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## A Guide to the IBM System/370 Model 168

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This Technical Newsletter provides replacement pages for the subject publication. Pages to be inserted and/or removed are:

3, 4	117 - 122
4.1, 4.2 (added)	125, 126
9 - 12	126.1, 126.2 (added)
31 - 34	135, 136
63, 64	139, 140
85, 86	145 - 152 (151.1 and 151.2 added)
95 - 98	

### Summary of Amendments

OS/VS2 Release 3.6 support of Model 168 hardware and new I/O devices have been added to the summary tables. Miscellaneous other corrections have been made also.

A vertical rule in the left margin indicates a change. Absence of a vertical rule on a page bearing a 'revised' notice means only that existing copy has been moved or that a minor typographical error has been corrected.

Please file this cover letter at the back of the manual to provide a record of changes.

- Processor storage is implemented using monolithic technology instead of discrete ferrite cores, and a Model 168 can have five million more bytes than a Model 165. Processor storage sizes of 1024K, 2048K, 3072K, 4096K, 5120K, 6144K, 7168K, and 8192K are available for the Model 168. Monolithic storage for the Model 168 is faster and more compact than core storage for the Model 165. As in a Model 165, processor storage in a Model 168 is four-way doubleword interleaved.

The physical size of a Model 168 CPU is not a function of the amount of processor storage installed. A Model 168 is smaller than a Model 165 with 512K and, therefore, is significantly smaller than Model 165 CPU's with more than 512K installed.

- The optional Power Warning feature, when installed on a Model 168 with uninterrupted power supplies, provides a warning machine check interruption when the utility supplied power is approximately 18 percent below the rated voltage. Program support of this interruption, which is provided by OS MVT (Releases 21.6, 21.7, and 21.8), OS/VS1 (as of Release 3), and OS/VS2 (Releases 1.6 and up), is designed to permit an orderly system shutdown after a power line disturbance occurs, when necessary, so that operations can be restarted once the power supply is stabilized.
- A high-speed buffer of 32K bytes is standard in Model 3 of the Model 168. Model 1 of the Model 168, like the Model 165, has an 8K buffer as standard and optionally a 16K buffer.
- The maximum aggregate channel data rate a Model 168 can support is significantly increased over that supported by a Model 165 because of the faster cycle time of processor storage and the new channel dual I/O bus that is used to transfer data from the channels to the storage control unit. A Model 168 configuration can handle a maximum aggregate data rate of 17 megabytes per second (MB/sec). The maximum aggregate data rate possible on a Model 165 is 9.4 MB/sec.
- 3330-series disk storage (all models) and/or 3340 direct access storage facilities can be attached to a 2880 channel on a Model 168 via the Integrated Storage Controls (ISC) feature as well as via 3830 Storage Control (Models 1 and 2). The optional ISC feature provides dual direct access storage control functions equivalent to two 3830 Storage Control Model 2 units, with the exception of four-channel switching. Four strings of from two to eight drives each can be attached to each of the two logical storage controls for a total of eight 3330-series and/or 3340 strings (64 drives) attached via the ISC feature. Optionally, the staging adapter feature can be installed on the ISC to permit attachment of the 3850 Mass Storage System via ISC instead of via 3830 Storage Control Model 3.
- The 3340 direct access storage facility can be attached to the Model 168 via 3830 Storage Control Model 2 and the Integrated Storage Controls feature. The 3340 facility is intermediate capacity direct access storage that, because of its unique design and advanced technology, offers advantages over 2314 disk storage in addition to those provided by 3330-series disk storage. Automatic error correction features and multiple requesting are standard on the 3340. Rotational position sensing is optional.

The storage medium for 3340 disk storage is the removable interchangeable 3348 Data Module which is a sealed cartridge that is never opened by the operator. In addition to the disks on which data is written, the 3348 Data Module contains a spindle, access arms, and read/write heads. The 3340 Disk Storage Drive contains

the mechanical and electrical components required to operate the 3348 Data Module.

The 3340 facility has an 885 KB/sec data transfer rate, average seek time of 25 ms, and full rotation time of 20.2 ms. A 3348 Data Module has a maximum capacity of approximately 35 million bytes or 70 million bytes, depending on the model. One model of the 3348 offers fixed heads for zero seek time to approximately 502,000 bytes maximum and movable heads for an average seek time of 25 ms to the remaining bytes in the data module. A string of from two to eight 3340 drives can be configured. From one to four strings can be attached to the 3830 Model 2 and to each of the logical controls in ISC. Any model of the 3348 can be mounted on a 3340 drive. Therefore, 3340 string capacity can vary from 70 million to 560 million bytes in 35 and/or 70 million byte increments.

The sealed cartridge design of the 3340 facility offers the advantages of multiple capacities per 3340 drive, increased data reliability, and simplified data module loading and unloading procedures.

- 3344 Direct Access Storage can be attached to a Model 168 via 3830 Storage Control Model 2 and Integrated Storage Controls. It offers significantly increased maximum online capacity per drive for 3340 users without the necessity of program conversion. The 3344 is fixed media disk storage. Data is recorded on nonremovable disks. The 3344 is designed to eliminate operator handling, eliminate exposure to external contamination (like the 3348 Data Module), and provide high reliability.

The 3344 has the same data transfer rate, average seek time, and full rotation time as the 3340. However, the maximum capacity of a 3344 drive is 280 megabytes, or the equivalent of four 70-million byte 3348 data modules. The 3344 is a two-drive unit that attaches to the 3340 Model A2. A 3340/3344 string can contain any mixture of 3344 and 3340 units (as long as the first is a 3340 Model A2) for a maximum of eight drives with a maximum capacity of over 1.8 billion bytes.

Automatic error correction, rotational position sensing, and multiple requesting are standard in the 3344. Fixed head models are also available that contain fixed heads for zero access time to a portion of the data and movable heads for access to the balance of the data.

- 3350 Direct Access Storage can be attached to a Model 168 via 3830 Storage Control Model 2 and Integrated Storage Controls. The 3350 is very large capacity, high-speed, fixed media direct access storage. Data is stored on nonremovable disks. The 3350 is designed to eliminate operator handling, eliminate exposure to external contamination, and provide high reliability.

The 3350 has a data transfer rate of 1198 KB/sec, average seek time of 25 ms, and full rotation time of 16.8 ms. A 3350 drive operating in native mode has a maximum capacity of 317.5 megabytes. A 3350 string can contain from two to eight drives in two drive increments for a maximum string capacity of over 2.5 billion bytes of online disk storage.

The Standard Selective Format feature enables the format of each 3350 to be set by programming during volume initialization. A 3350 drive can operate in 3350 native mode, 3330 Model 1 compatibility mode, or 3330 Model 11 compatibility mode. When operating in 3330 Model 1 compatibility mode, a 3350 drive is the equivalent of two

3330 Model 1 drives in capacity. When operating in 3330 Model 11 compatibility mode, a 3350 drive is the equivalent of one 3330 Model 11 drive in capacity. This feature enables 3330-series users to obtain the price performance and functional advantages of the 3350 without program conversion.

Automatic error correction, rotational position sensing, and multiple requesting features are standard. The 3350 is also available in fixed head models. These models provide fixed heads for zero access time to a portion of the data and movable heads for access to the balance of the data.

- A service processor unit is standard in the Model 3. This unit provides status data that is designed to improve problem analysis by the local customer engineer as well as facilities that improve the remote problem analysis capability available for a Model 3. It is also a replacement for the optional 2955 Remote Analysis Unit that is available for the Model 165 and Model 1 of the Model 168.

The Model 168 is designed primarily to support a virtual storage environment that allows programmers to write and execute programs that are larger than the processor storage available to them. When virtual storage is supported, restraints normally imposed by the amount of processor storage actually available in a system are eased. The removal of certain restraints can enable applications to be installed more easily, and can be valuable in the installation and operation of online applications. While some of the new hardware features of the Model 168 and some of the new facilities supported by System/370 operating systems are designed to improve performance, a virtual storage environment is designed primarily to help improve the productivity of data processing personnel and enhance the operational flexibility of the installation.

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Model 3) that has a comparable hardware configuration, with the following exceptions:

1. Time-dependent programs. (They may or may not execute correctly.)
2. Programs that depend on the nonusable lower processor storage area being smaller than 1938 bytes. (The nonusable area in the Model 165 is 1504 bytes.)
3. Programs that use machine-dependent data such as that which is logged in the machine-dependent logout area.
4. Programs deliberately written to cause certain program checks.
5. Programs that depend on the validity of storage data after system power has been turned off and then on.

OS control programs are designed to support either BC or EC mode of system operation. OS PCP, MFT, and MVT control programs generated for a Model 65, 67, or 75 support BC mode operations on a Model 168. OS control and processing programs being used on a Model 65, 67, or 75 are subject to the eight compatibility restrictions in the first list. If an OS MFT or MVT control program that was generated for a Model 65, 67, or 75 is used on a Model 168, the system should be set to check stop on machine checks. (Section 60:30 in A Guide to the IBM System/370 Model 165, GC20-1730, discusses the reason.)

OS MFT and MVT support for the Model 168 (Model 1) in BC mode is provided as of Release 21.6. OS MFT and MVT control programs generated for a Model 165 using OS Release 21.6 or later will also operate on a Model 168 to support BC mode of system operation (the Model 168 should be specified as an alternate CPU via the SECMODS macro at system generation). Processing programs that are used on the Model 165 will operate under OS MFT or MVT control on a Model 168 in BC mode subject to the five compatibility restrictions in the second list.

Support of Model 168 (Model 1) systems operating in EC mode is provided by OS/VS1, OS/VS2 Releases 1 and up, and VM/370, each of which is designated as system control programming (SCP). All of these programming systems support a virtual storage environment using dynamic address translation, which operates only when the system is in EC mode. OS/VS2 Releases 2 and up support multiple virtual storages and Model 168 tightly coupled and loosely coupled multiprocessing configurations. VM/370 supports a virtual machine environment.

User-written processing programs that operate on a Model 165 or Model 168 Model 1 under OS MFT or MVT control can operate under OS/VS1 or OS/VS2 Release 1, respectively, on a Model 168 (Model 1) with little or no modification, as discussed in the optional programming systems supplements (Sections 90 and 100). Hence, compatible growth from a System/360 or a BC mode nonvirtual storage environment to an EC mode virtual storage environment is provided.

The following are standard features of the Model 168 (Model 1) that are functionally identical to the same features of the Model 165:

- Instruction set that includes System/360 instructions and the following System/370 instructions:

COMPARE LOGICAL CHARACTERS UNDER MASK	SET CLOCK, STORE CLOCK
COMPARE LOGICAL LONG	SHIFT AND ROUND DECIMAL
INSERT CHARACTERS UNDER MASK	START I/O FAST RELEASE
LOAD CONTROL, STORE CONTROL	STORE CHANNEL ID
MOVE LONG	STORE CHARACTERS UNDER MASK
	STORE CPU ID

- Extended-precision floating point
- Overlap of instruction fetching and preparation with instruction execution (implementation of the instruction and execution units is enhanced in the Model 168)\*
- Store and fetch protection
- Multiple control registers (more registers are implemented in the Model 168 than in the Model 165)\*
- Interval timer (3.3 millisecond resolution)
- Time of day clock
- Byte-oriented operands
- Extended external interruption masking
- Expanded machine check interruption class (additional facilities are provided in the Model 168)\*
- Extended channel logout
- Instruction retry, ECC on processor storage, and command retry
- Writable monolithic control storage
- High-speed buffer storage - 8K
- Direct control

The following are optional features of the Model 168 (Model 1) that are functionally identical to the same features on the Model 165:

- High Speed Multiply (increases speed of fixed- and floating-point multiply operations by a factor of two to three)
- Buffer Expansion for the addition of 8K of buffer storage (the 16K buffer has a slightly different organization in the Model 168)\*
- 7070/7074 Compatibility
- 7080 Compatibility
- 709/7090/7094II Compatibility
- 2870 Multiplexer Channels and attachment feature, 2860 Selector Channels and attachment feature, and 2880 Block Multiplexer Channels (one 2860, one 2880, or one 2870 with one selector subchannel is required)
- Extended Channels (for up to twelve channels)
- Channel-to-Channel Adapter on 2860 selector channels
- Extended Unit Control Words on 2880 Block Multiplexer Channels
- 3066 Model 2 System Console (required) - a few new items are provided
- 2955 Remote Analysis Unit

The following are standard features of the Model 168 (Model 1) that are not available for the Model 165:

- New instructions\*
  - CLEAR I/O
  - COMPARE AND SWAP
  - COMPARE DOUBLE AND SWAP
  - INSERT PSW KEY
  - LOAD REAL ADDRESS
  - MONITOR CALL
  - PURGE TLB
  - RESET REFERENCE BIT
  - SET CLOCK COMPARATOR
  - SET CPU TIMER
  - SET PSW KEY FROM ADDRESS
  - STORE CLOCK COMPARATOR
  - STORE CPU TIMER
  - STORE THEN AND SYSTEM MASK
  - STORE THEN OR SYSTEM MASK

\*Part of the Dynamic Address Translation Facility of a Model 165 II. The functional descriptions of these items in this publication apply to their implementation in both the Model 168 and the Model 165 II, unless otherwise indicated.

- EC mode of system operation\*
- Dynamic address translation\*
- Reference and change recording\*
- CPU timer and clock comparator\*
- Program event recording\*
- Monitoring feature\*
- Program interruption for SET SYSTEM MASK instruction\*
- Store status function\*
- Monolithic read-only control storage (instead of capacitor read-only)\*
- Monolithic processor storage (instead of core storage)
- Channel dual I/O bus

\*Part of the Dynamic Address Translation Facility of a Model 165 II. The functional descriptions of these items in this publication apply to their implementation in both the Model 168 and the Model 165 II, unless otherwise indicated.

The following are optional features of the Model 168 (Model 1) that are not available for a Model 165:

- Channel Indirect Data Addressing for 2860, 2870, and 2880 channels (required by the virtual storage operating systems and available for the Model 165 II)
- Integrated Storage Controls for attachment of 3330-series and/or 3340 disk storage, or the 3850 Mass Storage System
- Two-Channel Switch for Integrated Storage Controls
- Staging adapter for Integrated Storage Controls
- Power Warning
- Multiprocessing (3068 Multisystem Unit)

All the new features of the Model 168 Model 1 except Integrated Storage Controls, multiprocessing, and those related to implementing virtual storage (such as dynamic address translation and reference and change recording) are discussed in the remainder of this section.

#### 20:10 THE CENTRAL PROCESSING UNIT

Like the Model 165, the Model 168 has a CPU cycle time of 80 nanoseconds and an internal data path that is eight bytes wide. The implementation of local storage (80 nanosecond cycle time), read-only and writable control storage (80 nanosecond cycle times), expanded external interruption masking, and parity checking is the same in the two models. Control registers in addition to the four implemented in the Model 165 are implemented in the Model 168 in order to support new EC-mode-only functions. Additional control registers are implemented in the Model 165 II as well.

Implementation of the instruction and execution units in Models 168 and 165 differs in several aspects in order to provide better overlap of instruction preparation with instruction execution and to provide functions required by new Model 168 hardware features, such as dynamic address translation. (This new implementation is also provided in a Model 165 II.) Significant differences are the following:

- In the Model 168, up to four instructions can be prepared and await execution while one instruction is being executed. The Model 165 can prepare and hold up to three instructions.
- When an incorrect estimate of the success of a conditional branch has been made, the Model 168 can decode the correct instruction one cycle sooner than can the Model 165, if the instruction is presently in an instruction buffer.



- In the Model 168, a doubleword from a given instruction stream can be placed in the instruction buffers every machine cycle. This can be done every other cycle in a Model 165.
- In the Model 168, two registers are provided to hold data that is awaiting placement in processor storage. Each can hold up to eight bytes. The Model 165 has only one such register.
- The instruction unit in the Model 168 includes an instruction pretest function (explained under "Instruction Nullification" in Section 30:10).
- Imprecise interruptions do not occur in a Model 168. In a Model 165, an imprecise interruption occurs if an attempt is made to store data at an invalid storage address or at a storage-protected location. The Model 168 implementation of pretesting (for the dynamic address translation function) also ensures that such conditions do not cause imprecise interruptions in the Model 168.

#### EXTENDED CONTROL MODE

Extended control mode, unlike basic control mode, is exclusively a System/370 mode and is not implemented in System/360. In a Model 168, the optional Channel Indirect Data Addressing feature must be installed on all standalone channels for the channels to operate with EC mode enabled. Note that IBM-supplied operating systems do not support System/370 models operating in EC mode without dynamic address translation operative also. Facilities that depend on which mode is in effect are discussed below. Any item not covered operates identically in BC and EC modes. (The discussion of EC/BC mode differences applies to the Model 165 II also.)

#### Change in PSW Format

When a System/370 operates in EC mode, the format of the PSW differs from the BC mode format. Both PSW formats are shown in Figure 20.10.1. In EC mode, the PSW does not contain individual channel mask bits, an instruction length code, or the interruption code for a supervisor call, external, or program interruption. The channel masks are contained in control register 2, and the other fields are allocated permanently assigned locations in fixed processor storage above address 127.

Removal of the fields indicated provides room in the EC mode PSW for control of new features that are unique to EC mode (such as PER and DAT) and for the addition of summary mask bits (such as channel and I/O masks). Use of a single mask bit to control the operation of an entire facility (such as program event recording) or an entire interruption class (such as I/O and external) simplifies the coding required to enable and disable the system for these interruptions.

#### Change in Permanently Assigned Processor Storage Locations

When a System/370 operates in EC mode, the number of permanently assigned locations in lower processor storage is increased to include fields for storing instruction length codes, interruption codes (for supervisor call, external, and program interruptions), program event recording data, the I/O device address for an I/O interruption, and an exception address for the DAT feature. The model-independent BC mode and EC mode fixed storage areas for System/370 models are shown in Figure 20.10.2. The balance of the fixed area for the Model 168, that which has model-dependent fields, is shown in Figure 20.10.3. This model-dependent area is not affected by whether EC or BC mode is in

should be positioned closest to the Model 168 processor on the bus to which they are attached. Channel priority is established by plugging jumpers on matrix cards in the storage control unit.

A 2780 channel without a selector subchannel or with 1 or 2 selector subchannels should be given as high a channel priority as possible. A 2780 channel with more than two selector subchannels should be assigned priority position 1, 2, 3, or 4.

An aggregate data rate of 8.5 MB/sec can be sustained on each bus, which provides a total maximum aggregate data rate of approximately 17 MB/sec for the system. As a general rule, devices with the highest data rates should be attached to the highest priority channels. Table 20.20.1 indicates the channel priorities that the highest speed System/370 I/O devices require. That is, each I/O device in the table can be assigned only those priorities indicated in its column. Each column also indicates the maximum number of channels to which the device can be attached (four for the 2305 Model 1, six for the 2305 Model 2, etc). Permissible I/O device configurations are also shown by table 20.20.1, which in turn indicates the I/O device configurations that can operate concurrently. In general, any other device type with similar characteristics and the same or a slower data rate than the listed device can also be assigned the indicated channel priority. Negligible or no overrun exposure exists in a Model 168 system when the guidelines indicated in Table 20.20.1 are followed.

Table 20.20.1. Permissible configurations and channel priorities for highest speed System/370 I/O devices

Channel Priority	Device Type				
	2305 Model 1* 3 MB/sec	2305 Model 2* 1.5 MB/sec	3420 Model 8 1.25 MB/sec	3330-series* 3340* .8 MB/sec	3420 Model 6 .8 MB/sec
1	X	X	X	X	X
2	X	X	X	X	X
3		X	X	X	X
4	X	X	X	X	X
5	X	X	X	X	X
6		X	X	X	X
7			X	X	X
9			X	X	X
A			X*	X	X
B				X	X
C					X
D					X

\*Attaches via 2880 channel only

The presence of the channel dual I/O bus in the Model 168 permits greater flexibility in the physical layout of Model 168 components since the channel frames are attached to two separate cable sets instead of

only one, as for a Model 165. Greater flexibility in the cable lengths between channel frames attached to the same I/O bus is also provided by the Model 168.

#### 20:25 SYSTEM CONSOLE

The 3066 Model 2 System Console for the Model 168 has the same features as the 3066 Model 1 System Console for the Model 165: a cathode ray tube and keyboard, a microfiche indicator viewer, a microfiche document viewer, a processor storage configuration panel, a system activity monitor, and a device for loading microcode and diagnostics. In addition, the store status function is implemented. (The store status function is implemented in a Model 165 II as well.)

The operator can cause the contents of the following to be placed in processor storage by pressing the new store status button on the control panel:

CPU timer - locations 216-223  
Clock comparator - locations 224-231  
Current PSW - locations 256-263  
Floating-point registers - locations 352-383  
General registers - locations 384-447  
Control registers - locations 448-511

In addition to the store status button, the control panel on the 3066 Model 2 has system clear and cooling reset alarm pushbuttons, and a switch associated with the dynamic address translation feature.

#### 20:30 STANDARD AND OPTIONAL SYSTEM FEATURES

##### STANDARD FEATURES

Standard features for the System/370 Model 168 (Models 1 and 3) are

- BC and EC mode of operation
- Instruction set that includes binary, decimal, floating-point, and extended precision floating-point arithmetic, and System/370 instructions. Standard System/370 instructions for the Model 168 are:

\*CLEAR I/O  
COMPARE AND SWAP  
COMPARE DOUBLE AND SWAP  
COMPARE LOGICAL CHARACTERS UNDER MASK  
COMPARE LOGICAL LONG  
INSERT CHARACTERS UNDER MASK  
\*INSERT PSW KEY  
\*LOAD CONTROL  
\*LOAD REAL ADDRESS  
MONITOR CALL  
MOVE LONG  
\*PURGE TLB  
\*RESET REFERENCE BIT  
\*SET CLOCK  
\*SET CLOCK COMPARATOR  
\*SET CPU TIMER  
\*SET PSW KEY FROM ADDRESS

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\*Privileged instruction

SHIFT AND ROUND DECIMAL  
\*START I/O FAST RELEASE  
\*STORE CHANNEL ID  
STORE CHARACTERS UNDER MASK  
STORE CLOCK  
\*STORE CLOCK COMPARATOR  
\*STORE CONTROL  
\*STORE CPU ID  
\*STORE CPU TIMER  
\*STORE THEN AND SYSTEM MASK  
\*STORE THEN OR SYSTEM MASK

\*Privileged instruction

- Dynamic Address Translation
- Reference and Change Recording
- Instruction retry
- Interval timer (3.3 ms resolution)
- Time of day clock
- Clock comparator and CPU timer
- Monitoring feature
- Program Event Recording
- Program interruption for SSM instruction
- Expanded machine check interruption class
- ECC on processor storage
- Byte-oriented operands
- Store and fetch protection
- High-speed buffer storage - 8K bytes in the Model 1, 32K bytes in the Model 3
- Attachment for up to seven channels
- Channel dual I/O bus
- Channel retry data in extended channel logout area
- Writable and read-only control storage
- Store status function
- Direct Control

OPTIONAL FEATURES

Optional features for the System/370 Model 168 (Models 1 and 3), which can be field installed unless indicated otherwise, are:

- 3066 Model 2 System Console (required in all configurations)
- High-Speed Multiply\*\*
- Buffer Expansion for inclusion of a 16K buffer (Model 1 only)
- 7070/7074 Compatibility\*\*
- 7080 Compatibility\*\*
- 709/7090/7094/7094II Compatibility\*\*
- 2870 Byte Multiplexer Channels, 2860 Selector Channels, and 2880 Block Multiplexer Channels
- Channel Indirect Data Addressing for 2870, 2860, and 2880 channels (required when OS/VS1, OS/VS2, or VM/370 is used)
- Extended Channels (for up to twelve channels)
- Channel-to-Channel Adapter on 2860 Channels
- Extended Unit Control Words on 2880 channels (mutually exclusive with the Two-Byte Interface feature)
- Integrated Storage Controls
- Two-Channel Switch for Integrated Storage Controls
- Staging Adapter for Integrated Storage Controls
- Power Warning
- 2955 Remote Analysis Unit
- Multiprocessing (3068 Multisystem Unit)

\*\*Not recommended for field installation

Note: Compatibility features are mutually exclusive

## SECTION 30: VIRTUAL STORAGE AND DYNAMIC ADDRESS TRANSLATION

The first subsection, 30:05, discusses the needs that virtual storage and dynamic address translation in System/370 are designed to address. No previous understanding of these facilities is assumed. In this discussion, an address space is defined as a consecutive set of addresses that can be used in programs to reference data and instructions. System operation in IBM-supplied virtual storage environments is explained conceptually, without use of all the terminology new to such an environment.

The general advantages of IBM-supplied virtual storage operating systems are presented also. Included in this subsection are those that apply to OS/VS1 and OS/VS2. Additional advantages of virtual storage that are specific to a particular IBM-supplied operating system are discussed in the optional supplement for that operating system.

The last portion of subsection 30:05 defines the terminology associated with virtual storage and dynamic address translation hardware. The terminology included is that common to the four IBM-supplied programming systems that support a virtual storage environment for System/370. However, specific references to DOS/VS are not made where a difference between DOS and OS exists, since DOS/VS does not support the Model 168. Terms unique to a particular programming system are defined in the optional supplement that describes that programming system.

Subsection 30:10 describes in detail the implementation and operation of dynamic address translation and channel indirect data addressing hardware in the Model 168 (Models 1 and 3). Other hardware items associated with dynamic address translation, such as reference and change recording, are discussed as well.

The last subsection, 30:15, discusses the new factors that affect system performance in a virtual storage environment. The information presented is related to efficient installation and utilization of an IBM-supplied virtual storage operating system.

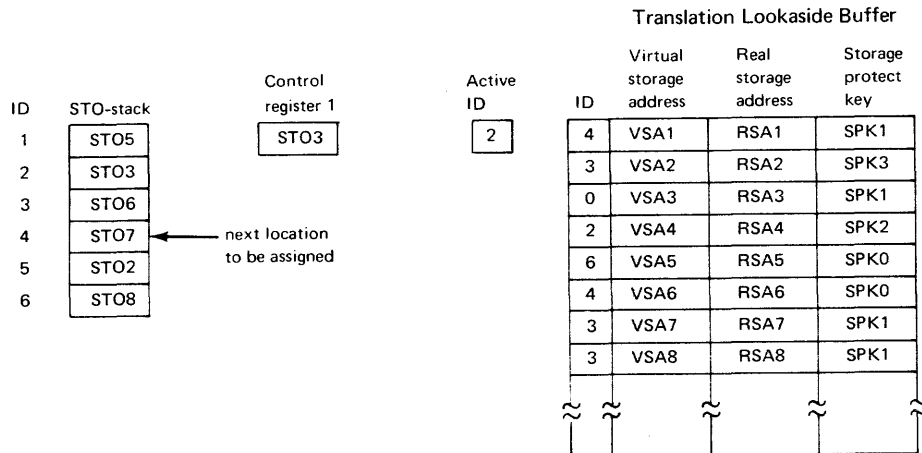
The two optional programming systems supplements (Sections 90 and 100) for the virtual storage operating systems for the Model 168 (OS/VS1 and OS/VS2 Release 1) assume knowledge of the entire contents of Section 30. The optional supplement for VM/370 (Section 110) assumes knowledge of subsections 30:05 and 30:10 only, since performance in a virtual machine environment is discussed in the VM/370 supplement. This entire section applies to the Model 165 II as well as to the Model 168, except where differences are noted.

### 30:05 VIRTUAL STORAGE CONCEPTS, ADVANTAGES, AND TERMINOLOGY

#### THE NEED FOR LARGER ADDRESS SPACE

The past and present rapid growth in the number and types of data processing applications being installed has led to an increasing demand for more freedom to design applications without being concerned about, or functionally constrained by, the physical characteristics of a particular computer system--system architecture, I/O device types, and processor storage size. As program design and implementation become easier, they can enable more rapid installation of applications, so that the benefits of data processing can be achieved sooner.

placed in the STO-stack, and the STO-stack identification number assigned becomes the active identification. A first-in first-out algorithm is used to determine which STO-stack location to assign. If the new address displaces another segment table address, the TLB entries associated with the displaced segment table (and virtual storage) must be purged. This is done by setting the identification number to zero for each entry in the TLB that has the same STO-stack identification number as the segment table address that was displaced. This identification number is now assigned to the newly stored segment table address. The other TLB entries need not be invalidated. See Figure 30.10.4 for an example of TLB purging when control register 1 is changed.



**Effect of Changing Control Register 1**

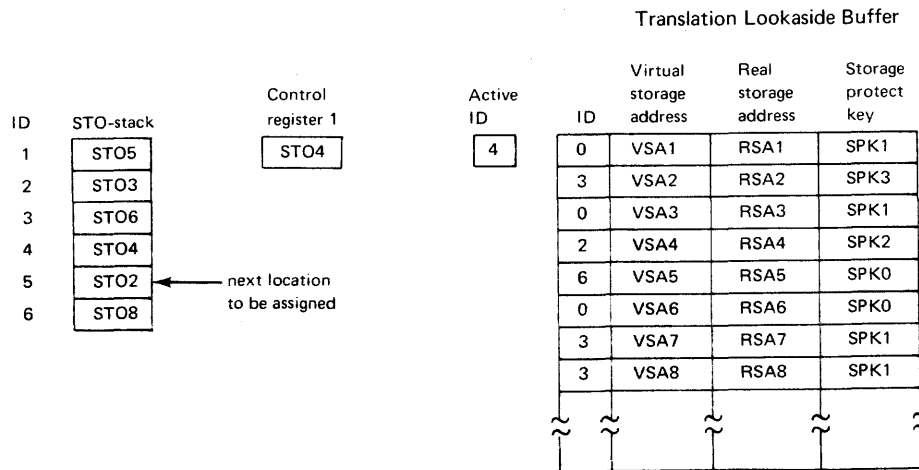


Figure 30.10.4. TLB purging when control register 1 is changed

Implementation of the STO-stack in the Model 168 enables a control program that supports multiple virtual storages (such as VM/370) to alter control registers 0 and 1 in order to change the virtual storage for which address translation is effective, without automatically causing purging of the entire TLB. The STO-stack facility will also be of benefit in an OS/VS2 environment, since OS/VS2 Release 1 supports two

segment tables to provide fetch protection for all regions (see OS/Virtual Storage 2 Release 1 Features Supplement).

### Addresses Translated

All storage addresses that are explicitly designated by a program and that are used by the CPU to refer to instructions or data in processor storage are virtual storage addresses and are subject to address translation. Thus, when DAT is operative, the starting and ending storage addresses used with the program event recording feature are virtual, as are the storage addresses stored in PSW's during interruptions. Address translation is not applied to addresses that explicitly designate protect key storage locations or to quantities that are formed as storage addresses from the values designated in the base and displacement fields of an instruction but that are not used to address processor storage (shift instructions, for example). In addition, address translation is not applied to the storage addresses in CCW lists used for I/O operations.

Some of the storage addresses supplied to a program by the CPU are virtual and some are real. Table 30.10.2 lists, for the Model 168, those storage addresses designated by a program, either explicitly or implicitly, that are virtual (and, therefore, are subject to translation) and those addresses that are real or not used to reference processor storage and, thus, are not translated. The table also indicates which storage addresses supplied to a program are virtual and which are real.

### FEATURES TO SUPPORT DEMAND PAGING

#### Reference and Change Recording Facility for Real Storage Blocks

A hardware recording facility is standard in the Model 168. This facility provides continuous recording of the activity of all 2K real storage blocks via reference and change bits. The settings of these recording bits can be used by control program routines to support a demand paging environment. This hardware facility is always active; it does not depend on EC or translation mode being operative.

The seven-bit key associated with each 2K real storage block in the Model 168 has four storage-protect bits, one fetch-protect bit, one reference bit, and one change bit. During system operation, the activity of each 2K real storage block is monitored by hardware. Whenever a fetch is made either by a CPU or a channel to a real storage address, the reference bit in the key associated with the 2K storage block that contains that real storage address is turned on by the hardware. A store into any real storage address causes the hardware to turn on both the change bit and the reference bit for the affected 2K block.

Store/display operations initiated from the 3066 console also cause appropriate changing of the reference and change bits. The RESET REFERENCE BIT instruction is provided to allow the reference bit of any 2K real storage block to be reset by programming without altering the contents of the other six bits in the protect key. A CPU fetch that is satisfied with data contained in the buffer does not cause reference recording in the Model 168. There are situations, however, in which instruction or operand prefetching may cause the reference bit for a page frame to be turned on even though the contents of that page are never used.

programs just as if the operating system were executing in a real machine. In order to initiate operations in a virtual machine, the user must log on the virtual machine and IPL an operating system in it. The logon procedure establishes a connection with CP and the existence of a specific virtual machine for this user. A logon is performed using a console or terminal device of the type that CP supports as a virtual operator's console.

The virtual operator's console is the means by which the user controls the operation of his virtual machine and communicates with the operating system executing in it. CP provides a set of commands that (1) simulate the system control panel of the virtual machine, (2) provide for alteration of a virtual machine configuration, (3) request various services from CP for a virtual machine, and (4) control operation of the real machine. When a CP command is entered via the virtual operator's console, CP receives control and performs the required functions. Communication between the user and the operating system is accomplished using the operating system command language and the virtual operator's console. CP performs any simulation required to make the real I/O device the operator is using as a virtual operator's console appear to be the primary console device type that is defined for the operating system.

In a VM/370 environment, a virtual operator's console is frequently called a remote terminal because, in most cases, a terminal device type is actually used as the virtual operator's console device. However, the real I/O device that is used as the virtual operator's console may be a System/370 console device as well as a local or a remote terminal.

VM/370 supports execution of any one of the following System/360 and System/370 programming systems in a virtual machine:

- CMS component of VM/370
- RSCS component of VM/370
- DOS Version 3, DOS Version 4, or DOS/VS
- APL 360-DOS
- OS PCP, MFT, or MVT
- OS ASP Version 3
- OS/VS1
- OS/VS2 Release 1
- OS/VS2 Releases 2 and up in uniprocessor mode only
- PS44
- VM/370

Any number and combination of the above operating systems can execute concurrently in a VM/370 environment, subject to the availability of the required real machine resources, including multiple copies of the same operating system (OS/VS1 executing in more than one virtual machine, for example). With a few exceptions, all the facilities that are supported by these operating systems when they execute in a real machine can be used when the operating system executes in a virtual machine in a VM/370 environment. Figure 40.05.1 conceptually illustrates the real and virtual machine environment that is supported by VM/370.



Each virtual machine that is to be supported by CP must be user defined and stored in the VM/370 directory. The size of virtual storage, the virtual I/O devices to be used, the options to be used, and a virtual console are usually specified. Virtual machine configurations can be different from each other and, within certain limitations, different from that of the real machine in terms of these specifications.

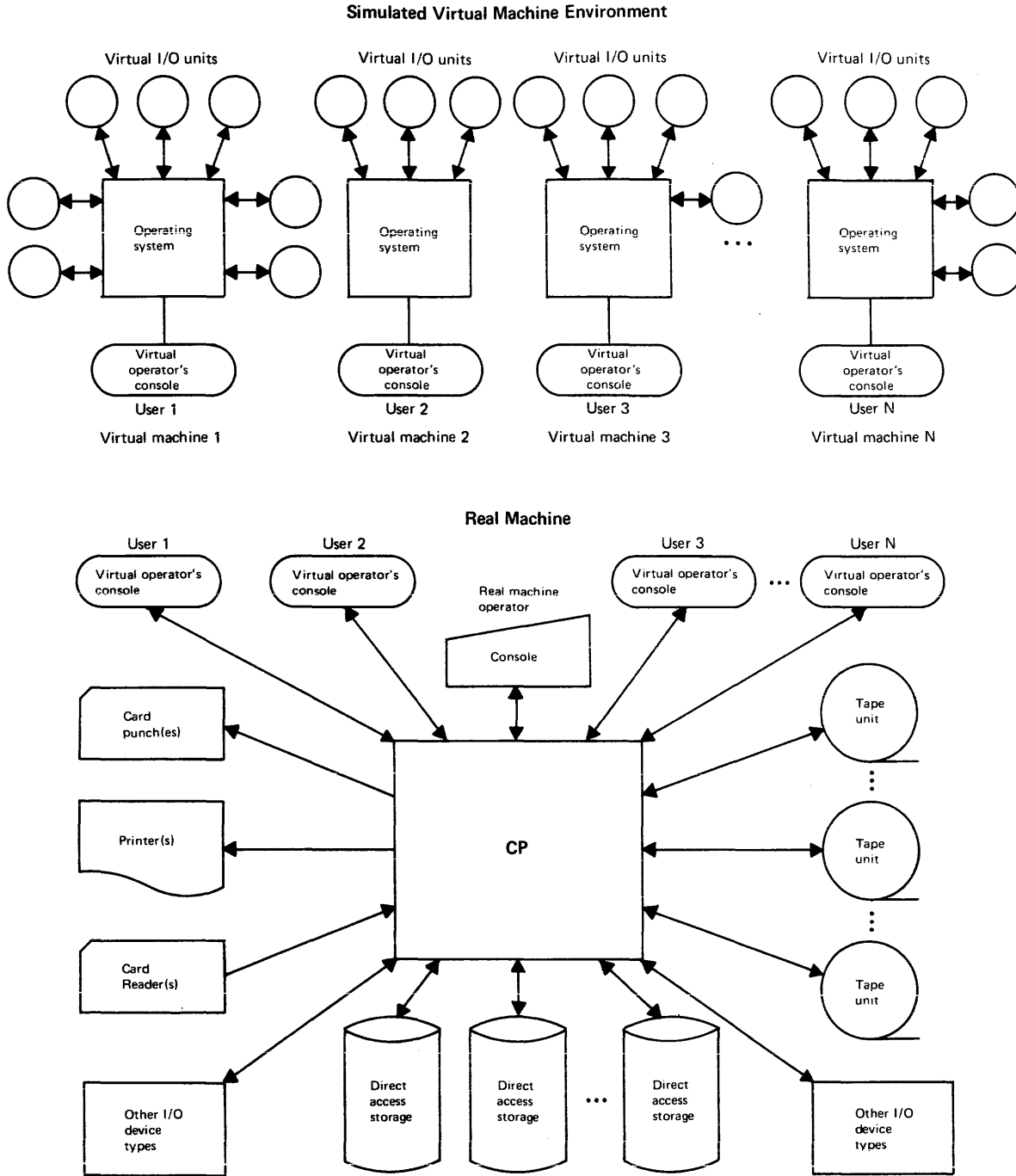


Figure 40.05.1. Conceptual illustration of the real and virtual machine environment that is supported by VM/370

Model 11 3336 Disk Packs are interchangeable across all 3330 Model 11 and 3333 Model 11 drives but cannot be used with Model 1 and 2 3330-series drives. The 3336 Model 11 Disk Pack has a physical interlock so that it cannot be mounted on a 3330 Model 1 or 2 drive or a 3333 Model 1 drive. The 3336 Model 1 Disk Pack has a physical interlock so that it cannot be mounted on a Model 11 drive. The 3336 Model 1 Disk Pack can be converted to a Model 11.

Table 50.10.1 compares Model 1, 2, and 11 drive characteristics. Table 50.10.2 compares 3336 Model 1 and 11 Disk Pack characteristics.

Table 50.10.1. Capacity and timing characteristics of 3330-series drives

Characteristic	3330-series Model 1 or 2 drive	3330-series Model 11 drive
Capacity in thousands of bytes (full-track records)	100,018	200,036
Seek time (ms)		
Maximum	55	55
Average	30	30
Average cylinder-to-cylinder	10	10
Time channel busy searching when SET SECTOR is used (ms)		
Minimum	.120	.120
Maximum	.380	.380
Rotation time (ms)	16.7	16.7
Rotation speed (rpm)	3600	3600
Data transfer rate (KB/sec)	806	806

Table 50.10.2 3336 Model 1 and 11 Disk Pack characteristics

Characteristic	3336 Model 1	3336 Model 11
Number of disks per pack	12	12
Number of recording disks	10	10
Number of recording surfaces	19	19
Disk thickness in inches	.075	.075
Disk diameter in inches	14	14
Disk pack weight in pounds	20	20
Disk pack maximum capacity in millions of bytes	100	200
Full track capacity in bytes	13,030	13,030
Cylinders per pack	404 plus 7 alternates	808 plus 7 alternates
Tracks per cylinder	19	19
Tracks per pack	7,676	15,352

#### ATTACHMENT VIA INTEGRATED STORAGE CONTROLS

Optionally, one Integrated Storage Controls (ISC) feature can be installed on a Model 168 to attach 3330-series and/or 3340 disk storage to one or two 2880 Block Multiplexer Channels. Attachment of 3330-series and 3340 disk storage via 3830 Storage Control is possible as well. The following discusses attachment to the ISC of 3330-series strings only.

The Integrated Storage Controls feature includes dual direct access storage controls, each of which operates independently of the other and

is functionally like 3830 Storage Control Model 2 except for the following:

- The Integrated Storage Controls feature is contained in the main frame of the Model 168 and is powered by it.
- The Two-Channel Switch, Additional feature (that provides four-channel switching) cannot be attached to the storage controls in the ISC feature.

Both logical storage controls in the ISC feature can be attached to the same 2880 channel or they can be attached to two different 2880 channels connected to the Model 168. Each logical storage control can have attached a maximum of four 3330-series strings of up to eight drives each. The 32 Drive Expansion and Control Store Extension optional features (field installable) must be installed in the ISC in order to attach more than two strings to each logical control. Therefore, up to 64 drives (eight strings) can be attached to the Model 168 via the ISC feature. The first module in each 3330-series string must be a 3333 Disk Storage and Control Model 1 or 11 unit.

The 3330-series drives attached to ISC operate just as if they were attached via 3830 Storage Control Model 2. That is, when multiple requesting is used, each logical storage control within the ISC can handle up to 32 channel programs concurrently, one on each of its drives, and only one of the 32 drives can be transferring data at a time. When a malfunction occurs, diagnostics can be run on one logical storage control and its drives, while normal operations take place on the other logical storage control in the ISC.

The ISC feature provides lower-cost attachment of 3330-series disk storage than 3830 Storage Control Model 2 when two storage control units are required, and floor space is saved since the ISC is in the Model 168 CPU. See Table 50.15.3 for a summary of the capabilities of the 3830 Models 1 and 2 and ISC.

The Two-Channel Switch optional feature is also available for the ISC feature. When installed, this feature provides a two-channel switching capability for both of the logical storage controls. The Two-Channel Switch feature permits each integrated storage control unit to be attached to two channels in the same Model 168 or to one channel in the Model 168 and one channel in another System/370. Figure 50.10.1 summarizes the 3330-series string configurations that are possible for the Model 168 ISC. Intermixing 3330-series and 3340 strings on an attachment is discussed in Section 50:15.

The 3333 String Switch optional feature can be installed on a 3333 Model 1 or 11 that is attached to the 3830 Model 2 or ISC. This field-installable feature enables the 3333 and all its attached 3330s (a 3330-series string) to be connected to two control unit type attachments instead of only one. The attachments can be any combination of two of the following:

- 3830 Storage Control Model 2
- Integrated Storage Controls for Models 158 and 168 (or the two logical controls in one ISC)
- Integrated Storage Control for the Model 145
- 3345 Storage and Control Frame Models 3, 4, and 5 for the Model 145
- 3330/3340 series IFA for the Model 135

The two attachments to which a 3333 with the 3333 String Switch feature is connected can be attached to the same or different channels in the same CPU, or to channels in two different CPU's. In addition, channel switching features can be installed on one or both of these attachments.

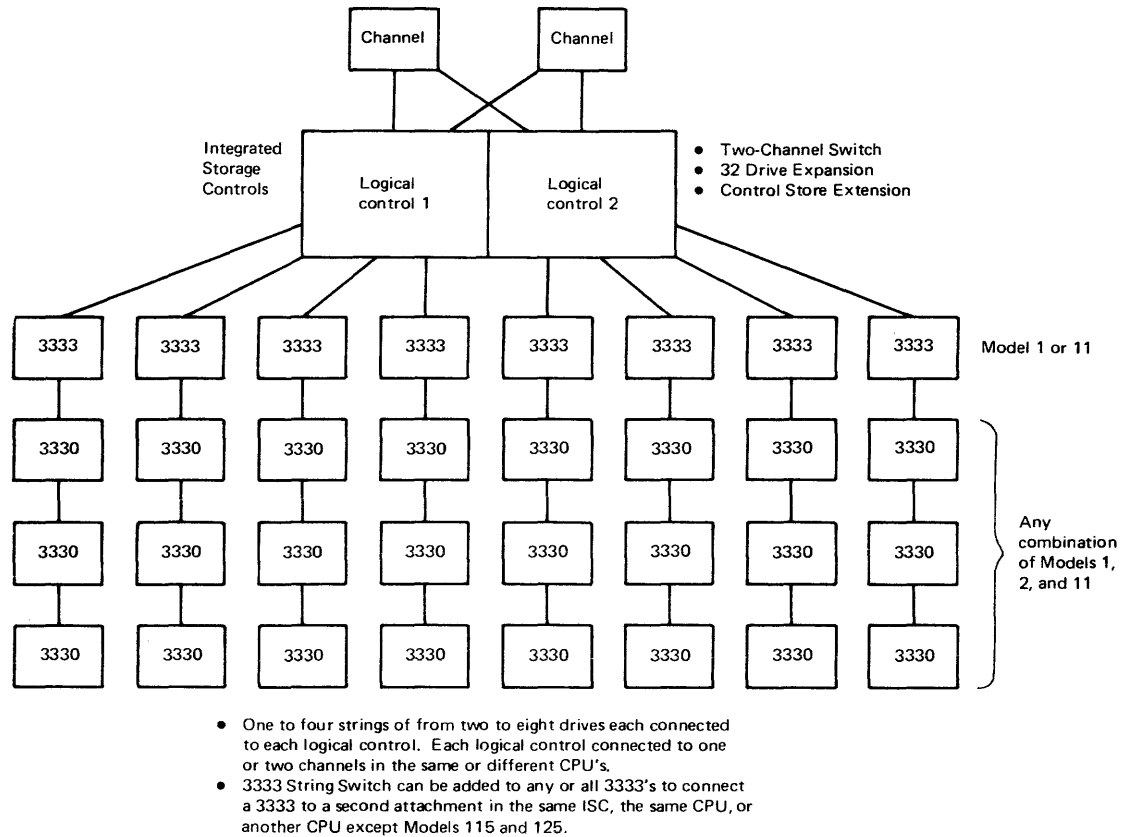


Figure 50.10.1. Permissible 3330-series string configurations for the Model 168 Integrated Storage Controls feature

The 3333 String Switch is functionally similar in its operation to the Two-Channel Switch. A switch can be set to allow the 3330-series string to be accessed via both attachments, one at a time. In effect, this setting provides two control unit paths to the string. String switching is accomplished dynamically under program control. Alternatively, the switch can be set to dedicate the string to one attachment or the other so that the string can be accessed only via that attachment.

Figure 50.10.2 illustrates 3333 string switching for four 3330-series strings. In the configuration shown, all strings can be accessed via two channels and two control units. Channel switching, string switching, and 32 Drive Expansion features can be used to enhance the availability of 3330-series disk storage and to extend backup capabilities when two System/370 systems (the same or different models) are present in an installation.

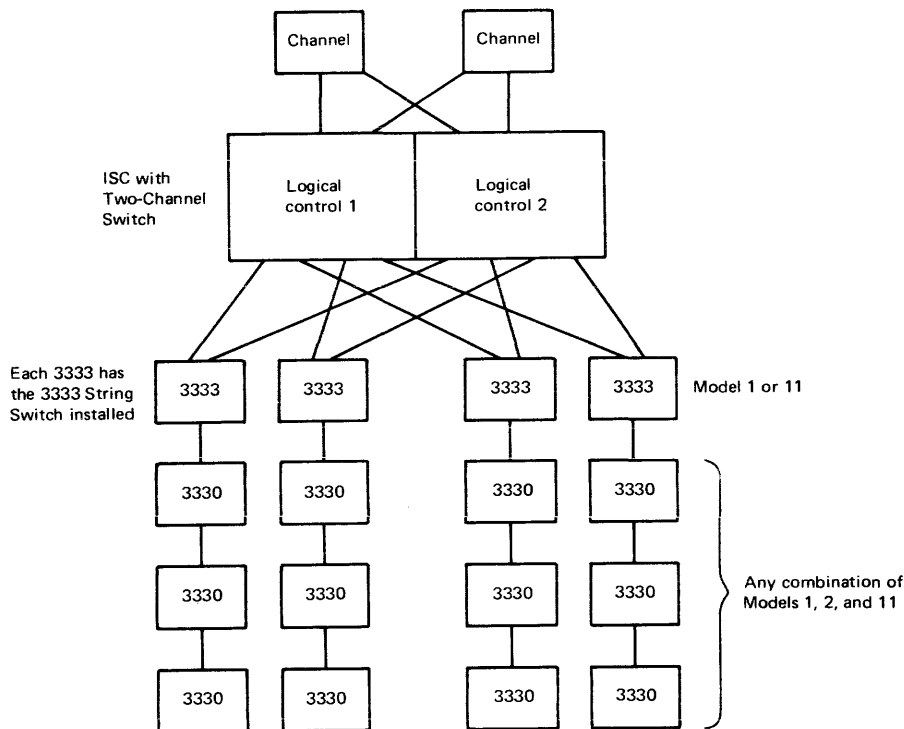


Figure 50.10.2. Sample 3330-series string configuration with string switching

Optionally, the staging adapter feature can be installed on the ISC to permit attachment of the 3850 Mass Storage System to the ISC. The ISC provides the same functions for the 3850 as 3830 Storage Control Model 3. The staging adapter permits the addressing capability of each of the four ISC paths to be expanded to a maximum of 64 unique addresses. When the staging adapter is installed, the control store extension feature must also be installed and 3340 disk storage cannot be attached to the ISC.

- Statistical usage recording by the 3830 Model 2. Statistical usage counters for each drive in a 3340 string are continuously maintained by the 3830 Model 2. These counters indicate the number of bytes read/searched, number of seeks issued, and number of command and data overruns for each device. When a counter reaches its threshold or a data module is removed from a drive, the 3830 Model 2 indicates the condition via a unit check when the next I/O operation is initiated to the drive or a data module is made ready on the drive. Counter data can be obtained and counters can be reset by issuing a READ AND RESET BUFFERED LOG command.
- Inline diagnostic testing of a malfunctioning drive. (Inline diagnostics are provided only for 2314 facilities.) A 3830 Model 2 control unit can execute diagnostic tests on a malfunctioning drive while normal operations take place on the remaining drives in the string. Diagnostic tests can be loaded into a transient area of the control storage of the 3830 Model 2 and executed on the malfunctioning drive. This can be done in an online environment using OLTEP or the CE panel on the 3830 Model 2. OLTSEP can be used in a standalone environment. This inline testing allows CE diagnosis and repair of most 3340 drive failures without the necessity of taking the entire 3340 string out of the system configuration.

A 3340 drive can be placed in CE mode (offline to the system) by means of a switch that is located inside the rear door of the drive so that maintenance functions can be performed. To take the 3340 drive out of CE mode and return it to online status, the attention pushbutton must be pressed. This also causes the access mechanism to move to physical track 0.

#### ATTACHMENT VIA INTEGRATED STORAGE CONTROLS

Optionally, one Integrated Storage Controls feature can be installed on a Model 168 to attach 3340 and/or 3340-series disk storage to one or two block multiplexer channels. Attachment of 3340 and 3330-series disk storage via 3830 Storage Control is possible as well. The following discusses attachment of 3340-series strings only.

The Integrated Storage Controls feature includes dual direct access storage controls, each of which operates independently of the other and is functionally like 3830 Storage Control Model 2 except for model following:

- The Integrated Storage Controls feature is contained in the main frame of the Model 168 and is powered by the Model 168 CPU.
- The Two-Channel Switch, Additional feature (that provides four-channel switching) cannot be attached to the logical storage controls in the ISC feature.

Both logical storage controls in the ISC feature can be attached to the same channel, two different channels in the Model 168 configuration, or a channel in the Model 168 configuration and a channel in another System/370. Each logical storage control can have attached a maximum of four 3340 strings of up to eight drives each. The 32 Drive Expansion and Control Store Extension optional features (field installable) must be installed in the ISC in order to attach more than two strings to each logical control. Therefore, up to 64 drives (eight strings) can be attached to the Model 168 via the ISC. The first unit in each 3340 string must be a 3340 Model A2.

The 3340 drives attached to the ISC operate just as if they were attached via 3830 Storage Control Model 2. That is, when multiple requesting is used, each logical storage control within the ISC can handle up to 32 channel programs concurrently, one on each of its drives, and only one of the 32 drives can be transferring data at a

time. When a malfunction occurs, diagnostics can be run on one logical storage control and its drives while normal operations take place on the other logical storage control in the ISC.

Intermixing 3340 and 3330-series strings on the ISC is discussed below. Figure 50.15.9 summarizes the 3340 string configurations that are possible for a Model 168 ISC.

The ISC feature provides lower-cost attachment of 3340 disk storage than 3830 Storage Control Model 2 when two storage control units are required, and physical space is saved since the ISC is in the Model 168 CPU.

The Two-Channel Switch optional feature is also available for the ISC. When installed, this feature provides a two-channel switching capability for both of the logical storage controls. The Two-Channel Switch permits each logical storage control to be attached to two channels in the same Model 168 configuration or to one channel in the Model 168 configuration and one channel in another System/370. Two switches are provided that can be set to dedicate a logical storage control to one channel or the other, or to enable the storage control to be accessed by both channels.

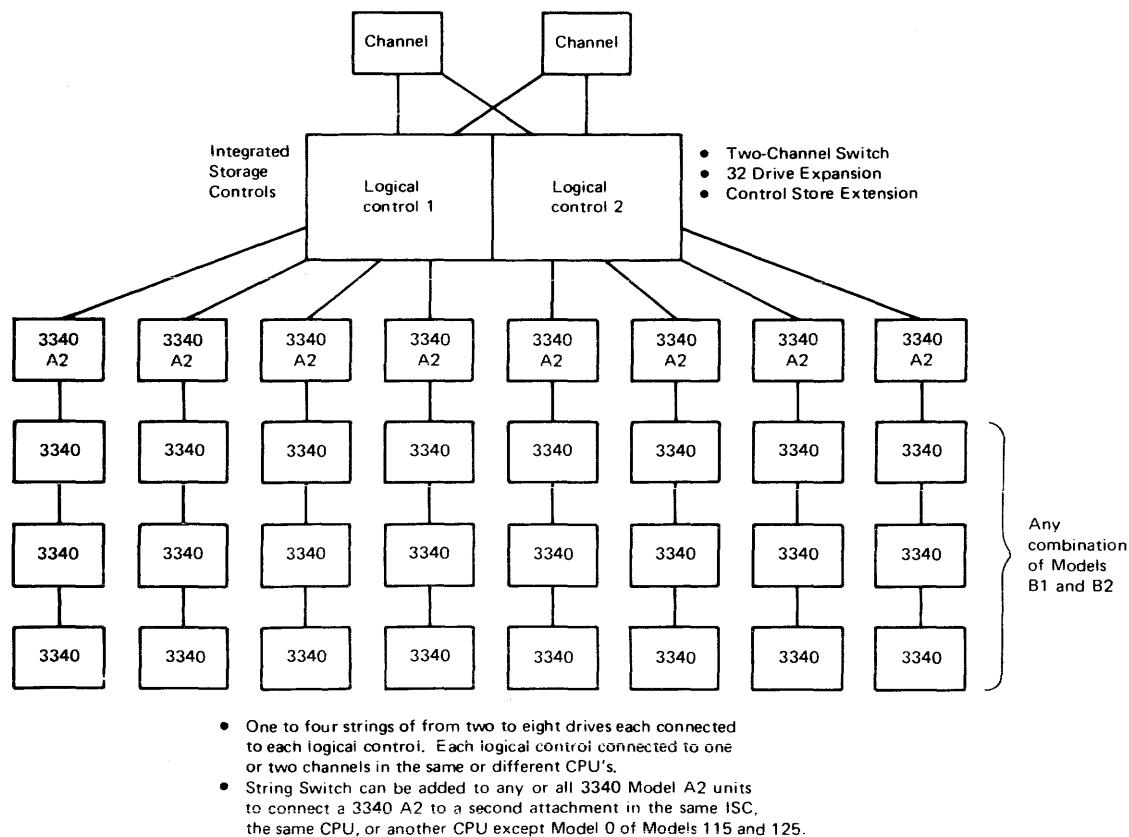


Figure 50.15.9. Permissible 3340 string configurations for the Model 168 Integrated Storage Controls feature

The String Switch optional feature can be installed on a 3340 Model A2 that is attached to the ISC. This field-installable feature enables the 3340 Model A2 and all its attached 3340s (a 3340 string) to be connected to two control unit type attachments instead of only one. The attachments can be any combination of two of the following:

- 3830 Storage Control Model 2
- Integrated Storage Controls for Models 158 and 168 (or the two logical controls in one ISC)
- Integrated Storage Control for the Model 145
- 3345 Storage and Control Frame Models 3, 4, and 5 for the Model 145
- 3330/3340 Series IFA for the Model 135
- Direct Disk Attachment of a Model 115 Model 2 or Model 125 Model 2

Except for the Direct Disk Attachment, the two attachments to which a 3340 Model A2 with the String Switch feature is connected can be attached to the same or different channels in the same CPU, or to channels in two different CPU's. In addition, channel-switching features can be installed on one or both of the attachments (except for the Direct Disk Attachment).

For Model 2 of Models 115 and 125, the String Switch enables two strings of 3340 drives to be attached to any System/370 model (except a Model 115 Model 0 or Model 125 Model 0) and a Model 115 Model 2 or Model 125 Model 2.

The String Switch is functionally similar in its operation to the Two-Channel Switch. A switch can be set to allow the 3340 string to be accessed via both attachments, one at a time. In effect, the setting provides two control unit paths to the string. String switching is accomplished dynamically under program control. Alternatively, the switch can be set to dedicate the string to one attachment or the other so that the string can be accessed only via that attachment.

Figure 50.15.10 illustrates string switching for four 3340 strings that are attached to the same ISC. In the configuration shown, all strings can be accessed via two channels and two control units. Channel switching, string switching, and 32 Drive Expansion features can be used to enhance the availability of 3340 disk storage and to extend backup capabilities when two System/370 systems (the same or different models) are present in an installation.



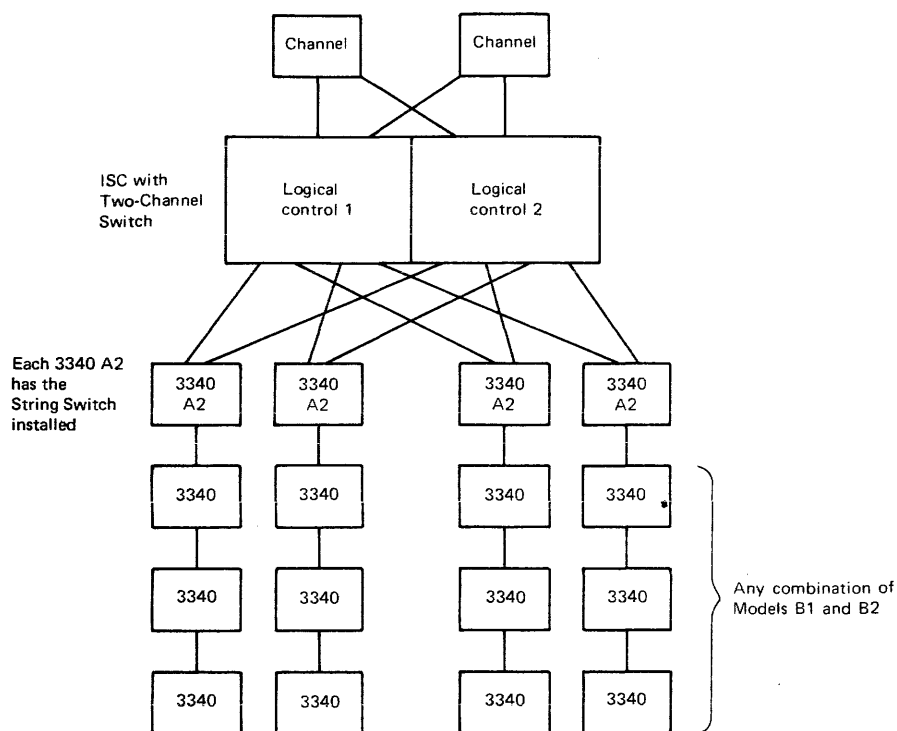


Figure 50.15.10. String switching for 3340 facilities attached to one ISC

#### INTERMIXING 3340 AND 3330-SERIES STRINGS ON AN ATTACHMENT

Optionally, the 3333/3340 Intermix feature can be installed on 3830 Storage Control Model 2 and integrated storage controls in the Model 168 CPU. When present, this field-installable feature permits both 3340 and 3330-series strings to be attached to a 3830 Model 2 or ISC. Each string must contain all 3340 drives or all 3330-series drives as usual.

The intermix feature requires installation of the Control Store Extension feature on the 3830 Model 2 or ISC and can coexist with other optional features for these units and their strings (channel switching, 32 Drive Expansion, string switching, and fixed head features).

#### SUMMARY

The hardware features of the 3340 and 2314 direct access storage facilities are summarized in Table 50.15.3. Table 50.15.4 compares the capabilities of the 3830 Model 1, 3830 Model 2, and Model 168 integrated storage controls for both 3340 and 3330-series disk storage.

When compared with the 2314 facility, the 3340 facility offers the following major advantages:

- **Faster access to data**
  - Data transfer rate almost three times that of the 2314
  - Seek times approximately 40% of those of the 2314 for movable head accesses
  - Zero seek time provided by the fixed heads in a 3348 Model 70F Data Module
  - Rotational delay interval approximately 20% shorter than for the 2314

- Larger capacity per drive
  - 17% for the Model 35 Data Module
  - 175% for Model 70 and 70F Data Modules
- Two capacity options per drive for expanded growth flexibility
- Multiple requesting and rotational position sensing capabilities for use with block multiplexer channels
- Operational improvements
  - Cover tightening/untightening and removable/replacement operations are eliminated, which speeds up data module loading and unloading
  - Load time to ready status for a mounted data module is three times faster
  - Write protection is provided on a data module basis
  - External labeling procedures are more flexible and leave less chance of erroneous data module labeling
- Significantly increased reliability
  - Sealed cartridge design eliminates head-to-disk alignment problems, minimizes the possibility of disk surface contamination, and eliminates hub wear and damage
  - Advanced head design makes head crashes a remote possibility and permits increased recording density without any loss of reliability
- Improved error handling capabilities
  - Error correction data is provided by the hardware for use by programmed error recovery procedures
  - Surface defect skipping reduces the need to use the error correction capability
- Improved availability and serviceability
  - No preventive maintenance is scheduled, because of the reliability features of the 3340 and 3348
  - Faster error isolation and correction is possible because the 3340 contains fewer circuit cards
  - Expanded microdiagnostics can test more than 95% of the circuits in a 3340

Table 50.15.3. Summary of the hardware features of 3340 and 2314 disk storage facilities

Feature	3340 attached to 3830 Model 2 or ISC	2314 (A-Series)
Number of drives per string or facility	Two to eight in one drive increments	One to eight in one-drive increments. (A ninth can be included as a spare only.)
Number of strings or facilities per control unit	One to four (maximum of eight strings for ISC)	One maximum
Data medium used	Removable interchangeable data module (sealed cartridge)	Removable interchangeable disk pack
Read only feature on drive or data medium	Yes on data module	No
Removable address plugs on drive	No	Yes
Attachment of a string or facility to two control units in the same or a different CPU	Yes via optional string switch feature. Only one data transfer operation permitted per string.	Yes via 2844 Auxiliary Storage control. Two concurrent data transfer operations per facility permitted.
Two-Channel Switch	Optional	Optional
Attachment of the control unit to four channels	Yes using the optional Two-Channel Switch and Two-Channel Switch Additional features (3830 Model 2 only)	Yes using the optional Two-Channel Switch and 2844 Auxiliary Storage Control
Record Overflow	Standard	Standard
File Scan	Not available	Standard
Multiple track operations	Standard	Standard
Multiple requesting	Standard	Not available
Rotational Position Sensing	Optional (on 3340 drives)	Not available
Error correction data presented by control unit	Yes	No
Surface defect skipping	Yes	No

## SECTION 65: DIFFERENCES BETWEEN THE MODEL 3 AND THE MODEL 1

Model 3 of the Model 168 differs from the Model 1 primarily in its faster internal performance and the improved serviceability and availability made possible by the service processor unit, which is standard in the Model 3.

A tightly coupled Model 168 multiprocessing configuration can include any combination of Model 3 and Model 1 systems. The same standard features are provided for both models except for the amount of high-speed buffer storage. The same optional features are available for the Model 3 (uniprocessor and multiprocessor models) as for the Model 1 except for the 16K Buffer Expansion feature, which is not available for the Model 3.

A Model 1 CPU (3168-1 Processor unit) can be field converted to a Model 3 CPU (3168-3 Processor Unit). The standalone 3066 Model 2 System Console for the Model 1 is also used with the Model 3. It must have the field-installable 3168-3 attachment feature in order to be used with a Model 3. The 3067 Model 3 Power and Coolant Distribution Unit must be used in a Model 3 system configuration. A 3067 Model 2 can be field converted to a 3067 Model 3. A motor generator set is required for the Model 3 as for the Model 1. The same motor generator can be used for both models.

The same standalone channels (2860, 2870, and 2880) and I/O devices attach to the Model 3 as to the Model 1. The 3165/3168 attachment is required on the standalone channels attached to a Model 3.

The model-dependent fixed storage locations are the same in the Model 3 as in the Model 1 (see Figure 20.10.3) except for minor differences in a few fields in the CPU extended logout area. For example, the buffer size installed bits for 8K and 16K are no longer used.

Both models are supported by the same IBM-supplied programming systems, that is, OS MFT and MVT Releases 21.6, 21.7, and 21.8, OS/VS1, OS/VS2 Releases 1 and up, and VM/370. OS MFT and MVT Releases 21.7 and 21.8, OS/VS1 Releases 1 and up, OS/VS2 Releases 1 and up, and VM/370 Releases 2 and up are modified to process the model-dependent logout area data for the Model 3 that differs slightly from that of the Model 1. Although the EREP program in Release 21.6 of OS MFT and MVT will not be modified, it can still be used on a Model 168 Model 3.

A program can determine whether it is operating on a Model 1 or a Model 3 by issuing the STORE CPU ID instruction. The version field byte (bits 0 to 7 in the doubleword stored) indicate the model of the 3168 processor being used.

### 65:05 PERFORMANCE ENHANCEMENTS

The internal performance of the Model 3 Model 168 CPU is generally in the range of 5 to 13 percent faster than that of the Model 1 CPU (using a 16K buffer) when the same hardware configurations, programs, and programming systems that do not use 2K pages are used. The increase in Model 3 internal performance will be less for users of VS1 since it supports a 2K page size.

The faster internal performance of the Model 3 is the result of the following differences between the Model 3 and the Model 1:

- 32K of high-speed monolithic buffer storage is standard for the Model 3. The 32K capacity is not utilized when a page size of 2K is being used. The buffer operates at a capacity of 16K in this situation (see buffer discussion below). Buffer fetch times, the way in which the buffer is used, and the buffer assignment algorithm are the same in both models. The 32K buffer and processor storage contain 128 columns, as shown in Figure 65.05.1, instead of 64 columns as in the Model 1. A column in the Model 3 buffer contains eight 32-byte blocks, as does a column in the buffer in the Model 1.
- The execution time of each of the following instructions is improved: SUPERVISOR CALL (SVC), MONITOR CALL (MC), STORE THEN OR SYSTEM MASK (STOSM), STORE THEN AND SYSTEM MASK (STNSM), INSERT STORAGE KEY (ISK), INSERT PSW KEY (IPK), SET PSW KEY FROM ADDRESS (SPKA), LOAD PSW (LPSW), SET SYSTEM MASK (SSM), STORE CLOCK (STCK), and SET PROGRAM MASK (SPM). In addition, under certain conditions execution of the following instructions is faster in the Model 3: OR CHARACTERS (OC), AND CHARACTERS (NC), EXCLUSIVE OR CHARACTERS (XC), TEST AND SET (TS), COMPARE LOGICAL CHARACTERS UNDER MASK (CLM), INSERT CHARACTERS UNDER MASK (ICM), STORE CHARACTERS UNDER MASK (STCM), COMPARE AND SWAP (CS), and COMPARE DOUBLE AND SWAP (CDS). These instructions are more heavily used by the virtual storage programming systems.
- Improved execution time for all levels of interruption

Improvements in the execution time of the instructions listed above and all interruptions are made possible by the increase in the size of writable control storage in the Model 3. The Model 3 has 1024K instead of 512K words of writable control storage. A denser technology is used for the implementation of writable control storage in the Model 3 so that less space is required for 1024K words in the Model 3 than for 512K words in the Model 1.

The 32K high-speed buffer in the Model 3 is also implemented in a denser technology than is used for the high-speed buffers in the Model 1 and it requires less space than a 16K buffer. The 32K buffer operates at its 32K capacity when the Model 3 CPU is operating with dynamic address translation mode disabled or with dynamic address translation mode and a 4K page size enabled. When dynamic address translation and a 2K page size are enabled, the 32K buffer operates at a 16K capacity just like the 16K buffer in the Model 1.

The reason for using a 16K capacity when a 2K page size is enabled is the following. Bits 20 to 26 of the referenced processor (real) storage address are required to determine the column address (0 to 127) in the buffer address array for a 32K buffer size. For a 16K buffer size, processor storage address bits 21 to 26 are required to determine the column address (0 to 63).

When a 4K page size is used, bits 20 to 31 of the referenced virtual storage address are the same as bits 20 to 31 of the corresponding real storage address and do not need to be translated. However, when a 2K page size is used, bit 20 must be translated as only bits 21 to 31 in the virtual and corresponding real storage addresses are equal.

Therefore, if the 32K capacity were to be used for a 2K page size, bit 20 would not be available for buffer address array addressing until after address translation had been performed. By using a 16K capacity for a 2K page size, bits 21 to 26 are available for accessing the buffer address array before address translation is performed.

Whenever the buffer in the Model 3 is reset, it is set to operate at its 32K capacity. The buffer is reset when one of the following occurs:

- IPL, program reset, power on reset, or system clear
- CPU reset caused by any condition except pushing the computer reset pushbutton
- All console loads except load microdiagnostics

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itself. In addition, status data about intermittent errors can be analyzed by the specialist concurrently with normal system operations.

As in a Model 1 environment, a 2955 OLT operating under OLTSEP can control the operation of the HDM Diagnostic Program in the Model 168 Model 3 CPU. A service processor maintenance program is also provided that operates under the control of the HDM Diagnostic Program. This program runs diagnostics that test the operation of the lines between the Model 168 CPU and the service processor.

#### ADVANTAGES

The advantages of the service processor in the Model 3 Model 168 are the following:

- More detailed information about intermittent and recoverable errors is provided than for the Model 1 and on a real time basis. The customer engineer can obtain this information and perform problem analysis concurrently with normal system operations.
- The need to try to recreate intermittent failures for analysis by the customer engineer is reduced.
- More detailed information about solid errors is provided than for the Model 1. This data can be analyzed by the local customer engineer or sent via a communication line to the Large Systems Support Group for analysis by customer engineers with more expertise.
- Customer engineer operation of the service processor is controlled by a separate CE panel in the unit instead of by the operator console so that problem analysis operations can be performed concurrently with normal system operations.
- The service processor is physically independent of the Model 168 CPU so that no processing time is taken from the Model 168 CPU and an error in the service processor does not impact the Model 168 CPU. Similarly, the service processor can operate when the Model 168 CPU is down for maintenance.

The detailed, timely status information provided about errors, remote analysis capability, and concurrent problem analysis capabilities provided by the service processor should result in a reduction in the number of times normal system operation is interrupted for intermittent error analysis and the amount of time the system is not operational for the purpose of locating the cause of solid failures. Since more data about failures is provided by the service processor, faster error analysis should occur even if the remote analysis capability is not utilized.



SECTION 70: COMPARISON TABLES

These tables have been included for quick reference. The first compares hardware features of the System/360 Model 65 and System/370 Models 158, (Models 1 and 3), 165, 165 II, and 168 (Models 1 and 3). The second compares OS MFT, MVT, VS1, VS2 Release 1.7, and VS2 Release 3 support of the Model 168 (Models 1 and 3).

<u>Hardware Feature</u>	<u>System/360 Model 65</u>	<u>System/370 Model 158 (Models 1 and 3)</u>	<u>System/370 Model 165</u>	<u>System/370 Model 165 II</u>	<u>System/370 Model 168 (Models 1 and 3)</u>
O. Compatibility features (all are optional and mutually exclusive except where noted otherwise)	1. 7070/7074 2. 7080 (for both 705 and 7080) 3. 709/7040/7044/ 7090/7094/7094II	1. 1401/40/60, 1410/7010 2. OS/DOS 3. 7070/7074 (features are no-charge and not mutually exclusive)	1. 7070/7074 2. 7080 (for both 705 and 7080) 3. 709/7090/7094 7094II (does not include 704, 7040, 7044)	Same as Model 165	Same as Model 165
P. Control logic	Microprogram in ROS	Microprogram in reloadable control storage	Microprogram in capacitor ROS and monolithic WCS.	Same as Model 168	Microprogram in monolithic ROS and monolithic WCS
Q. Instruction retry by hardware	No	Yes	Yes	Yes	Yes
R. Machine check interruption	One level of machine check provided for all machine errors and one machine check mask.	Occurs after corrected and uncorrected errors. There are seven types of machine check and many are individually maskable.	Occurs after corrected and uncorrected errors. There are four types of machine check and many are individually maskable.	Same as Model 168	Same as Model 165, except five types of machine check are implemented and more data is logged by a Model 168.
S. Fixed storage area size in lower storage (including logout area for machine and channel errors)	328 bytes including CPU and channel logouts	1184 bytes reducible to 512 if extended logout area of 672 bytes is moved	1504 bytes reducible to 512 if the extended logout area of 992 bytes is moved	Same as Model 168	1928 bytes reducible to 512 if the extended logout area of 1416 bytes is moved
T. Multiprocessor systems	1. Multisystem optional feature permits interconnection of two Model 65s. Main storage is shared (512K or more). Direct control is required. 2. The support or main processor in an ASP configuration can be a Model 65. Two or three systems are connected via a Channel-to-Channel Adapter.	Same as Model 168	1. A multisystem feature is not available. 2. A Model 165 can be a support or a main processor in an ASP configuration	Same as Model 165	1. The 3068 Multisystem Communication Unit is used to connect two Model 168 systems (any combination of Models 1 and 3) together for a tightly-coupled multiprocessing shared storage configuration. 2. JES3 (Job Entry Subsystem 3) of CS/VS2 Release 3 supports the Model 168 in a loosely-coupled multiprocessing configuration.

<u>Hardware Feature</u>	<u>System/360 Model 65</u>	<u>System/370 Model 158 (Models 1 and 3)</u>	<u>System/370 Model 165</u>	<u>System/370 Model 165 II</u>	<u>System/370 Model 168 (Models 1 and 3)</u>
					3. A Model 168 can be a main or support processor in an ASP configuration.
U. Power warning	Not available	Optional	Not available	Not available	Optional
V. Virtual machine assist	Not available	Optional	Not available	RPQ feature	RPQ feature
W. Remote analysis unit	Not available	Yes - service processor is standard	Yes - 2955 Remote Analysis Unit is optional	Same as a Model 165	Yes - 2955 Remote Analysis Unit is optional in the Model 1, service processor is standard in the Model 3
X. Integrated Storage Controls	Not available	Optional for attachment of 3330-series, 3340/3344, and/or 3350 disk storage, or the 3850 Mass Storage System	Not available	Not available	Same as Model 158
<b>II. STORAGE</b>					
A. Processor (main) storage sizes	256K 512K 768K 1024K	- 512K - 1024K 1536K 2048K 3072K 4096K	- 512K - 1024K 1536K 2048K 3072K	- - - 1024K - 2048K 3072K	- - - 1024K - 2048K 3072K 4096K 5120K 6144K 7168K 8192K
B. Type of processor storage	Ferrite cores	Monolithic technology	Ferrite cores	Ferrite cores	Monolithic technology
C. Processor storage interleaving	Two-way interleaving of sequential accesses other than by the channels is provided.	None	Storage is 4-way doubleword interleaved for CPU and channel requests.	Same as Model 165	Storage is 4-way doubleword interleaved.
D. High-speed buffer storage	No	8K is standard in the Model 1. 16K is standard	8K is standard, 8K more can be added. 80 nano-	Same as Model 165	Model 1 is same as Model 165. 32K is standard in

<u>Hardware Feature</u>	<u>System/360 Model 65</u>	<u>System/370 Model 158 (Models 1 and 3)</u>	<u>System/370 Model 165</u>	<u>System/370 Model 165 II</u>	<u>System/370 Model 168 (Models 1 and 3)</u>
D. Direct access devices (2311, 2314, 2303, 2301, and 2321)	All attach	All except 2301 drum	Same as Model 65	Same as Model 65	Same as Model 65
E. 3330-series disk storage	No	Yes (all models)	Yes (Models 1 and 2 only)	Yes (all models)	Yes (all models)
1. 3830 Storage Control Model 1	-	Yes	Yes	Yes	Yes
2. 3830 Storage Control Model 2	-	Yes	Yes	Yes	Yes
3. Integrated Storage Controls feature	-	Yes	No	No	Yes
F. 2305 facility Models 1 and 2	No	2305 Model 2 only	Yes on 2880	Yes on 2880	Yes on 2880
G. 3340 Direct Access Storage Facility	No	Yes (attachment via 3830 Model 2 and integrated storage controls)	No	Yes (attachment via 3830 Model 2)	Yes (attachment via 3830 Model 2 and integrated storage controls)
H. 3344 Direct Access Storage	No	Yes (attachment via 3830 Model 2 and integrated storage controls)	No	Yes (attachment via 3830 Model 2)	Yes (attachment via 3830 Model 2 and integrated storage controls)
I. 3350 Direct Access Storage	No	Yes (attachment via 3830 Model 2 and integrated storage controls)	No	Yes (attachment via 3830 Model 2)	Yes (attachment via 3830 Model 2 and integrated storage controls)
J. 3410/3411 Magnetic Tape Subsystem	No	Yes	No	No	No
K. 3540 Diskette I/O Unit	No	Yes	No	No	No
L. 3600 Finance Communication System	No	Yes	No	Yes	Yes
M. 3650 Retail Store System	No	Yes	No	Yes	Yes
N. 3660 Supermarket System	No	Yes	No	Yes	Yes
O. 3704 and 3705 Communi- cations Controllers	Yes, emulation mode only	Yes, emulation mode and network control program modes.	Same as Model 158	Same as Model 158	Same as Model 158
P. 3740 Data Entry System	Yes	Yes	Yes	Yes	Yes

<u>Hardware Feature</u>	<u>System/360 Model 65</u>	<u>System/370 Model 158 (Models 1 and 3)</u>	<u>System/370 Model 165</u>	<u>System/370 Model 165 II</u>	<u>System/370 Model 168 (Models 1 and 3)</u>
Q. 3767 Data Communication Terminal	Yes	Yes	No	Yes	Yes
R. 3770 Data Communication System	Yes	Yes	No	Yes	Yes
S. 3780 Data Communications Terminal	Yes	Yes	Yes	Yes	Yes
T. 3790 Communication System	No	Yes	No	Yes	Yes
U. 3800 Printing Subsystem	No	Yes	No	Yes	Yes
V. 3850 Mass Storage System	No	Yes via 3830 Model 3 and Integrated Storage Controls	No	Yes via 3830 Model 3	Yes via 3830 Model 3 and Integrated Storage Controls
W. 3881 Optical Mark Reader	No	Yes	No	No	No
X. 3886 Optical Character Reader	No	Yes	No	Yes	Yes
Y. 3890 Document Processor	No	Yes	No	Yes	Yes

## 70:10 OS AND OS/VS SUPPORT OF THE MODEL 168 (MODELS 1 AND 3)

Hardware Feature	OS MFT and MVT	OS/VS1	OS/VS2 - Release 1.7	OS/VS2 - Release 3
<b>I. CPU</b>				
<b>A. Mode of system operation</b>				
	BC mode only. Up to 15 problem program partitions or regions.	EC and DAT modes only. One virtual storage of up to 16 million bytes is supported. Up to 52 partitions of which 15 can be problem program.	EC and DAT modes only. One virtual storage of 16 million bytes is supported. Up to 63 problem program regions of which up to 42 can be TSO foreground regions.	EC and DAT modes only. Multiple virtual storages are supported. Each user has one 16 million byte virtual storage for user programs, system programs, shared data, and shared program areas. The maximum number of concurrent users is limited only by the availability of system resources (external page and real storage)
<b>B. Instruction set</b>				
1. Standard set (binary arithmetic)	All languages	All languages	All languages	All languages
2. Decimal arithmetic	All languages except FORTRAN	All languages except FORTRAN	All languages except FORTRAN	All languages except FORTRAN
3. Floating-point arithmetic	All languages except RPG	All languages except RPG	All languages except RPG	All languages except RPG
4. Extended precision floating-point	Assemblers F and H, PL/I Optimizing Compiler, PL/I Checkout Compiler, FORTRAN H, FORTRAN H-Extended	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
5. New instructions	Mnemonics in Assemblers F and B. Option to generate certain instructions in ANS Full COBOL (CLCL, MVCL, ICM, SRP)	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
a. COMPARE LOGICAL CHARACTERS UNDER MASK COMPARE LOGICAL LONG INSERT CHARACTERS UNDER MASK LOAD CONTROL MONITOR CALL MOVE LONG SET CLOCK SHIFT AND ROUND DECIMAL START I/O FAST RELEASE STORE CHANNEL ID STORE CHARACTERS UNDER MASK STORE CLOCK STORE CONTROL STORE CPU ID				

<u>Hardware Feature</u>	<u>OS MFT and MVT</u>	<u>OS/VS1</u>	<u>OS/VS2 - Release 1.7</u>	<u>OS/VS2 - Release 3</u>
b. LCAD REAL ADDRESS PURGE TLB RESET REFERENCE BIT SET CLOCK COMPARATOR SET CPU TIMER STORE CLOCK COMPARATOR STORE CPU TIMER STORE THEN AND SYSTEM MASK STORE THEN OR SYSTEM MASK	Supported by Assembler F, as of OS Release 21.6. Not supported by Assembler H	All are supported by the System Assembler	Same as OS/VS1	Same as OS/VS1
c. CLEAR I/O COMPARE AND SWAP COMPARE DOUBLE AND SWAP INSERT PSW KEY SET PSW KEY FROM ADDRESS	Not supported	Supported	Supported	Supported
C. Interval timer	Supported for timing facilities, except for time of day	Supported for all timing facilities (except time of day) unless the extended timer option is included in the VS1 control program	Not supported	Not supported
D. Time of day clock	Supported for time of day	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
E. Clock comparator and CPU timer	Not supported	Supported for job step and interval timing when extended timer option is included in the VS1 control program	Supported for timing facilities except for time of day	Supported for timing facilities except time of day
F. Expanded machine check interruptions	Supported by MCH	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
G. Monitoring feature	Supported by GTF and an Assembler mnemonic	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
H. Program event recording	Not supported	Supported by Dynamic Support System	Supported by Dynamic Support System	Supported by Dynamic Support System
I. Interruption for SSM instruction	Not supported	Supported	Supported	Supported

<u>Hardware Feature</u>	<u>OS MFT and MVT</u>	<u>OS/VS1</u>	<u>OS/VS2 - Release 1.7</u>	<u>OS/VS2 - Release 3</u>
J. Compatibility features	All are supported	All are supported	All are supported	All are supported
K. Power warning	Supported by MVT as of Release 21.6	Supported	Supported	Supported
L. Multiprocessing				
1. Tightly coupled	Not supported	Not supported	Not supported	Two multiprocessor models connected via the 3068 multisystem communication unit that share real storage are supported
2. Loosely coupled	Supported under MVT by ASP	Not supported	Yes by ASP Version 3.1	JES3, an upward compatible extension of ASP Version 3, supports one to eight System/370 systems connected via channel-to-channel adapters. JES2 with the multi-access spool capability enables from two to seven systems operating with OS/VS2 Release 3 to share input and output work queues on shared DASD.
<b>II. STORAGE</b>				
A. Real storage sizes (1024K to 8196K)	All are supported	All are supported	All are supported	All are supported
B. Byte-oriented operands	Programmers can use the byte alignment hardware facility in Assembler programs	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
C. Store and fetch protection	Store protect only is supported	Store and fetch protection are supported	Store and fetch protection are supported for all regions	Store and fetch protection are supported for all virtual storages
<b>III. CHANNELS</b>				
A. Byte multiplexer channels	One or two are supported	One or two are supported	One or two are supported	One or two are supported
B. Block multiplexer and selector channels	Supported	Supported	Supported	Supported
C. Channel retry performed	Yes	Yes	Yes	Yes
D. Channel indirect data addressing	Not supported	Supported	Supported	Supported



<u>Hardware Feature</u>	<u>OS MFT and MVT</u>	<u>OS/VS1</u>	<u>OS/VS2 - Release 1.7</u>	<u>OS/VS2 - Release 3</u>
<b>IV. CONSOLES</b>				
A. 3066 Console	Supported. MCS and LIDOCs required.	Same as MFT and MVT	Same as MFT and MVT	Same as MFT and MVT
B. Alternate and additional consoles supported	Yes	Yes	Yes	Yes
<b>V. I/O DEVICES</b>				
A. 3505 Card Reader and 3525 Card Punch	Supported	Supported	Supported	Supported
B. 3211 Printer	Supported	Supported	Supported	Supported
C. 3803/3420 Magnetic Tape Subsystem (Models 3, 5, 7 and 4, 6, 8)	Supported	Supported	Supported	Supported
D. 2314/2319 facilities	Supported for system residence, data sets, SYSIN devices, and SYSIN and SYSOUT data sets. Record Overflow and channel switching features are supported.	Supported for system residence, data sets, paging devices, JES spooling devices and data sets, and SYSIN devices. Record Overflow and channel switching features are supported.	Supported for system residence, data sets, paging devices, SYSIN and SYSOUT data sets, and SYSIN devices. Record Overflow and channel switching features are supported.	Same as OS/VS1
E. 3330-series Direct Access Storage	Supported as V.D. above. RPS, multiple requesting, sixteen-drive addressing, 32 Drive Expansion, Two-Channel Switch, Two-Channel Switch Additional, 3333 String Switch, and Record Overflow are supported. Only Models 1 and 2 are supported.	Same as V.D. above. RPS, multiple requesting, sixteen-drive addressing, 32 Drive Expansion, Two-Channel Switch, Two-Channel Switch Additional, 3333 String Switch, and Record Overflow are supported. All models are supported.	Same as V.D. above. RPS, multiple requesting, sixteen-drive addressing, 32 Drive Expansion, Two-Channel Switch, Two-channel Switch Additional, 3333 String Switch, and Record Overflow are supported. All models are supported.	Same as OS/VS1
F. 3340 Direct Access Storage Facility	Not Supported	Support same as for 3330-series	Support same as for 3330-series (not yet available)	Support same as for 3330-series
G. 3344 Direct Access Storage	Not supported	Support same as for 3330-series	Support same as for 3330-series (not yet available)	Support same as for 3330-series

<u>Hardware Feature</u>	<u>OS MFT and MVT</u>	<u>OS/VS1</u>	<u>OS/VS2 - Release 1.7</u>	<u>OS/VS2 - Release 3</u>
H. 3350 Direct Access Storage	Not supported	Supported in native and 3330 compatibility modes as for 3330-series	Supported in native and 3330 compatibility modes as for 3330-series (not yet available)	Supported in native and 3330 compatibility modes as for 3330-series
I. 2305 Facility Models 1 and 2	Supported for system residence, data sets, and SYSIN/SYSOUT data sets. RPS and multiple requesting are supported.	Same as V.D. above except for SYSIN devices. RPS and multiple requesting are supported.	Same as V.D. above. RPS and multiple requesting are supported.	Same as OS/VS1
J. 3600 Finance Communication System	Not supported	Supported attached to a 3704/3705 in NCP/VS mode by VTAM and TCAM through VTAM	Not supported	Same as OS/VS1
K. 3650 Retail Store System	Not supported	Supported in binary synchronous control mode attached to a 3704/3705 in emulation mode by BTAM  Supported in synchronous data link control mode attached to a 3704/3705 in NCP/VS mode by VTAM and TCAM through VTAM	Not supported	Supported in synchronous data link control mode attached to a 3704/3705 in NCP/VS mode by VTAM and TCAM through VTAM
L. 3660 Supermarket System	Not Supported	Supported in binary synchronous mode attached to a 3704/3705 in emulation mode by BTAM Supported in synchronous data link control mode attached to a 3704/3705 in NCP/VS mode by VTAM	Supported in binary synchronous mode attached to a 3704/3705 in emulation mode by BTAM	Supported in synchronous data link control mode attached to a 3704/3705 in NCP/VS mode by VTAM
M. 3704 and 3705 Communications Controllers	Supported in emulation mode Supported in NCP mode by TCAM	Supported in emulation mode Supported in NCP mode by TCAM Supported in NCP/VS mode by TCAM and VTAM	Supported in emulation mode Supported in NCP mode by TCAM Supported in NCP/VS mode by TCAM	Same as OS/VS1
N. 3740 Data Entry System	Supported (BTAM, TCAM)	Supported (BTAM, TCAM, and TCAM through VTAM)	Supported (BTAM, TCAM)	Same as OS/VS1

<u>Hardware Feature</u>	<u>OS MFT and MVT</u>	<u>OS/VS1</u>	<u>OS/VS2 - Release 1.7</u>	<u>OS/VS2 - Release 3</u>
O. 3767 Data Communication Terminal	Not supported	Supported (as a start/stop device) attached to a 3704/3705 in emulation mode by BTAM and TCAM Supported attached to a 3704/3705 in NCP/VS mode by VTAM and TCAM through VTAM	Supported (as a start/stop device) attached to a 3704/3705 in emulation mode by BTAM and TCAM	Same as OS/VS1
P. 3770 Data Communication System	Not supported	Supported for synchronous data link control (SDLC) operations attached to a 3704/3705 in NCP/VS mode by VTAM and TCAM through VTAM. Supported for binary synchronous communication (BSC) operations attached to a 2701 or 3704/3705 by 2770 support in BTAM, TCAM, and VTAM.	Supported for binary synchronous communication operations attached to a 2701 or 3704/3705 by 2770 support in BTAM and TCAM.	Same as OS/VS1
Q. 3780 Data Communications Terminal	Supported (BTAM, TCAM)	Supported (BTAM, TCAM, and TCAM via VTAM)	Supported (BTAM, TCAM)	Same as OS/VS1
R. 3790 Communication System	Not supported	Supported attached to a 3704/3705 in NCP/VS mode by VTAM	Not supported	Same as OS/VS1
S. 3800 Printing Subsystem	Not supported	Supported	Not supported	Supported
T. 3850 Mass Storage System	Not supported	Supported	Not supported	Supported
U. 3886 Optical Character Reader	Not supported	Supported	Not supported	Supported
V. 3890 Document Processor	Not supported	Supported	Supported	Supported

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