System/370 extended
System/370 extended, additional
Extended-precision floating point
Direct control (with external interrupt)
OS/DOS compatibility
1401/1440/1460 and 1410/7010 compatibility

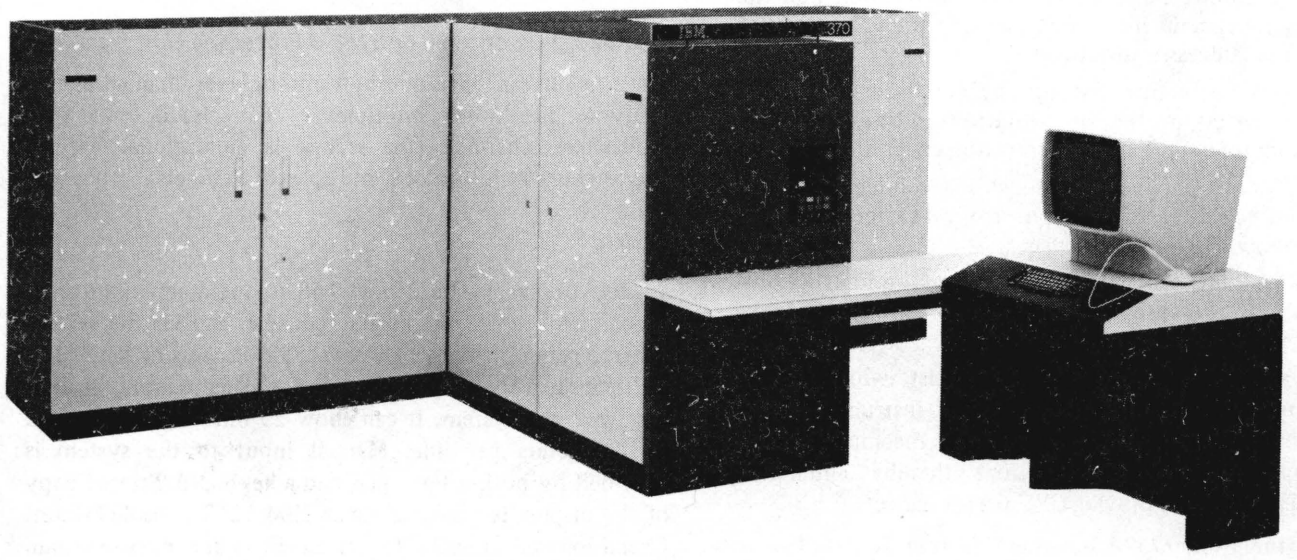


Figure 5-7. IBM System/370 Model 158 with Display Console

7070/7074 compatibility
Virtual machine assist
Power warning
Staging adapter
Block multiplexer channel (up to three more)
Byte multiplexer channel (one more, in place of a fourth block multiplexer channel)
Channel-to-channel adapter
Integrated storage controls
3056 Remote System Console (3158 and 3158-3)

System Components

Processing Unit: IBM 3158 or 3158-3 Processing Unit

Attached Processing Unit: IBM 3052 Attached Processing Unit Model 1

Basic Machine Cycle Time: 0.115 microsecond (115 nanoseconds).

Instruction Set: The System/370 universal instruction set is standard on the Model 158. Other standard instructions include those associated with the following features listed in the *IBM System/370 Principles of Operation,* GA22-7000: translation, CPU timer and clock comparator, conditional swapping, and PSW key handling. The multiprocessing feature instructions are part of the Model 158 attached processor system and the Model 158 multiprocessing system.

System/370 Extended: The System/370 extended feature, which is supported by the MVS/System Extensions program product, includes:

- Low-address protection, which improves system reliability, availability, and serviceability by increasing the protection of low-address main storage (addresses 0 through 511) vital to the system control program.
- The Invalidate Page Table Entry instruction and the common-segment bit, which increase the efficiency of dynamic address translation.
- The Test Protection instruction, which performs tests for potential protection violations without causing program interruptions for protection exceptions.
- The SVC Assist instruction, which reduces the time needed to enter MVS supervisory services, thereby improving CPU performance.
- The Fix Page instruction, the six tracing instructions, and the four lock-handling instructions, which improve CPU performance.
- Virtual-machine extended-facility assist, which permits the preceding 12 MVS/SE-dependent instructions to be executed directly by the virtual machine without requiring program interruptions thereby eliminating simulation and improving CPU performance.

When the System/370 extended feature is installed on each processor of the Model 158 attached processor (AP) or multiprocessor (MP) system, the System/370 extended, additional feature is also required.

Monitoring: Monitoring provides a means of selectively recording designated events in the execution of a program.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and usually reattempts its execution.

Error Checking and Correction: For data read from processor storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Processor Storage: Part of 3158 or 3158-3 Processing Unit

Processor Storage Capacities:

	158 Model Designation	
Capacity (Bytes)	*If 3158 Used*	*If 3158-3 Used*
524,288 (512K)	I, AP1, or MP1	U31, A31, or M31
1,048,576 (1,024K)	J, AP2, or MP2	U32, A32, or M32
1,572,864 (1,536K)	JI, AP3, or MP3	U33, A33, or M33
2,097,152 (2,048K)	K, AP4, or MP4	U34, A34, or M34
3,145,728 (3,072K)	KJ, AP5, or MP5	U35, A35, or M35
4,194,304 (4,096K)	L, AP6, or MP6	U36, A36, or M36
5,242,880 (5,120K)	LJ or AP7	U37, A37, or M37
6,291,456 (6,144K)	LK or AP8	U38, A38, or M38

Storage Access Width: 16 bytes (one quadword).

High-Speed Buffer Storage: The 8,192-byte buffer of the 3158, the 16,384-byte buffer of the 3158-3, and the 16,384-byte buffer of the 3052 can satisfy many requests for storage, making the effective storage access time much less than the actual processor-storage cycle time.

Channels: Part of 3158 or 3158-3 Processing Unit

The system can have one byte multiplexer channel and as many as five block multiplexer channels, or two byte multiplexer channels (the second as an optional feature) and as many as four block multiplexer channels.

System

System Control: The Model 158 is operated, monitored, and controlled via the display console, and via the system control panel on the 3158 or 3158-3 Processing Unit. The cathode-ray tube display provides a visual communication link with the system. It can show 25 lines per display and 80 characters per line. Manual input to the system is provided by both a light pen and a keyboard. Printed copy of the display is available via an IBM 3213 Console Printer. Execution of console functions is under microprogram control.

Remote Console: The IBM 3056 Remote System Console, an optional feature for the 3158 and 3158-3, is a stand-alone display and keyboard for the Model 158. The display and keyboard are identical to those on the 3158 and 3158-3. This console permits remote operation of the system up to 150 feet from the 3158 or 3158-3, thus providing increased flexibility in system configuration and operation.

Uniprocessing System: The Model 158 uniprocessing system consists of:

IBM 3158 or 3158-3 Processing Unit
Appropriate input/output devices for a minimum or larger system configuration

Attached Processor System: The Model 158 attached processor system consists of:

IBM 3158 AP-series or 3158-3 A-series Processing Unit
IBM 3052 Attached Processing Unit Model 1 (with an IBM 3056 Remote System Console attached for diagnostic use)
Appropriate input/output devices for a minimum or larger system configuration

The 3158 or 3158-3 Processing Unit and the 3052 Attached Processing Unit operate under a single system control program. The 3052 is an instruction processor that uses monolithic technology and contains an instruction execution unit and a buffer. A 3056 is attached to the 3052 as part of its service processor. (See "Service Processor" in this section.) The 3052 retains, in its buffer, data from processor storage of the 3158 or 3158-3, and works primarily with the buffer. The combined instruction processing capability of the 3158 or 3158-3 and the 3052 processors can increase system instruction execution rates beyond those of the uniprocessing system.

Multiprocessing System: The Model 158 multiprocessing system consists of:

Two IBM 3158 MP-series or 3158-3 M-series Processing Units
IBM 3058 Multisystem Unit
Appropriate input/output devices for a minimum or larger system configuration

The two multiprocessor processing units operate under a single system control program. These processing units share each other's processor storage and can also share input/output devices whose control units have two-channel switching capability. The IBM 3058 Multisystem Unit, located between the two processing units, enables intersystem communication. The 3058 also has configuration control facilities for selection of the mode of operation (MP or UP), assignment of storage addresses, and attachment of I/O control units having the remote switch attachment feature.

In a 3158 multiprocessing version, both processing units must have the same real storage capacity. In a 3158-3 multiprocessing version, the two processing units (except in Models M31 and M33) may have different real storage capacities. A multiprocessor model of a 3158 and one of a 3158-3 are compatible and can be interconnected in a multiprocessing configuration if each has the same real storage capacity, in which case alternate power down is not operational. A Model 158 multiprocessing system can have 8,388,608 bytes of processor storage.

Processing Unit Conversion: A 3158 can be field-converted to a 3158-3.

Compatibility Features: The compatibility features available for the Model 158 are:

OS/DOS
1401/1440/1460, 1410/7010
7070/7074

Integrated Storage Controls: The integrated storage controls (ISC) feature provides dual storage controls (paths), each of which can attach up to four of the following: IBM 3333 Disk Storage and Control units (with associated 3330 drives), IBM 3340-A2 Direct Access Storage Facility units (with associated 3340-B1, 3340-B2, 3344-B2, or 3344-B2F models), or IBM 3350-A2 or 3350-A2F Direct Access Storage units (with associated 3350-B2, 3350-B2F, 3350-C2, or 3350-C2F models). If ISC control store extension, 32-drive expansion, and 3333/3340 intermix features are installed, any combination of up to four 3333's with 3330's or 3340-A2's with 3340-B1's or 3340-B2's can be attached to each control of the ISC (permitting attachment of up to 32 drives for each). A two-channel switch attaches an integrated storage control to a second channel, thus providing channel sharing ability.

Staging Adapter for ISC: The staging adapter for the ISC feature provides for direct attachment to a Model 158 of one or two IBM 3851 Mass Storage Facilities and up to four IBM 3333 Disk Storage and Control units and their associated 3330 drives to each path of the ISC (maximum 32 drives per path) in a mass storage system configuration. Sixteen of the disk drives (Model 1 or 2) or eight of the disk drives (Model 11) can be used as staging drives. This feature precludes attachment of 3340 Direct Access Storage units.

Service Processor: The service processor (SVP) is a functionally separate realtime monitor that improves serviceability and availability in the Model 158. The 3158 or 3158-3 has a service processor in the system console. The display and keyboard of the system console are part of this SVP. The attached processor system has an additional service processor in the 3052. The display and keyboard of the 3056 that is attached to the 3052 are part of this SVP.

Programming Support

The Model 158 is supported by DOS/VS, OS/VS1, OS/VS2, MVS/System Extensions program product (for the System/370 extended feature), and VM/370, as well as OS/MFT and OS/MVT. The Model 158 attached processor system is supported by the latest release level of OS/VS2 modified by a selectable unit (SU). The Model 158 multiprocessing system, when operating in MP mode, is supported by OS/VS2 Releases 2 and 3.

System/370 Model 168

The System/370 Model 168 (Figure 5-8), with either the IBM 3168 Processing Unit or the IBM 3168-3 Processing Unit, is designed for large-scale, high-speed scientific and commercial applications.

The Model 168 offers:

1. Integrated monolithic processor storage, which provides real storage capacities of 1,024K (1,048,576 bytes) to 8,092K (8,388,608 bytes).
2. Virtual storage capability, which permits users to program as though the system has use of as many as 16,777,216 bytes of processor storage.
3. The System/370 extended feature, which is supported by the MVS/System Extensions program product, improves the execution of some of the functions of MVS, the operation of the translation lookaside buffer (TLB), and the protection of some of the storage locations used by the operating system.
4. High-speed buffer storage, which can sharply reduce the time required for fetching currently used sections of processor storage.
5. Instruction retry and processor storage error checking and correction (ECC), which improve operations.
6. An attached processor capability in the 3168-3, which, by means of the IBM 3062 Attached Processing Unit, increases the instruction execution rate of the system.
7. A multiprocessing capability, which increases flexibility and availability, permits the sharing of processor storage and I/O devices, and improves workload balance between the two processing units.

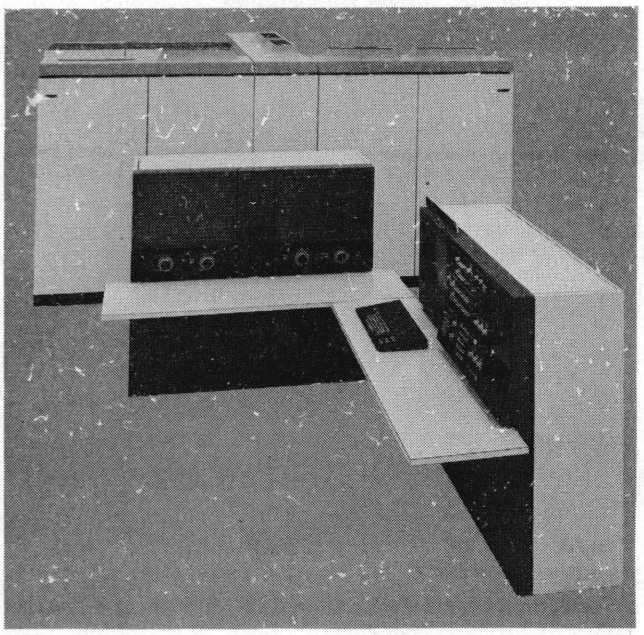


Figure 5-8. IBM System/370 Model 168 with IBM 3066 System Console

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

CPU timer
Clock comparator
Error checking and correction
Instruction retry
Extended-precision floating point (with rounding)
High-speed buffer storage
Writable control storage
Channel retry
Command retry
Direct control (with external interrupt)
Channel reconfiguration (MP models)
Service processor (SVP) (3168-3)

Optional Features

System/370 extended
Channel indirect data addressing
Buffer expansion (3168)
High-speed multiply
7070/7074 compatibility
7080 compatibility
709/7090/7094/7094II compatibility
2860 Selector Channel (as many as six units, providing as many as six selector channels)
2870 Multiplexer Channel (as many as two byte- multiplexer channels)
Selector subchannels (as many as four on each 2870)
2880 Block Multiplexer Channel (as many as six) (with the extended channels feature, as many as seven units, providing as many as 11 block multiplexer channels)
Extended channels feature (see channel attachment chart)
Channel-to-channel adapter (for 2860 and 2880)
Two-byte interface (for 2880)
Integrated storage controls
Power warning
Staging adapter
3213 Printer attachment (3168-3)

System Components

Processing Unit: 3168 or 3168-3 Processing Unit

Attached Processing Unit: IBM 3062 Attached Processing Unit Model 1

Basic Machine Cycle Time: 0.08 microsecond (80 nanoseconds).

Instruction Set: The System/370 universal instruction set is standard on the Model 168. Other standard instructions include those associated with the following features listed in the *IBM System/370 Principles of Operation*, GA22-7000: extended-precision floating point, translation, CPU timer and clock comparator, conditional swapping, and PSW key handling. The direct control feature and

associated instructions are standard on the 3168 and the 3168-3. The multiprocessing feature instructions are part of the Model 168 attached processor system and the Model 168 multiprocessing system.

High-Speed Multiply: This feature substantially enhances internal performance on both fixed- and floating-point multiply operations by reducing multiplication time by one-half to one-third.

System/370 Extended: The System/370 extended feature, which is supported by the MVS/System Extensions program product, includes:

- Low-address protection, which improves system reliability, availability, and serviceability by increasing the protection of low-address main storage (addresses 0 through 511) vital to the system control program.
- The Invalidate Page Table Entry instruction and the common-segment bit, which increase the efficiency of dynamic address translation.
- The Test Protection instruction, which performs tests for potential protection violations without causing program interruptions for protection exceptions.
- The SVC Assist instruction, which reduces the time needed to enter MVS supervisory services, thereby improving CPU performance.
- The Fix Page instruction, the six tracing instructions, and the four lock-handling instructions, which improve CPU performance.
- Virtual-machine extended-facility assist, which permits the preceding 12 MVS/SE-dependent instructions to be executed directly by the virtual machine without requiring program interruptions thereby eliminating simulation and improving CPU performance.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and in most cases reattempts its execution.

Error Checking and Correction: For data read from processor storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Processor Storage: Part of 3168 or 3168-3 Processing Unit

Processor Storage Capacities:

Capacity (Bytes)	*168 Model Designation*	
	If 3168 Used	*If 3168-3 Used*
1,048,576 (1,024K)	J or MP1	U31, A31, or M31
2,097,152 (2,048K)	K or MP2	U32, A32, or M32
3,145,728 (3,072K)	KJ or MP3	U33, A33, or M33
4,194,304 (4,096K)	L or MP4	U34, A34, or M34
5,242,880 (5,120K)	LJ or MP5	U35, A35, or M35
6,291,456 (6,144K)	LK or MP6	U36, A36, or M36
7,340,032 (7,168K)	LKJ or MP7	U37, A37, or M37
8,388,608 (8,192K)	M or MP8	U38, A38, or M38

Storage Cycle Time: 0.32 microsecond (320 nanoseconds).

Storage Access Width: 8 bytes (one doubleword).

Storage Interleaving: Four-way.

High-Speed Buffer Storage: The effective storage cycle time in the 3168 is reduced by using an 8K buffer storage. With the optional buffer expansion feature installed, the 3168 buffer storage capacity is increased to 16K. The 3168-3 and 3062 each have a 32K high-speed buffer storage.

Channels: IBM 2860 Selector Channel Models 1-3, 2870 Multiplexer Channel, and 2880 Block Multiplexer Channel Models 1 and 2

Channels may be attached to the processing unit as follows:

Maximum Number of Channels or Channel Units	*Without Extended Channels Feature*	*With Extended Channels Feature*
Channel Units (Frames)	7	7
Channels	7	12

Maximum Number of Channels or Channel Units	*Without Extended Channels Feature*	*With Extended Channels Feature*
Byte Multiplexer Channels	2	2
Block Multiplexer Channels	6	11
Selector Channels	6	6
Byte Multiplexer and Selector Channels	7	7
Byte and Block Multiplexer Channels	7	12

Two-Byte Interface: This feature permits a 2880 Block Multiplexer Channel to transfer data at rates as high as three million bytes per second.

System

System Control: The system controls are located on the standalone IBM 3066 System Console. Here, through a keyboard, a console (CRT) display, and a system control panel, the operator may enter data, obtain visual output, be alerted by an audible alarm, or interact with the system, for example, by presenting an attention signal.

Uniprocessing System: The Model 168 uniprocessing system consists of:

- IBM 3168 Model J, K, KJ, L, LJ, LK, LKJ, or M or 3168-3 U-series Processing Unit
- IBM 3066 System Console Model 2
- IBM 3067 Power and Coolant Distribution Unit (Model 2 for the 3168 and Model 3 for the 3168-3)
- Channels (one or more 2860 Selector Channels, 2870 Multiplexer Channels with one selector subchannel, or 2880 Block Multiplexers) Channels
- Appropriate input/output devices for a minimum or larger system configuration

Attached Processor System: The Model 168 attached processor system consists of:

- IBM 3168-3 A-series Processing Unit
- IBM 3062 Attached Processing Unit Model 1
- IBM 3066 System Console Model 3 (allows diagnostic or system activity choices for either processing unit)
- IBM 3067 Power and Coolant Distribution Units (one Model 3 for the 3168-3 and one Model 5 for the 3062)
- Channels (one or more 2860 Selector Channels, 2870 Multiplexer Channels with one selector subchannel, or 2880 Block Multiplexers Channels)
- Appropriate input/output devices for a minimum or larger system configuration

The 3168-3 Processing Unit and the 3062 Attached Processing Unit operate under a single system control program. The 3062 is an instruction processor using monolithic system technology that attaches to and works only with the 3168-3. The combined instruction processing capability of the two processors can increase system instruction execution rates beyond those of the uniprocessing system. The 3062 achieves high performance by retaining processor storage data on which it is currently operating in its own 32K buffer and by working primarily with the buffer. This reduces effective storage cycle time. The system channels attach only to the 3168-3.

Multiprocessing System: The Model 168 multiprocessing system consists of:

- IBM 3168 MP-series or 3168-3 M-series Processing Units
- IBM 3066 System Console Model 2 (one for each processor)
- IBM 3067 Power and Coolant Distribution Units (one Model 2 for the 3168 and one Model 3 for the 3168-3)
- IBM 3068 Multisystem Communication Unit
- Channels (one or more 2860 Selector Channels, 2870 Multiplexer Channels with one selector subchannel, or 2880 Block Multiplexer Channels for each processor)
- Appropriate input/output devices for a minimum or larger system configuration

The two processors operate under a single system control program. These processors, which need not have the same processor storage capacities, share each other's processor storage and can also share input/output devices whose control units have two-channel switching capability. The 3068 Multisystem Communication Unit, located between the processors, provides for intersystem communication. The 3068 also has configuration control facilities for selection of the mode of operation (MP or UP), assignment of storage addresses, and attachment of I/O control units having the remote switch attachment feature.

The 3168 Processing Unit MP-series and the 3168-3 Processing Unit M-series are compatible and may be interconnected in the multiprocessing configuration.

Processing Unit Conversion: The 3168 Processing Unit can be field upgraded as follows:

- 3168 Models J-M to a 3168 MP-series Processing Unit or to a 3168-3 U-series, A-series, or M-series Processing Unit

All conversions require appropriate changes and additions to the associated 3066 System Console and the 3067 Power and Coolant Distribution Unit.

Compatibility Features: The compatibility features available for the 3168 and the 3168-3 are:

7070/7074
7080
709/7090/7094/7094 II

Integrated Storage Controls: The integrated storage controls (ISC) feature provides dual storage controls (paths), each of which can attach up to four IBM 3333 Disk Storage and Control units (with associated 3330 drives), 3340-A2 Disk Storage units (with associated 3340-B1, 3340-B2, 3344-B2, or 3344-B2F models), or 3350-A2 or 3350-A2F Direct Access Storage units (with associated 3350-B2 or 3350-B2F models). If ISC control store extension, 32-drive expansion, and 3333/3340 intermix features are installed, any combination of up to four 3333's with 3330's or 3340-A2's with 3340-B1's or -B2's can be attached to each control of the ISC (permitting attachment of up to 32 drives per path). A two-channel switch attaches an integrated storage control to a second channel, thus providing channel sharing ability.

Staging Adapter for ISC: The staging adapter for the ISC feature provides for direct attachment to a Model 168 of one or two IBM 3851 Mass Storage Facilities and up to four IBM 3333 Disk Storage and Control units and their associated 3330 drives to each path of the ISC (maximum 32 drives per path) in a mass storage system configuration. Sixteen of the disk drives (Models 1 or 2) or eight of the disk drives (Model 11) can be used as staging drives. This feature precludes attachment of 3340 Direct Access Storage units.

Service Processor: In a Model 168 uniprocessing or multiprocessing system, the 3168-3 has a service processor (SVP), a functionally separate realtime monitor to improve serviceability and availability.

In a Model 168 attached processor system, the 3062 has a realtime monitor that provides additional input to the service processor of the 3168-3 Processing Unit.

Programming Support

The Model 168 is supported by OS/VS1, OS/VS2, MVS/System Extensions program product (for the System/370 extended feature), and VM/370, as well as OS/MFT and OS/MVT. The Model 168 multiprocessing system, when operating in MP mode, is supported by OS/VS2 Releases 2 and 3. The Model 168 attached processor system is supported by the latest level of OS/VS2 Release 3.

IBM 3031 Processor Complex
IBM 3031 Attached Processor Complex

The IBM 3031 Processor Complex (Figure 5-9) and the IBM 3031 Attached Processor Complex are designed for both commercial and scientific applications.

The 3031 Processor Complex offers:

1. A performance level, which is greater than that of the System/370 Model 148 when operating in the same configuration under identical programming. This increased performance results from the faster basic machine cycle time, the use of high-speed buffer storage, and the improved internal hardware design of the 3031 Processor.
2. Integrated monolithic processor storage, which provides capacities of 2M bytes (2,097,152) to 6M bytes (6,291,456) in 1M-byte (1,048,576) increments.
3. Virtual storage, which permits the user to program as though the system has use of as many as 16,777,216 bytes of processor storage.
4. The System/370 extended facility, which is supported by the MVS/System Extensions program product, improves the execution of some of the functions of MVS, the operation of the translation lookaside buffer (TLB), and the protection of some of the storage locations that are used by the operating system.
5. Channels within the processor, which keep power, space, and cooling requirements at a minimum.
6. A console with an operator panel and two operating stations, which are individually addressable for system operation or service support.
7. Instruction retry and processor storage error checking and correction (ECC), which improve operations.

The IBM 3031 Processor Complex consists of:

IBM 3031 Processor Model 2, 3, 4, 5, or 6
IBM 3036 Console Model 1
IBM 3017 Power Unit Model 1

The IBM 3031 Attached Processor Complex offers all of the features of the 3031 Processor Complex and an increase in the combined rate of instruction execution by means of the IBM 3041 Attached Processor.

The 3031 Attached Processor Complex consists of:

IBM 3031 Processor Model A2, A3, A4, A5, or A6
IBM 3041 Attached Processor Model 1
IBM 3036 Console Model 1
IBM 3017 Power Unit Model 1 (one for the 3031 Processor and one for the 3041 Attached Processor)

Plan views of the 3031 Processor Complex and 3031 Attached Processor Complex are shown in Figure 5-10.

IBM 3031 Processor

The IBM 3031 Processor, which has a basic machine cycle time of 115 nanoseconds, provides arithmetic and control functions, processor storage with a high-speed buffer, and channels for the 3031 Processor Complex.

Processor Storage: Part of 3031 Processor

Processor storage has a storage cycle time of 345 nanoseconds and a storage access width of eight bytes. The four-way interleaved operation of processor storage permits effective reduction of the storage cycle time.

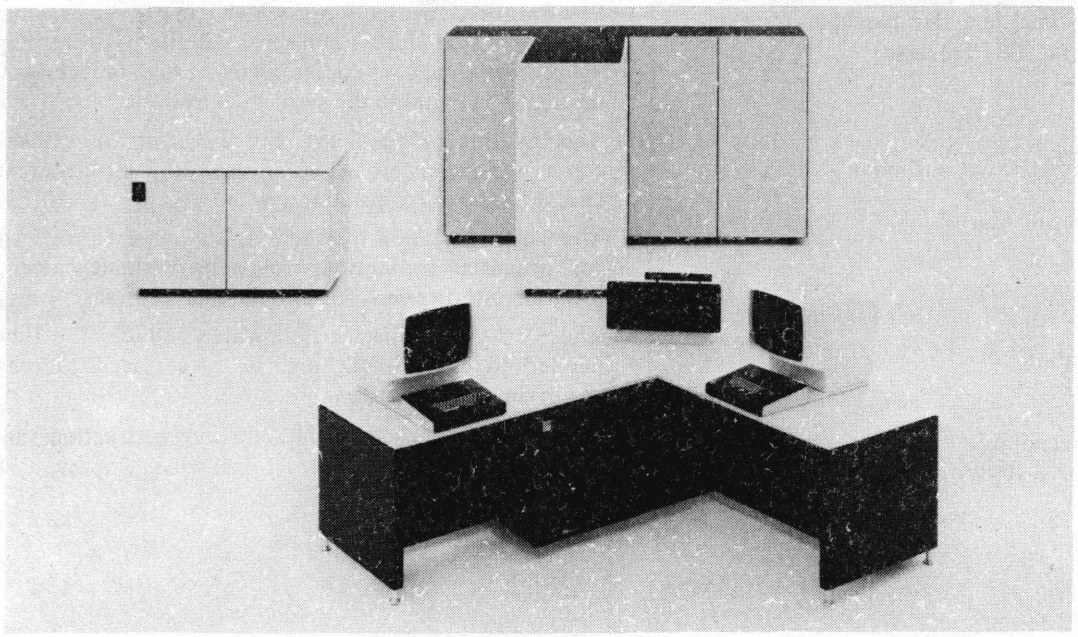
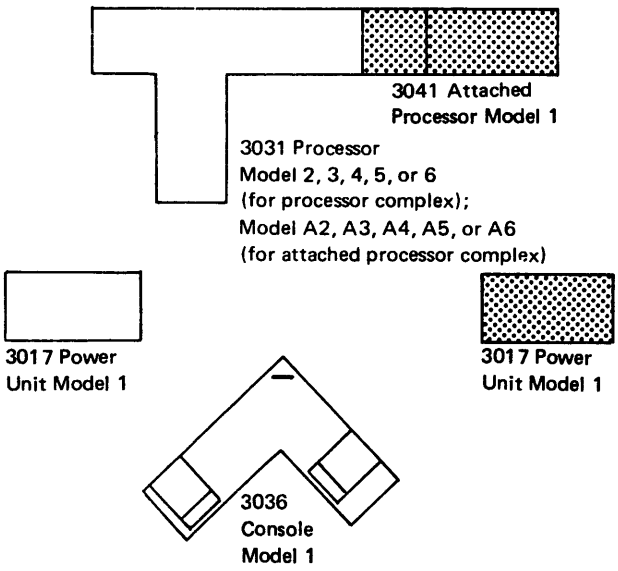


Figure 5-9. IBM 3031 Processor Complex (Design Model)



Note: The processor complex includes only nonshaded elements; the attached processor complex includes all elements.

Figure 5-10. Representative Plan Views of the 3031 Processor Complex and 3031 Attached Processor Complex

Processor Storage Capacities:

Capacity (Bytes)	*3031 Processor Model Designation*
2,097,152 (2M)	2, A2
3,145,728 (3M)	3, A3
4,194,304 (4M)	4, A4
5,242,880 (5M)	5, A5
6,291,456 (6M)	6, A6

Channels: Part of 3031 Processor

One byte multiplexer channel and five block multiplexer channels are standard on the 3031 Processor.

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

Extended-precision floating point
Multiprocessing feature instructions (A-series models)
CPU timer
Clock comparator
Conditional swapping
PSW key handling
System/370 extended facility
Error checking and correction
Instruction retry
Processor storage
High-speed buffer storage
OS/VS1 ECPS (extended control-program support)
Virtual machine assist
Reloadable control storage (RCS)
Storage configuration control
Byte multiplexer channel
Block multiplexer channels (five)
Channel indirect data addressing
Limited channel logout
I/O extended logout
Channel retry
Command retry (block multiplexer channels)
Start I/O fast release
Clear I/O

Instruction Set: The System/370 universal instruction set is standard on the 3031 Processor. Other standard instructions include those associated with the following features listed in the *IBM System/370 Principles of Operation,* GA22-7000: extended-precision floating point, translation, CPU timer, clock comparator, conditional swapping, and PSW key handling.

The multiprocessing feature instructions signal processor, set prefix, store prefix, and store CPU address are associated with the multiprocessing function of the 3031 Attached Processor Complex.

System/370 Extended Facility: The System/370 extended facility, which is supported by the MVS/System Extensions program product, includes:

- Low-address protection, which improves system reliability, availability, and serviceability by increasing the protection of low-address main storage (addresses 0 through 511) vital to the system control program.
- The Invalidate Page Table Entry instruction and the common-segment bit, which increase the efficiency of dynamic address translation.
- The Test Protection instruction, which performs tests for potential protection violations without causing program interruptions for protection exceptions.
- The SVC Assist instruction, which reduces the time needed to enter MVS supervisory services, thereby improving CPU performance.
- The Fix Page instruction, the six tracing instructions, and the four lock-handling instructions, which improve CPU performance.

- Virtual-machine extended-facility assist, which permits the preceding 12 MVS/SE-dependent instructions to be executed directly by the virtual machine without requiring program interruptions thereby eliminating simulation and improving CPU performance.

Error Checking and Correction: For data read from processor storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and usually reattempts its execution.

High-Speed Buffer Storage: The 32,768-byte buffer storage of the 3031 can satisfy many requests for storage, making the effective storage access time much less than the actual processor-storage cycle time.

OS/VS1 ECPS (Extended Control-Program Support): OS/VS1 ECPS assists OS/VS1 by emulating certain supervisor functions.

Virtual Machine Assist: Virtual machine assist (VMA) helps virtual storage operating systems that operate under VM/370 by emulating certain privileged operations.

Reloadable Control Storage (RCS): Basic control and diagnostic microprograms are loaded into RCS from a diskette drive either by a power-on sequence or by pressing the IMPL pushbutton on the console operator panel.

Storage Configuration Control: Storage configuration control permits processor storage to be configured from the console in 1M-byte (1,048,576) increments.

Channel Indirect Data Addressing: This feature provides a means of translating data addresses for I/O operations in a virtual storage system.

Limited Channel Logout: This feature permits storage of channel error information in fixed locations for use by error-recovery routines.

I/O Extended Logout: This feature allows storing channel error information in an area designated by a pointer. Extensive status information is then available to error-recovery routines.

Channel Retry: When a channel error occurs, this feature permits storage of retry data for subsequent use by the error-recovery routines to retry the operation.

Command Retry: This channel and control unit procedure causes an improperly executed command in a channel program to be retried automatically.

Start I/O Fast Release: This feature provides for early release of the processor by a channel during execution of the start I/O fast release instruction.

Clear I/O: This feature provides the CLRIO function called for by the privileged instruction clear I/O (CLRIO).

Optional Features

Direct control
Channel-to-channel adapter

Direct Control: Direct control provides two instructions and six external interruption lines that permit the transfer of control information either between the 3031 and another processor or between the 3031 and external devices.

Channel-to-Channel Adapter: This feature provides a path for, and synchronizes, data transfer between two channels on the 3031 or between a channel on the 3031 and a channel on another processor.

IBM 3041 Attached Processor

The IBM 3041 Attached Processor, which has a basic machine cycle time of 115 nanoseconds, provides arithmetic and control functions that work with those of the 3031 Processor to increase the combined rate of instruction execution. The 3041 and 3031 operate together under a single control program. The 3041 has its own 32,768-byte buffer and accesses processor storage, which is part of the 3031 Processor.

For a description of the standard and optional features, see "IBM 3031 Processor."

Standard Features

System/370 universal instruction set (except I/O), including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval Timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

Multiprocessing feature instructions
Extended-precision floating point
CPU timer
Clock comparator
Conditional swapping
PSW key handling
System/370 extended facility
Error checking and correction

Instruction retry
High-speed buffer storage
OS/VS1 ECPS (extended control-program support)
Virtual machine assist
Reloadable control storage (RCS)

Optional Feature

Direct control

IBM 3036 Console Model 1

The 3031 Processor in a 3031 Processor Complex, and the 3031 Processor with the 3041 Attached Processor in a 3031 Attached Processor Complex are operated, monitored, controlled, and serviced through the IBM 3036 Console Model 1. The 3036 has an operator panel and two operating stations. Each station consists of a display, which can show as many as 25 lines of 80 characters per line; a keyboard; a station processor; and a diskette drive. Each station is addressable so that it can be designated as either the operator station or the service support station.

A console security keylock is provided on the right side of each display:

1. With the key turned to the horizontal position, an initial microprogram load (IMPL) and normal display functions can be performed.
2. With the key turned to the vertical position, an IMPL cannot be performed. Any effort to change the frame that is presented on either display causes an alarm to sound.

IBM 3017 Power Unit

The IBM 3017 Power Unit Model 1 is a motor generator that produces 208 V ac, 415 Hz. One 3017 is required for the 3031 Processor in a 3031 Processor Complex; an additional 3017 is required for the 3041 Attached Processor in a 3031 Attached Processor Complex.

Programming Support

Programming support for the 3031 Processor Complex or the 3031 Attached Processor Complex running in uniprocessor mode includes:

- SVS (Single Virtual Storage)
- MVS (Multiple Virtual Storage)
- MVS/System Extensions program product
- VM/370 (Virtual Machine Facility/370)
- VM/System Extensions program product
- OS/VS1 (Operating System/Virtual Storage 1)
- DOS/VS (Disk Operating System/Virtual Storage)

Programming support for the 3031 Attached Processor Complex running in attached processor mode with the 3041 Attached Processor includes:

- MVS (OS/VS2)
- MVS/System Extensions program product
- VM/370 (Virtual Machine Facility/370)
- VM/System Extensions program product

IBM 3032 Processor Complex

The IBM 3032 Processor Complex (Figure 5-11), which is designed for both commercial and scientific applications, is part of System/370 and consists of:

IBM 3032 Processor
IBM 3036 Console Model 1
IBM 3027 Power and Coolant Distribution Unit Model 1

The 3032 Processor Complex offers:

1. A performance level, which is greater than that of the System/370 Model 158 with the 3158-3 when operating in the same configuration under identical programming. This increased performance results from the faster basic machine cycle time and from the improved internal hardware design of the 3032 Processor.
2. Integrated monolithic processor storage, which provides capacities of 2M (2,097,152 bytes), 4M (4,194,304 bytes), and 6M (6,291,456 bytes).
3. Virtual storage, which permits users to program as though the system has use of as many as 16,777,216 bytes of processor storage.
4. The System/370 extended facility, which is supported by the MVS/System Extensions program product, improves the execution of some of the functions of MVS, the operation of the translation lookaside buffer (TLB), and the protection of some of the storage locations that are used by the operating system.
5. Channels within the processor, which keep power, space, and cooling requirements at a minimum.
6. High-speed buffer storage, which stores currently used sections of processor storage for faster accessing of data.
7. A console with an operator panel and two operating stations, which permits system operation concurrent with maintenance activity.
8. Instruction retry and processor storage error checking and correction (ECC), which improve operations.

IBM 3032 Processor

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode

Extended-precision floating point
Direct control (including external interrupt)
CPU timer
Clock comparator
Conditional swapping
PSW key handling
Clear I/O
Channel indirect data addressing
System/370 extended facility
Error checking and correction
Instruction retry
High-speed buffer storage
Storage configuration control
Byte multiplexer channel
Block multiplexer channels (five)
Channel retry
Command retry (block multiplexer channels)

Figure 5-11. IBM 3032 Processor Complex (Design Model)

Optional Features

Extended channels (one group that includes one byte multiplexer channel and five block multiplexer channels)
Channel-to-channel adapter
Two-byte channel interface

Basic Machine Cycle Time: 0.08 microsecond (80 nanoseconds).

Instruction Set: The System/370 universal instruction set is standard on the 3032 Processor. Other standard instructions include those associated with the following features listed in the *IBM System/370 Principles of Operation,* GA22-7000: extended-precision floating point, translation, CPU timer, clock comparator, conditional swapping, PSW key handling, and direct control.

Monitoring: Monitoring provides a means of selectively recording designated events in the execution of a program.

Direct Control: Direct control provides two instructions and six external interruption lines that permit the transfer of control information either between the 3032 and another processor or between the 3032 and external devices.

System/370 Extended Facility: The System/370 extended facility, which is supported by the MVS/System Extensions program product, includes:

- Low-address protection, which improves system reliability, availability, and serviceability by increasing the protection of low-address main storage (addresses 0 through 511) vital to the system control program.
- The Invalidate Page Table Entry instruction and the common-segment bit, which increase the efficiency of dynamic address translation.
- The Test Protection instruction, which performs tests for potential protection violations without causing program i nterruptions for protection exceptions.
- The SVC Assist instruction, which reduces the time needed to enter MVS supervisory services, thereby improving CPU performance.
- The Fix Page instruction, the six tracing instructions, and the four lock-handling instructions, which improve CPU performance.
- Virtual-machine extended-facility assist, which permits the preceding 12 MVS/SE-dependent instructions to be executed directly by the virtual machine without requiring program interruptions thereby eliminating simulation and improving CPU performance.

Error Checking and Correction: For data read from processor storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and usually reattempts its execution.

Processor Storage: Part of 3032 Processor

Processor Storage Capacities:

Capacity (Bytes)	*3032 Processor Designation*
2,097,152 (2M)	2
4,194,304 (4M)	4
6,291,456 (6M)	6

Storage Cycle Time: 0.320 microsecond (320 nanoseconds).

Storage Access Width: Eight bytes (one doubleword).

Storage Interleaving: Four way.

High-Speed Buffer Storage: The 32,768-byte buffer storage of the 3032 can satisfy many requests for storage, making the effective storage access time much less than the actual processor-storage cycle time.

Channels: Part of 3032 Processor

One byte multiplexer channel and five block multiplexer channels are standard on the 3032 Processor.

Extended Channels: This feature provides an additional group of channels that includes one byte multiplexer channel and five block multiplexer channels.

Channel Indirect Data Addressing: This feature provides a means of translating data addresses for I/O operations in a virtual storage system.

Channel Retry: When a channel operation fails, this feature permits storage of retry data for subsequent use by the error-recovery routines to retry the operation.

Command Retry: A channel and control unit procedure that causes an improperly executed command in a channel program to be automatically retried.

Channel-to-Channel Adapter: This feature provides a path for, and synchronizes, data transfer between two channels on the 3032 or between a channel on the 3032 and a channel on another processor.

Two-Byte Channel Interface: This feature allows for an increase in the data transfer rate to as high as 3 megabytes per second for the first block multiplexer channel of a group of channels.

IBM 3036 Console

The 3032 Processor is operated, monitored, controlled, and serviced through the IBM 3036 Console Model 1. The 3036 has an operator panel and two operating stations. Each station consists of a display, which can show as many as 25 lines of 80 characters per line; a keyboard; a console processor; and a diskette drive. Each station is addressable so that it can be designated as either the operator console or the service support console.

A console security keylock is provided on the right side of each display:

1. With the key turned to the horizontal position, an initial microprogram load (IMPL) and normal display functions can be performed.
2. With the key turned to the vertical position, an IMPL cannot be performed. Any effort to change the frame that is presented on either display causes an alarm to sound.

IBM 3027 Power and Coolant Distribution Unit

The IBM 3027 Power and Coolant Distribution Unit Model 1 provides control for the distribution of power and coolant to the 3032 Processor Complex.

Programming Support

The 3032 Processor, except for the System/370 extended facility, is supported by VM/370, OS/VS1, and OS/VS2 (SVS and MVS). Support of the extended facility under MVS requires MVS/System Extensions program product.

IBM 3033 Processor Complex
IBM 3033 Multiprocessor Complex

The IBM 3033 Processor Complex (Figure 5-12) and the IBM 3033 Multiprocessor Complex (Figure 5-13), which are designed for large-scale, high-speed scientific and commerical applicications, offer:

1. A performance level, which is greater than that of the System/370 Model 168 with the 3168-3 when operating in the same configuration under identical programming. This increased performance results from the faster basic machine cycle time and from the improved internal hardware design of the 3033 Processor.
2. Integrated monolithic processor storage, which provides real storage capacities of up to 8M bytes (8,388,608) in the 3033 Processor Complex, and up to 16M bytes (16,777,216) in the 3033 Multiprocessor Complex by sharing processor storage.
3. Virtual storage, which permits users to program as though the system has use of as many as 16,777,216 bytes of processor storage.
4. The System/370 extended facility, which, supported by the MVS/System Extensions program product, improves the execution of some of the functions of MVS, the operation of the translation lookaside buffer (TLB), and the protection of some of the storage locations that are used by the operating system.
5. Integrated channels, which reduce power, space, and cooling requirements over a similarly configured Model 168.
6. A console with an operator panel and two operating stations, which permit system operation concurrent with maintenance activity. The processor complex has one console, and the multiprocessor complex has two consoles.
7. Instruction retry and processor storage error checking and correction (ECC), which improve operations.
8. High-speed buffer storage, which stores currently used sections of processor storage for faster accessing of data.

The IBM 3033 Processor Complex consists of:
IBM 3033 Processor U-series model
IBM 3036 Console Model 1
IBM 3037 Power and Coolant Distribution Unit Model 1

The IBM 3033 Multiprocessor Complex consists of:
IBM 3033 Processor (two M-series models)
IBM 3036 Console Model 1 (one for each processor)
IBM 3037 Power and Coolant Distribution Unit Model 1 with the multiprocessing feature (one for each processor)
IBM 3038 Multiprocessor Communication Unit Model 1

Note: The 3033 Processor U-series models can be field converted to the M-series models.

The two processors of a 3033 Multiprocessor Complex, which operate under one control program, can share each other's processor storage.

Power boundaries, alternate CPU recovery (ACR) of MVS, and channel-set switching enable the 3033 Multiprocessor Complex to provide greater availability than the 3033 Processor Complex.

Power boundaries permit elements that have been logically configured out of the system (by the VARY command) to be physically varied offline, repaired, tested, and placed back online. This activity may require a reIPL of the system.

Alternate CPU recovery (ACR) of MVS permits the functioning processor to attempt the recovery of work in process on the failing processor.

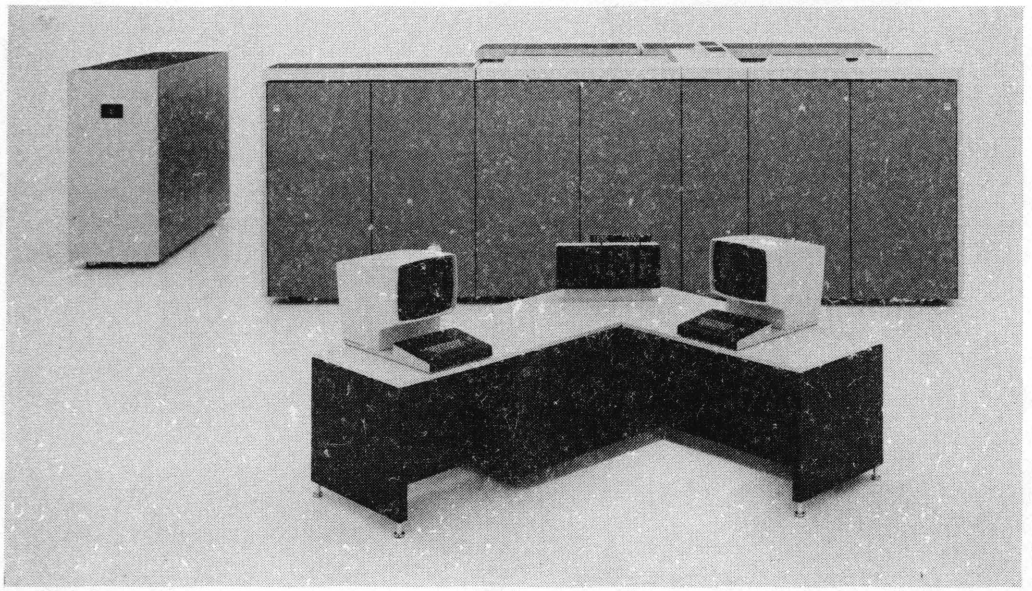


Figure 5-12. IBM 3033 Processor Complex (Design Model)

In MP mode, as an aid to recovery, channel-set switching permits the channel controls of the failing processor to be shared alternately with the channel controls of the functioning processor. Channel-set switching operates under program control without an IPL through the channel reconfiguration hardware (CRH) function of MVS.

IBM 3033 Processor

The IBM 3033 Processor, which has a basic machine cycle time of 57 nanoseconds, provides arithmetic and control functions, processor storage with high-speed buffer, and channels for the 3033 Processor Complex and the 3033 Multiprocessor Complex.

Processor Storage: Part of 3033 Processor

Processor storage has a storage cycle time of 348 nanoseconds and a storage access width of eight bytes. The eight-way interleaved operation of processor storage permits effective reduction of the storage cycle time.

Processor Storage Capacities:

Capacity (Bytes)	*3033 Processor Model*
4,194,304 (4M)	U4 M4
6,291,456 (6M)	U6 M6
8,388,608 (8M)	U8 M8

Channels: Part of 3033 Processor

Twelve channels (two groups, each containing one byte multiplexer channel and five block multiplexer channels) are standard on the 3033 Processor.

Standard Features

System/370 universal instruction set, including:
- Byte-oriented operand
- Key-controlled storage protection
- Interval timer
- Time-of-day clock
- Monitoring

Translation, including:
- Dynamic address translation
- Program event recording
- Extended control mode
- Extended-precision floating point
- Direct control (including external interrupt)
- CPU timer
- Clock comparator
- Conditional swapping
- PSW key handling
- Clear I/O
- Channel indirect data addressing
- System/370 extended facility
- Multiprocessing (M-series models)
- Error checking and correction
- Instruction retry
- Processor storage (4M, 6M, or 8M bytes)
- High-speed buffer storage
- Storage configuration control
- Byte multiplexer channel (two)
- Block multiplexer channels (10)
- Channel retry
- Command retry (block multiplexer channels)
- Channel-set switching (M-series models)

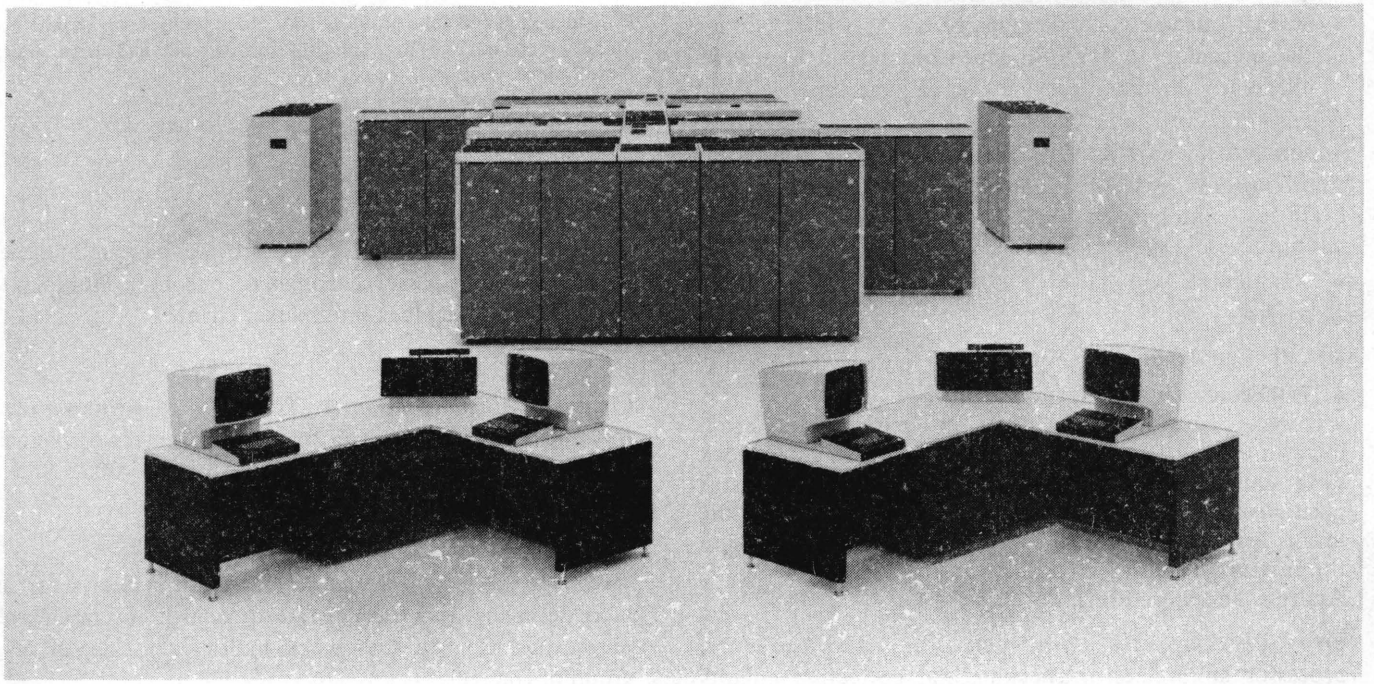


Figure 5-13. IBM 3033 Multiprocessor Complex (Design Model)

Instruction Set: The System/370 universal instruction set is standard on the 3033 Processor. Other standard instructions include those associated with the following features listed in the *IBM System/370 Principles of Operation,* GA22-7000: extended-precision floating point, translation, CPU timer, clock comparator, conditional swapping, PSW key handling, direct control, and multiprocessing (M-series models).

Monitoring: Monitoring provides a means of selectively recording designated events in the execution of a program.

Direct Control: Direct control provides two instructions and six external interruption lines that permit the transfer of control information either between the 3033 and another processor or between the 3033 and external devices.

System/370 Extended Facility: The System/370 extended facility, which is supported by the MVS/System Extensions program product, includes:

- Low-address protection, which improves system reliability, availability, and serviceability by increasing the protection of low-address main storage (addresses 0 through 511) vital to the system control program.
- The Invalidate Page Table Entry instruction and the common-segment bit, which increase the efficiency of dynamic address translation.
- The Test Protection instruction, which performs tests for potential protection violations without causing program interruptions for protection exceptions.
- The SVC Assist instruction, which reduces the time needed to enter MVS supervisory services, thereby improving CPU performance.
- The Fix Page instruction, the six tracing instructions, and the four lock-handling instructions, which improve CPU performance.
- Virtual-machine extended-facility assist, which permits the preceding 12 MVS/SE-dependent instructions to be executed directly by the virtual machine without requiring program interruptions thereby eliminating simulation and improving CPU performance.

Multiprocessing: This feature includes the following facilities, which permit the formation of a two-CPU multiprocessing system:

- Shared main storage
- Prefixing
- CPU signaling and response
- TOD clock synchronization

These facilities include four extensions to external interruption (external call, emergency signal, TOD clock sync check, and malfunction alert), control-register positions for the TOD-clock-sync control bit and for the masks for the four external-interruption conditions, and the instructions Set Prefix, Signal Processor, Store CPU Address, and Store Prefix.

Error Checking and Correction: For data read from processor storage, error checking and correction circuits automatically detect all single- and double-bit errors and some multiple-bit errors, and automatically correct the single-bit errors.

Instruction Retry: Instruction retry automatically examines any instruction during whose execution an error is detected, and usually reattempts its execution.

High-Speed Buffer Storage: The 65,536-byte buffer storage of the 3033 can satisfy many requests for storage, making the effective storage access time much less than the actual processor-storage cycle time.

Channel Indirect Data Addressing: This feature provides a means of translating data addresses for I/O operations in a virtual storage system.

Channel Retry: When a channel operation fails, this feature permits storage of retry data for subsequent use by the error-recovery routines to retry the operation.

Command Retry: A channel and control unit procedure that causes an improperly executed command in a channel program to be automatically retried.

Channel-Set Switching: This feature permits program-controlled switching of channel controls between processors in a multiprocessor complex, as an aid to recovery (standard on M-series models).

Optional Features

Extended channels (one group of four block multiplexer channels or one group of one byte multiplexer channel and three block multiplexer channels)
Channel-to-channel adapter (two)
Two-byte channel interface

Extended Channels: This feature provides a group of either four block multiplexer channels or one byte multiplexer channel and three block multiplexer channels.

Channel-to-Channel Adapter: This feature provides a path for, and synchronizes, data transfer between two channels on the 3033 or between a channel on the 3033 and a channel on another processor.

Two-Byte Channel Interface: This feature allows for an increase in the data transfer rate to as high as 3 megabytes per second for the first block multiplexer channel of a group of channels.

IBM 3036 Console

The 3033 Processor is operated, monitored, controlled, and serviced through the IBM 3036 Console Model 1. The 3036 has an operator panel and two operating stations. Each station consists of a display, which can show as many as 25 lines of 80 characters per line; a keyboard; a console processor; and a diskette drive. Each station is addressable so that it can be designated as either the operator console or the service support console.

A console security keylock is provided on the right side of each display:

1. With the key turned to the horizontal position, an initial microprogram load (IMPL) can be performed. The display that is addressed as the operator console can present either the program (PR) frame or the power control (PC) frame; and the display that is addressed as the service support console can present any other frame.
2. With the key turned to the vertical position, an IMPL cannot be performed. Any effort to change the frame that is presented on either display causes an alarm to sound.

In a 3033 Multiprocessor Complex, either of the two 3036 Consoles can be designated as the primary console. The primary console can be used to display and enter the mode of operation (MP or UP), and to assign addresses in processor storage.

IBM 3037 Power and Coolant Distribution Unit

The IBM 3037 Power and Coolant Distribution Unit Model 1 supplies power to the 3036 Console and, under control of the 3036, distributes power and coolant to the 3033 Processor. The optional multiprocessing feature is required on each of the two 3037s in a 3033 Multiprocessor Complex.

IBM 3038 Multiprocessor Communication Unit

The IBM 3038 Multiprocessor Communication Unit Model 1 contains hardware for communications between the two processors of a 3033 Multiprocessor Complex. The 3038 is located between the two processors.

Programming Support

Programming support for the 3033 Processor Complex is provided by OS/VS1, OS/VS2 (SVS and MVS), VM/370, and the VM/System Extensions program product. Programming support for the 3033 Multiprocessor Complex is provided by OS/VS2 (MVS). Support for the System/370 extended facility in both a 3033 Processor Complex and a 3033 Multiprocessor Complex is provided by the MVS/System Extensions program product.

Figure 5-14. Comparison of IBM System/370 Processors (Part 1 of 3)

Features and Characteristics	Application on Processors												
	3115-0 3115-2	3125-0 3125-2	3135	3135-3	3138	3145	3145-3	3148	3158 3158-3	3168 3168-3	3031	3032	3033
Basic machine cycle time (nanoseconds)	480	480	275-1,485	275-1,485	275-1,485	202.5-315	180-270	180-270	115	80	115	80	57
Instruction sets													
System/370 Commercial	std	std	std	std	std	std	–	–	–	–	–	–	–
System/370 Universal	opt	opt	opt	std	std	opt	std	std	std	std	std	std	std
Dynamic address translation	std	std	std	std	std	std	std	std	std	std	std	std	std
Program event recording	std	std	std	std	std	std	std	std	std	std	std	std	std
Extended control mode	std	std	std	std	std	std	std	std	std	std	std	std	std
Byte-oriented operand	std	std	std	std	std	std	std	std	std	std	std	std	std
Floating point	opt	opt	opt	std	std	opt	std	std	std	std	std	std	std
Extended-precision floating point	opt	opt	opt	opt*	std	opt	std	std	opt	std	std	std	std
Direct control (with external interrupt)	–	–	opt	opt	opt	opt	opt	opt	opt	std	std	std	std
External signals	opt	opt	–	–	–	–	–	–	–	–	–	–	–
Instruction retry or micro-instruction retry	–	std	std	std	std	std	std	std	std	std	std	std	std
High-speed multiply	–	–	–	–	–	–	–	–	–	opt	–	–	ⓡ
Interval timer	std	std	std	std	std	std	std	std	std	std	std	std	std
Time-of-day clock	std	std	std	std	std	std	std	std	std	std	std	std	std
Clock comparator and CPU timer	std	std	opt	std	std	opt	opt*	std	std	std	std	std	std
Monitoring	std	std	std	std	std	std	std	std	std	std	std	std	std
System/370 extended feature	–	–	–	–	–	–	–	–	opt	opt	–	–	–
System/370 extended facility	–	–	–	–	–	–	–	–	–	–	std	std	std
Processor Storage													
Storage access width (number of bytes fetched per access)	2	2	2 or 4	2 or 4	2 or 4	8	8	8	16	8	8	8	8
Storage cycle time (nanoseconds)	480	480, 320	770-935 read, 935 write	770-935 read, 935 write	715-880 read, 935 write	540 read, 607.5 write	405 read, 540 write	405 read, 540 write	1,035 read, 690-920 write	320	345	320	342
Storage interleaving	–	–	–	–	–	–	–	–	–	4-way	4-way	4-way	8-way
High-speed buffer storage	–	–	–	–	–	–	–	–	std	std	std	std	std
Buffer storage extension	–	–	–	–	–	–	–	–	–	ⓑ	–	–	–
Key-controlled storage protection	std	std	std	std	std	std	std	std	std	std	std	std	std
Processor storage capacities (bytes)													
(Entries are processor designations)													
65,536	F, F2	–	–	–	–	–	–	–	–	–	–	–	–
98,304	FE, FE2	FE, FE2	FE	–	–	–	–	–	–		–	–	–
131,072	G, G2	G, G2	–	–	–	–	–	–	–		–	–	–
147,456	–	–	GD	–	–	–	–	–	–		–	–	–
163,840	GE, GE2	GE, GE2	–	–	–	GE	–	–	–		–	–	–
196,608	GF, GF2	GF, GF2	GF	–	–	–	–	–	–		–	–	–
212,292	–	–	–	–	–	GFD	A1	–	–		–	–	–
262,144	–, H2	H, H2	H	A1	–	H or H2	–	–	–	–	–	–	–
327,680	–	–	HF	A2	–	–	A2	–	–	–	–	–	–
393,216	HG2	HG2	HG	A3	–	HG or HG2	–	–	–		–	–	–
458,752	–	–	–	–	–	–	A3	–	–		–	–	–
524,288	–	I2	I	A4	I	I or I2	–	–	I, AP1, MP1, U31, A31, or M31		–	–	–
720,896	–	–	–	–	–	–	A4	–	–	–	–	–	–
786,432	–	–	–	–	–	IH2	–	–	–	–	–	–	–
983,040	–	–	–	–	–	–	A5	–	–	–	–	–	–
1,048,576	–	–	–	–	J	J2	–	J	J, AP2, MP2, U32, A32, or M32	J, MP1, U31, A31, M31	–	–	–
1,507,328	–	–	–	–	–	–	A6	–	–	–	–	–	–
1,572,864	–	–	–	–	–	JI2	–	–	I, AP3, MP3, U33 A33, or M33	–	–	–	–
2,031,616	–	–	–	–	–	–	A7	–			–	–	–

Features and Characteristics	Application on Processors												
	3115-0 3115-2	3125-0 3125-2	3135	3135-3	3138	3145	3145-3	3148	3158 3158-3	3168 3168-3	3031	3032	3033
Processor storage capacities (bytes) (continued)													
2,097,152	–	–	–	–	–	K2	–	K	K, AP4, MP4, U34, A34, or M34	K, MP2, U32, A32, M32	2	2	–
3,145,728	–	–	–	–	–	–	–	–	KJ, AP5, MP5, U35, A35, or M35	KJ, MP3, U33, A33, M33	3	–	–
4,194,304	–	–	–	–	–	–	–	–	L, AP6, MP6, U36, A36, or M36	L, MP4, U34, A34, M34	4	4	U4, M4
5,242,880	–	–	–	–	–	–	–	–	LJ, AP7, U37, A37, or M37	LJ, MP5, U35, A35, M35	5	–	–
6,291,456	–	–	–	–	–	–	–	–	LK, AP8, U38, A38, or M38	LK, MP6, U36, A36, M36	6	6	U6, M6
7,340,032	–	–	–	–	–	–	–	–	–	LKJ, MP7, U37, A37, M37	–	–	–
8,388,608	–	–	–	–	–	–	–	–	–	M, MP8, U38, A38, M38	–	–	U8, M8
Compatibility Features													
1401/1440/1460, 1410/7010	–	–	–	–	–	opt	opt	opt	opt	–	–	–	–
1401/1440/1460	opt	opt	opt	opt	opt	opt	opt	opt	–	–	–	–	–
7070/7074	–	–	–	–	–	–	–	–	opt	opt	–	–	–
7080	–	–	–	–	–	–	–	–	–	opt	–	–	–
709/7090/7094 II	–	–	–	–	–	–	–	–	–	opt	–	–	–
OS/DOS	–	–	std	std	std	std	std	std	std	–	–	–	–
System/360 Model 20	opt	opt	opt	opt	opt	–	–	–	–	–	–	–	–
Programming Support													
DOS	–	yes	yes	yes	–	yes	yes	–	yes	–	–	–	–
DOS/VS	yes	yes	yes	yes	yes	yes	yes	yes	yes	–	yes	–	–
OS/MFT	–	–	yes	yes	–	yes	yes	–	yes	yes	–	–	–
OS/MVT	–	–	–	–	–	yes	yes	–	yes	yes	–	–	–
OS/VS1	–	–	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
OS/VS2	–	–	–	–	–	yes	yes	–	yes	yes	yes	yes	yes
VM/370	–	–	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Channels per Processor													
Maximum Channels (j)	1	1	4 (c)	4 (c)	4 (c)	5	5	5	6	12	6	12	16
Byte Multiplexer (standard)	1	1	1	1	1	1	1	1	1	–	1	1	2
Byte Multiplexer (optional)	–	–	–	–	–	–	–	–	1 (l)	2	–	1	1
Block Multiplexer (standard)	–	–	–	–	2	–	1	4	2	–	5	5 (q)	10 (q)
Block Multiplexer (optional)	–	–	(k)	2	–	(k)	3	–	3	11	–	5	4
Selector (standard)	–	–	–	–	–	1	–	–	–	–	–	–	–
Selector (optional)	–	–	2	–	–	3	–	–	–	6	–	–	–
Channel Units (2860, 2870, and 2880 frames) per Processor													
Maximum number of frames (combined)	–	–	–	–	–	–	–	–	–	7	–	–	–
2870 Multiplexer Channel (byte mpx) (maximum) (m)	–	–	–	–	–	–	–	–	–	2	–	–	–
2880 Block Multiplexer Channel (maximum) (n)	–	–	–	–	–	–	–	–	–	6	–	–	–
2860 Selector Channel (maximum) (o)	–	–	–	–	–	–	–	–	–	2	–	–	–
Subchannels (type and no., std or opt) (n = nonshared, s = shared) (b)													
Byte multiplexer, of 1st byte mpx channel													
16 n + 0s to 8n + 8s	–	–	all	all	all	all	–	–	–	–	–	–	–
32n + 0s to 24n + 8s	all	all	–	–	–	all	–	–	–	–	–	–	–
64n + 0s to 56n + 8s	–	–	all	all	all	all	all	all	–	–	–	–	–
120n + 8s	–	–	–	–	–	–	–	–	all	–	–	–	–

Figure 5-14. Comparison of IBM System/370 Processors (Part 2 of 3)

Figure 5-14. Comparison of IBM System/370 Processors (Part 3 of 3)

Features and Characteristics	Application on Processors												
	3115-0 3115-2	3125-0 3125-2	3135	3135-3	3138	3145	3145-3	3148	3158 3158-3	3168 3168-3	3031	3032	3033
Byte multiplexer, of 1st byte mpx channel (continued)													
128n	–	–	–	–	–	–	–	–	–	–	–	–	–
128n + 0s to 120n + 8s	–	–	all	all	all	all	all	all	–	–	–	–	–
192n	–	–	–	–	–	–	–	–	–	all	–	–	–
256n	–	–	all	all	all	all	all	all	all	–	–	–	–
256n/s (p)	–	–	–	–	–	–	–	–	–	–	all	all	all
Byte multiplexer, of 2nd byte mpx channel													
120n + 8s	–	–	–	–	–	–	–	–	all	–	–	–	–
128n	–	–	–	–	–	–	–	–	–	–	–	–	–
192n	–	–	–	–	–	–	–	–	–	all	–	–	–
256n	–	–	–	–	–	–	–	–	all	–	–	–	–
256n/s (p)	–	–	–	–	–	–	–	–	–	–	all	all	all
Block multiplexer, of block mpx channels													
16n + 1s	–	–	all	all	all	all	–	–	–	–	–	–	–
16s to 512s, in increments of 16	–	–	–	–	–	all	–	–	–	–	–	–	–
56n (max, with 1s)	–	–	–	–	–	–	–	–	–	all	–	–	–
96n + 16s	–	–	–	–	–	–	–	–	–	–	–	–	–
64n, 128n, 256n, or 512n	–	–	–	–	–	–	all	all	–	–	–	–	–
160n + 16s	–	–	–	–	–	–	–	–	–	–	–	–	–
224n + 16s	–	–	–	–	–	–	–	–	–	–	–	–	–
252n + 16s	–	–	–	–	–	–	–	–	–	–	–	–	–
256n + 16s	–	–	–	–	–	–	–	–	–	all (f)	–	–	–
256n/s (p)	–	–	–	–	–	–	–	–	–	–	all	all	all
480n + 16s	–	–	–	–	–	–	–	–	all 3158	–	–	–	–
480n + 0s to 448n + 32s (g) or 736n + 0s to 696n + 40s	–	–	–	–	–	–	–	–	all 3158-3	–	–	–	–
Selector, of 1st byte mpx channel													
4s	–	–	–	–	–	–	–	–	–	all	–	–	–
Selector, of 2nd byte mpx channel													
2s	–	–	–	–	–	–	–	–	–	–	–	–	–
4s	–	–	–	–	–	–	–	–	–	all	–	–	–
Channel-to-channel adapter	–	–	–	–	–	opt	opt	opt	opt	opt	opt	opt	opt
Channel indirect data addressing	std	std	std	std	std	std	std	std	std	opt	std	std	std

Legend:

all all models
opt optional
std standard
– not applicable
• required

Notes:

(a) The storage cycle times given for the 3168 do not reflect the time reductions that are due to storage interleaving or, additionally for 3168 and 3168-3 time reductions resulting from the use of the high-speed buffer.

(b) Shared subchannels can control several I/O devices or modules having a common control unit; nonshared subchannels can control only one I/O device.

(c) Includes the integrated file adapter, addressed as a selector or block multiplexer channel.

(f) With extended unit control word feature.

(g) If channel 4 is a second byte multiplexer channel.

(h) Optional on the 3168.

(j) With the extended channels feature installed on applicable processors.

(k) The block multiplexer channel feature provides block multiplexer capabilities for all attached selector channels.

(l) Takes the place of the fourth block multiplexer channel.

(m) The 2870 frame has one channel.

(n) The 2880 frame can have one or two channels.

(o) The 2860 frame can have one, two, or three channels.

(p) The number of unshared subchannels per channel equals 256 minus 8, 16, 32, or 64 (addresses for each shared subchannel). Each channel can have up to eight shared subchannels.

(q) The 3032 has a group of one byte multiplexer channel and five block multiplexer channels as standard. A group of one byte multiplexer channel and five block multiplexer channels is optional.
The 3033 has two groups of one byte multiplexer channel and five block multiplexer channels as standard. A group of either four block multiplexer channels or one byte multiplexer channel and three block multiplexer channels is optional.

(r) Uses an efficient multiply algorithm similar to the high-speed multiply algorithm used in the 3168 and 3168-3.

Appendix A. Glossary and Abbreviations

(Refer to the *IBM Data Processing Glossary,* GC20-1699, for definition of those terms not included in this listing).

alter/display: A feature whereby main storage data may be displayed and altered at the display/keyboard console.

APF: authorized program facility.

APG: automatic priority group.

ASB: automatic SYSIN batching.

block multiplex mode: The transmission of data to multiple I/O devices by the realtime interleaving of records in block form.

buffer storage: An area of storage set aside for temporary use to compensate for differences in the rate or time of data transmission.

byte multiplex mode: The transmission of data to multiple I/O devices by the realtime interleaving of bytes.

byte-oriented operand: A feature that allows certain operands to reside on any byte boundary.

character generator: A feature that translates the byte necessary to trace an alphameric character on the face of a display tube.

code-dependent device: A device whose operation depends on the code used in representing data.

command retry: A channel and control-unit procedure that causes a command to be retried without requiring an I/O interruption.

commercial instruction set: A combination of instructions of the standard instruction set and the decimal instructions.

communications–start-stop: One of three classifications of adapter used for connecting remote and local devices to the 2701 Data Adapter Unit.

compatibility feature: A feature, also called an emulator, that allows an IBM system to execute programs written for another system.

console file: A disk file, one of the major operational components of the Model 158 System Console.

CP: control program.

DADSM: direct-access device space management.

data acquisition and control: The process of identifying, isolating, and gathering source data and providing the correct facility for its transmission.

data transfer rate: the number of bytes (or packed decimal digits and signs) per second transferred to or from the processor by a storage unit.

decimal arithmetic: Arithmetic operations performed on decimal numbers.

DIDOCS: device-independent operator console support.

DOS/VS: Disk Operating System/Virtual Storage.

DSO: direct system output.

editing: The process of modifying data such as inserting or deleting special characters.

error checking and correction (ECC): The detection, in the processor, and correction of all single-bit errors, plus the detection of double-bit and some multiple-bit errors.

extended floating-point number: A floating-point number with a 112-bit fraction. This is approximately 34-decimal-place precision.

extended-precision floating point: A feature that provides operations on extended floating-point numbers.

field length: The length of a specified area in a record used for a particular category of data.

fixed length data format: A format in which data is present in units or equal and unvarying length.

floating-point feature: A processing unit feature that has at its disposal four 64-bit floating-point registers and the instructions to perform floating-point arithmetic calculations.

GMT: Greenwhich Mean Time.

ICA: integrated communications adapter.

IDR: identification record.

in-flight: During the process of moving.

instruction retry: The process of recovering from intermittent failures through the use of program routines that, when an error is detected, return the processor to a point in the operation that was correctly executed. The operation continues from there.

instruction set: A set of instructions grouped for convenience in marketing.

internal performance: A factor in the total productivity of a system determined by a combination of throughput, response time, and availability.

interruption, classes of: The six classes of program interruption are: program, supervisor call, external, restart, machine check, and I/O.

interruptions, disallowing of: The delaying of or prevention of an interruption.

interval timer: A timer that resides at location 80 in main storage. The interval timer causes a request for an external interruption when it steps from positive to negative.

I/O interface: The physical and the logical connection between the channel and the I/O control unit.

ISC: integrated storage controls.

IVP: installation verification procedure.

logical operations: The comparing, testing, translating, editing, and relocating of logical data.

long floating-point number: A floating-point number with a 56-bit fraction. This is approximately 17-decimal-place precision.

M: 1,048,576 bytes of storage.

machine-dependent: Relates to a program or procedure that requires the use of specific hardware.

MIC: missing interruption checker.

MVS: multiple virtual storage.

native attachment: An attachment that is an integral part of the basic hardware.

NCP/VS: Nework Control Program/Virtual Storage.

unprivileged instruction: An instruction that is valid in both the problem and the supervisor states, as contrasted to a privileged instruction, which is valid only in the supervisor state.

nonshared subchannel: A division of a channel data path that can control only one I/O device.

op code: operation code.

OS/DOS compatibility: A feature that provides a System/370 processor with the ability to execute DOS programs under OS control.

OS/MVT: Operating System/Multiprogramming Varied Task.

OS/VS1: Operating System/Virtual Storage 1.

OS/VS2: Operating System/Virtual Storage 2.

packed format: A data format in which a byte may contain either two decimal digits or one decimal digit and a sign.

PEP: Partitioned Emulation Programming.

program switching: The switching from one program to another in the performance of a transaction.

PSQA: pageable system queue area.

RAM: Resident Access Methods.

RAS: reliability, available, and serviceability.

RBA: relative byte address.

RDE: reliability data extractor.

realtime application: An application that processes input as it is generated, as opposed to batch-type processing.

realtime process: A process in which response to input is fast enough to affect subsequent input.

reloadable control storage (RCS): Storage used to execute a set of microprograms that is used to control the processor, plus channel functions and features. These microprograms are loaded into the RCS from the console as an initial microprogram load procedure.

RES: remote entry services.

RR: register to register (instruction format).

RS: register and storage (instruction format).

RSCS: Remote Spooling Communication System.

RTAM: Remote Terminal Access Method.

RX: register and indexed storage (instruction format).

S: implied operand and storage (instruction format).

SDS: status display support

selectable unit (SU): A collection of macro instructions and modules that provides new function and device support. Selectable units are shipped independently of OS/VS2 releases.

selector mode: One or two modes in which a block multiplexer channel can operate, the other being block multiplex mode.

selector subchannel: A subchannel of the shared type that operates in burst mode and can operate one I/O device concurrently with byte multiplexer subchannels.

shared path: The single data path of a byte multiplexer channel shared concurrently, in byte mode, by more than one low-speed I/O device.

shared subchannel: A division of a channel data path; one that can control several I/O devices through one unit.

short floating-point number: A floating-point number with a 24-bit fraction. This is approximately seven-decimal-place precision.

SI: immediate operand and storage (instruction format).

SS: storage to storage (instruction format).

SSI: system status index (instruction format).

standard instruction set: A facility that includes all System/370 instructions that are not part of any separately defined grouping.

storage access width: The number of bytes fetched in each storage access.

storage cycle time: The time required by storage to process a reference to it.

storage interleaving: A performance factor that allows 2, 4, 8, or 16 storage accesses to be started during a storage cycle.

subchannel: A division of a channel data path.

supervisor-call interruption: An interruption caused by the supervisor-call instruction in passing control to the supervisor.

switch, two-channel: A feature that allows each of the two data paths of the integrated storage controls (ISC) feature to be connected to two channels on the same or separate systems.

time-of-day clock: A feature that provides a precise measure of time suitable for accurate elapsed time measurements and time-of-day indication.

translation lookaside buffer (TLB): A buffer that, in dynamic address translation, holds information that would otherwise have to be maintained in and accessed from main storage.

transparency: A feature in data communications that allows the sending and receiving of control characters as data, negating their control function.

two-byte interface: A feature that permits a block multiplexer channel to transfer data at rates as high as 3 megabytes per second.

universal instruction set: A facility of the commerical instruction set and the floating-point feature.

utility: Pertaining to a problem program designed to perform a common task.

VSAM: Virtual Storage Access Method.

VTAM: Virtual Telecommunications Access Method.

wait time: Time the processor spends in the wait state.

writable control storage (WCS): A part of control storage that allows data in its storage locations to be overlaid with new data. Therefore, certain microprogram routines may be used that would otherwise require additional storage capacity.

zoned decimal format: A data format in which a zone character accompanies each decimal digit, except in the low-order byte position, which is occupied by a sign and decimal digit.

IBM System/370 System Summary: Processors

Order No. GA22-7001-7

READER'S COMMENT FORM

This manual is part of a library that serves as a reference source for systems analysts, programmers, and operators of IBM systems. This form may be used to communicate your views about this publication. They will be sent to the author's department for whatever review and action, if any, is deemed appropriate. Comments may be written in your own language; use of English is not required.

IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligations whatever. You may, of course, continue to use the information you supply.

Note: *Copies of IBM publications are not stocked at the location to which this form is addressed. Please direct any requests for copies of publications, or for assistance in using your IBM system, to your IBM representative or to the IBM branch office serving your locality.*

Possible topics for comment are:

Clarity Accuracy Completeness Organization Coding Retrieval Legibility

If you wish a reply, give your name and mailing address:

_____

_____

_____

Note: Staples can cause problems with automated mail sorting equipment. Please use pressure-sensitive or other gummed tape to seal this form.

What is your occupation? _____

Number of latest Newsletter associated with this publication: _____

Thank you for your cooperation. No postage stamp necessary if mailed in the U.S.A. (Elsewhere, an IBM office or representative will be happy to forward your comments or you may mail directly to the address in the Edition Notice on the back of the front cover or title page.)

Reader's Comment Form

Cut or Fold Along Line

Fold and tape | Please Do Not Staple | Fold and tape

FIRST CLASS
PERMIT NO. 419
POUGHKEEPSIE,
NEW YORK

Business Reply Mail
No postage stamp necessary if mailed in U.S.A.

Postage will be paid by:

International Business Machines Corporation
Department B98
P.O. Box 390
Poughkeepsie, New York 12602

Fold and tape | Please Do Not Staple | Fold and tape

International Business Machines Corporation
Data Processing Division
1133 Westchester Avenue, White Plains, N.Y. 10604

IBM World Trade Americas/Far East Corporation
Town of Mount Pleasant, Route 9, North Tarrytown, N.Y., U.S.A. 10591

IBM World Trade Europe/Middle East/Africa Corporation
360 Hamilton Avenue, White Plains, N.Y., U.S.A. 10601

IBM System/370 System Summary: Processors (File No. S370-00) Printed in U.S.A. GA22-7001-7

GA22-7001-7

IBM System/370 System Summary: Processors (File No. S370-00) Printed in U.S.A. GA22-7001-7

International Business Machines Corporation
Data Processing Division
1133 Westchester Avenue, White Plains, N.Y. 10604

IBM World Trade Americas/Far East Corporation
Town of Mount Pleasant, Route 9, North Tarrytown, N.Y., U.S.A. 10591

IBM World Trade Europe/Middle East/Africa Corporation
360 Hamilton Avenue, White Plains, N.Y., U.S.A. 10601