The equipment that comprises the IBM 9020 multiprocessing system is described, emphasizing capabilities not appearing in the standard SYSTEM/360 line.

System characteristics are related to availability requirements for program-controlled reconfiguration capabilities. With these capabilities, subsystems can be formed from system elements as the need arises.

Other discussed functional capabilities center on recovery by program control, shared storage, and malfunction alerting.

An application-oriented multiprocessing system

II Design characteristics of the 9020 system

by G. R. Blakeney, L. F. Cudney, and C. R. Eickhorn

In accordance with Federal Aviation Administration (FAA) requirements[1] for a large-scale multisystem of high availability, the IBM 9020 system has been designed to provide automated aids for the processing and updating of flight information. Major tasks are to aid in establishing and maintaining radar identification of aircraft and to automate the display of altitude or flight-level information with aircraft position. The system will also provide an automation base for subsequent improvements in air traffic control.

The 9020 system, as an embodiment of SYSTEM/360, is compatible with SYSTEM/360 when operating in the 360 mode.[2] The 9020 design provides "stand-alone" computing, storage, and input/output capabilities with seven basic types of elements:

- Computing Element
- Input/Output Control Element
- Storage Element
- Tape Control Unit
- Tape Drive
- System Console
- Peripheral Adapter Module

In accordance with application requirements, the 9020 system may be varied in its computational, shared storage, and input/output capacities to accommodate several possible configurations based on enroute flight loads. The number of elements in a typical system

Table 1 Number of elements required for a typical system configuration

Computing Element	3
Storage Element	9
I/O Control Elements	3
Multiplexor Channels	3
Selector Channels	6
Tape Control Unit	3
System Console	1
Peripheral Adapter Modules	3

configuration is shown in Table 1, and the whole system configuration is shown in Figure 1. The number of Computing Elements may be increased to four; the number of Storage Elements may be increased to 12, three of which may be large-capacity elements; and the number of selector channels may be increased to eight by adding another such channel in each of two I/O Control Elements.

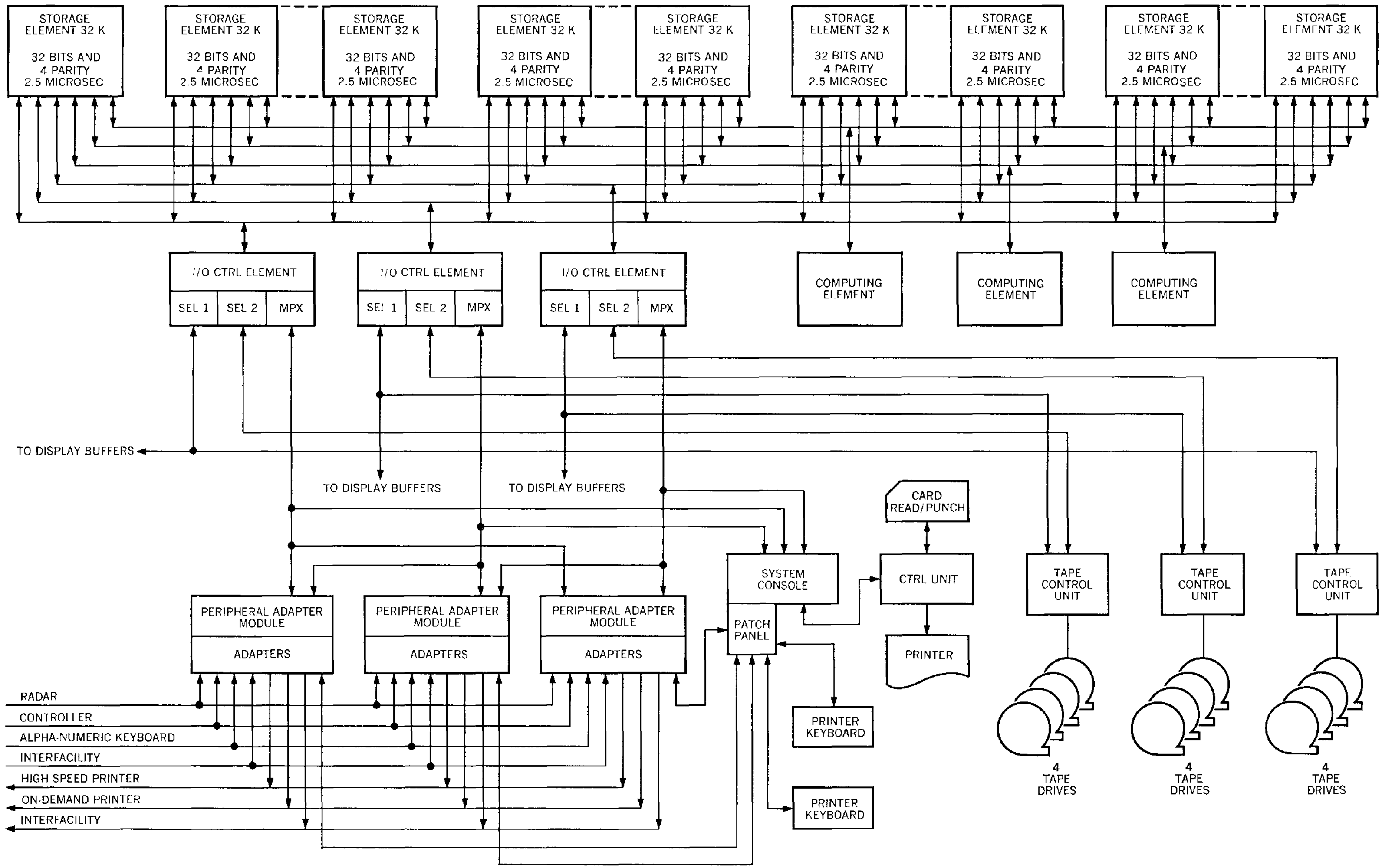
Because all elements are connected by well-defined interfaces, and because no single major element is critical to the operation of the system, it is possible under program control to structure the 9020 into virtually any desired system configuration. For instance, a system with three Computing Elements can be configured into a single system using all the available resources; at the other extreme, the same resources can be configured into three independent, single-computer subsystems. All elements of one type are identical and interchangeable.

A system consisting of two or more automatically linked Computing Elements has been called a *multisystem*.[3] One of the principal motivations for a multisystem lies in the possibility of attaining higher degrees of capacity "availability" at extra cost in equipment and systems planning. The FAA specifications for availability necessitated an integrated 9020 approach to the design of equipment, systems programs, and maintenance procedures. Inasmuch as the system programs and maintenance procedures are discussed elsewhere in this paper, in this Part we discuss equipment capabilities only. Although the need for multisystems was foreseen in SYSTEM/360 design, the needs of air traffic control led to a significant extension of the standard design. The special functional capabilities of the 9020 can be broken down into the following main categories:

- Configuration control
- Storage interlocking
- Preferential storage areas
- Partitioning and logical addressing
- Inter-element signaling
- Malfunction alerting

Each of these capabilities is associated with instructions that augment the standard SYSTEM/360 set.

Figure 1 A typical system configuration



System elements

computing element

The Computing Element is the computational, logical, and control element of the 9020 system. This element has the capability of establishing, organizing, and controlling the multisystem that performs the air traffic control task. As an embodiment of SYSTEM/360 architecture, the 9020 uses Computing Elements that have a 32-bit adder path, an 8-bit-wide data path for handling individual bytes, approximately 30 bytes of working registers, plus about 60 bytes of working locations in the local storage.

In addition to the universal instruction set, the Computing Element incorporates instructions specifically oriented toward 9020 multi-element operation. These instructions provide programmed configuration control, storage partitioning, system monitoring, and operational control of the multiprocessor. The Computing Element executes I/O instructions that select an I/O Control Element and present it with the control data needed in carrying out an I/O operation. Two-way communication interfaces are provided between each Computing Element and each of the other basic elements mentioned earlier.

An analysis of air traffic control program kernels,[1] coded in the SYSTEM/360 instruction set, indicated that an average instruction execution rate of approximately 300,000 instructions per second is required for a typical processing load. Since one Computing Element executes approximately 160,000 instructions per second, two of these elements fulfill the basic requirements, and a third provides fifty percent redundancy.

storage element

The 9020 system uses Storage Elements in modules of 131,072 bytes, and large-capacity Storage Elements in modules of 1,048,576 bytes. Up to twelve modules are allowed in a given installation, of which not more than three may be large-capacity Storage Elements. Each byte consists of eight data bits plus one parity bit. Bytes are accessed in groups of four, called words. Total cycle time is 2.5 μsec per word for a Storage Element, and 8 μsec for a large-capacity Storage Element. Each storage module can be accessed asynchronously from any of four Computing Elements and three I/O Control Elements. Storage accesses are honored with the aid of priority circuitry; I/O Control Elements are served with higher priorities than Computing Elements.

Provision has been made for a Computing Element or I/O Control Element to stop a Storage Element that signals an error during an access. A Computing Element may then record pertinent information "latched" in the Storage Element at the time of the error. Among other items, the available information includes the contents of the Storage Element's storage data register, storage address register, and configuration control register.

I/O control element

Input/output units are attached to the 9020 system through I/O Control Elements. Two selector channels and a multiplexor channel are provided in each I/O Control Element. A third selector channel is available as a special feature on two of the three I/O Control Elements.

In diagnostic mode, the I/O Control Element has the ability to execute the SYSTEM/360 basic instruction set for off-line self-diagnosis. The I/O Control Element, containing a private 32K-byte main storage, is used for multiplexor channel control words and self-diagnosis in the off-line mode. When in the diagnostic mode, program instructions and data are stored and fetched from this internal storage. This feature enables the 9020 to restrict off-line maintenance subsystems to a minimum of equipment.

The I/O Control Element can simultaneously control 256 subchannels on the multiplexor channel, as well as one high-speed I/O device on each selector channel. A standard SYSTEM/360 interface connects to various device control units.[4] The Tape Control Unit and the unit-record control unit (IBM 2821) are examples of device control units used on the 9020. In addition, the 9020 System Console and the Peripheral Adapter Module provide I/O capability to the multiplexor channel.

peripheral adapter module

The Peripheral Adapter Module has been designed to accommodate various adapters that allow I/O operations with customer-supplied devices, both local and remote. Typical of such devices would be Teletypewriters and Modems. IBM 1052 printer keyboards may also be attached to the adapters of the Peripheral Adapter Module.

Each Peripheral Adapter Module is divided into a common area and adapters. The common area provides the addressing, priority, configuration, and general control capabilities needed to service the adapters. In turn, the adapters provide for necessary bit/byte conversion, data control, message initiation, and termination functions. One adapter in each of two Peripheral Adapter Modules may be attached to a peripheral device to allow alternate data paths.

system console

The System Console is the central monitoring and control element in the 9020 multiprocessing system. The console, addressable as an input/output device, displays the system mode of operation, controls audible alarms, and displays configuration indicators. In systems containing multiple I/O Control Elements, the System Console also contains an electronic switch for connection of a 1052 printer keyboard and a unit-record control unit to a selected multiplexor channel. The switching is under manual control on the operator's panel.

The System Console has data and address entry keys for storing data through a connection with any selected Computing Element. A similar connection provides data display in a set of indicators. The System Console also displays the instruction address registers of the Computing Elements. Initial program load, start, stop, address compare, and set instruction counter are among the other facilities through which a System Console can control a selected Computing Element.

Since any Computing Element can duplicate the essential system control functions performed by the System Console, multiple system consoles are not provided. The Peripheral Adapter Modules and Tape Control Units used in the 9020 are equipped with dual-channel interfaces that allow simultaneous connection to two channels. This feature, together with the System Console switch mentioned above, allows alternate data and control paths to all input/output devices if multiple I/O Control Elements exist in a system.

maintenance

The requirements of the 9020 maintenance system are defined in terms of system elements and their current status. The status of an element is called *active* whenever the element is actually performing air traffic control functions; it is called *redundant* whenever the element is not being used to perform any air traffic control function, but is available for use by the operational system within a 30-second recovery period. Elements not available to the operational system within thirty seconds are called *inactive*. Typical reasons for inactivity might be component failure or "power off."

A maintenance function is classified as on-line if it involves any active elements. An off-line maintenance function may employ redundant elements (elements that can be returned to active status within 30 seconds). Only a few of the programmed maintenance functions are performed on-line. These report on element status, detect errors, isolate faulty elements, and print detailed error information. The bulk of scheduled and unscheduled maintenance can be performed off-line because the 9020 design ensures that subsystems can be formed and used in tests (including even the on/off cycling of power) without generating logical or electrical disturbances in the main operational system. To expedite the repair of a malfunctioning element, maintenance personnel may utilize special off-line test equipment in conjunction with the test subsystem redundant elements. Of course, if an active element fails, the maintenance subsystem may have to release a redundant element to the active system.

The off-line maintenance library contains a comprehensive number and variety of maintenance programs. Included are routines to test all of the 9020 system elements, including the computer-oriented peripheral devices and peripheral-device adapters. A subset of these programs accomplishes the preventive maintenance function. Because of its size, the library is stored on tape; only a subset of the library is used by the off-line maintenance function at any given time. Inasmuch as these programs are intended to pinpoint failures within an element, they have a quite different function than the on-line error-analysis program, which seeks to identify a failing element within the system.

battery backup

The major system elements (Computing Element, I/O Control Element, and Storage Element) are equipped with battery packs that can sustain their operation for up to 5.5 seconds during possible ac power interruption. This enables the 9020 multiprocessing system to undertake an orderly shutdown of processing and to preserve the necessary environmental data required for recovery. When main-line power is restored, the time and effort for reinitialization is held near a minimum. Initial program loads are avoided if restarts suffice.

Special functional capabilities

system recovery

The system is capable of recovery by program control. Failures are detected and system recovery is effected without manual intervention. A tape system is used for legally required records, maintenance history, and the recording of data for recovery purposes.

The objective of continuous operation with a minimum of lost time is achieved by providing

- Redundant capacity for all major elements
- Automatic error detection and dynamic system recovery capabilities
- Restart techniques for intermittent element failures
- Rescheduling of application functions when necessitated by solid (non-intermittent) failures

When faced with a solid failure, the system can operate in a "fail-safe" mode by calling upon a redundant element. In this case, no functions are discontinued, the rate at which functions are performed is not changed, and system operation is not affected. Thirty seconds are allowed for element substitution, including the housekeeping operations necessary for resumption of system operation.

Whenever the number of available elements drops below the number needed to maintain fail-safe operation, the system can continue in a "fail-soft" mode if the system still includes at least one element of each major type (and an appropriate multiplicity of connections) as well as a suitable control program. In this case, the system excludes the failing elements, adjusts the scheduling of application tasks, and resumes operation at a reduced level of effectiveness. In the fail-soft mode, the time for handling selected functions is extended and/or some of the less critical functions are discontinued.

configuration

A set of system elements among which communication and control paths have been established is said to constitute a *configuration*. When elements are added to or deleted from a given set, a new configuration is formed; the process of forming a new configuration is called *reconfiguration*. The equipment resources in a 9020 system installation may be reconfigured as a single system in the performance of one task and then reconfigured again into a number of isolated subsystems in the performance of other tasks.

The requirements of the air-traffic-control application dictate fast and efficient reconfiguration control. In particular, the system must be able to isolate elements performing the primary task of air traffic control from elements assigned to non-related, less-critical tasks. Elements not required for the primary task must be available to redundant subsystems for secondary tasks, including maintenance. Moreover, elements in a redundant subsystem must be available for recall to the primary task, regardless of their current off-line task status.

Equipment failures reduce the short-range system capacity in a modular way: (1) a Computing Element failure reduces computational capability but not shared-storage capacity or I/O transfer capability; (2) a Storage Element failure reduces storage capacity but not the computing speed or I/O transfer capability; and (3) an I/O Control Element failure degrades only the I/O transfer capability of the system—it does not remove any peripheral device, reduce the computing speed capability of the system, or lower the Storage Element capacity.

Excess capacity implies at least one redundant element of each basic type for backup in case of failure under peak load conditions. The need for multiplicity also extends to the independent paths to peripheral devices. The only exceptions are found in the System Console and the following peripheral devices: card reader, card punch, line printer, and keyboard entry device for servicing.

configuration control

Because the time required to reconfigure upon the occurrence of a malfunction, or in response to the demands of a changing flight load, may not exceed thirty seconds, reconfiguration was placed under program control with no manual intervention.

Each configurable element (Computing Element, Storage Element, I/O Control Element, Tape Control Unit, and Peripheral Adapter Module) contains a Configuration Control Register (CCR). As explained below, the contents of the CCR's establish the prevailing system structure by specifying to each element its "state," the Computing Elements from which it accepts configuration changes, and the elements to which it "listens" in the exchange of data and certain control signals.

The privileged instruction SET CONFIGURATION is used to insert information into the CCR's. The appropriate sections of a configuration mask are placed into the CCR of each element that is designated by a selection mask. Figure 2 shows configuration and selection mask formats and CCR contents.

Figure 2 Configuration- and selection-mask formats and configuration contents

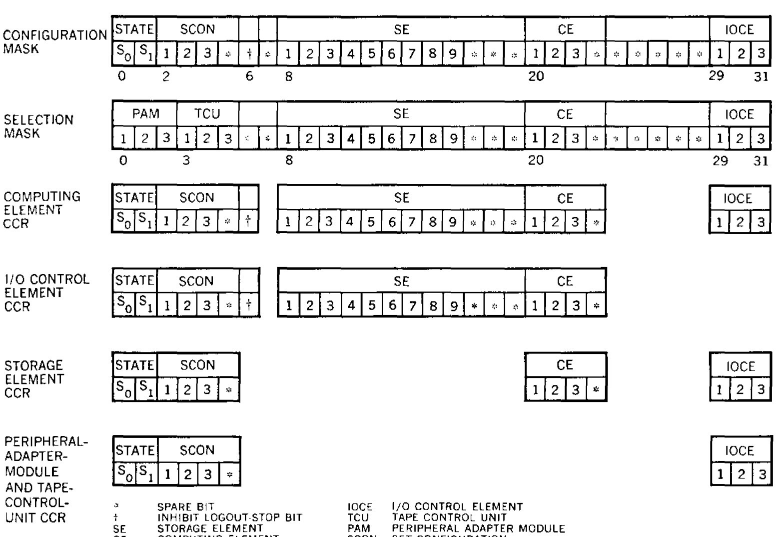


Table 2 Some state-dependent Computing Element operations

Computing Element state	*Enabled to execute* SET CONFIGURATION	*Operator controls enabled*	*Possible usage*
3	Yes	None	On-line air traffic control
2	No	None	On-line redundant
1	No	Partial	Off-line subsystem
0	Yes	All	Testing

Although details vary from element to element, a CCR can be broken into three fields—the *state* field, *set configuration* (SCON) field, and *communication* field. The state field places the element in one of four states: 0, 1, 2, or 3. Although precise interpretations differ for each element, the states are most significant for the Computing Element where they control the ability to make configuration changes and determine which manual controls are operative. Table 2 summarizes the pertinent Computing Element operations permitted in each state, and suggests possible uses for each state.

The SCON field in each CCR designates which Computing Elements are permitted to change the CCR in question—and thereby alter the system configuration. The communication field designates the elements to which the element in question "listens." As may be seen from Figure 2, a Computing Element may be configured to listen to other Computing Elements, Storage Elements, and I/O Control Elements; a Storage Element may listen to Computing Elements and I/O Control Elements; an I/O Control Element may listen to any one Computing Element and to Storage Elements; and Peripheral Adapter Modules and Tape Control Units may listen only to I/O Control Elements.

storage interlocking

The 9020 system uses shared storage as a common medium for data, restart information, programs, and tables. When several Computing Elements are active, certain tables or non-re-entrant subroutines may be common to all. In this case, the instruction TEST AND SET provides a rapid way of determining the availability of a facility by testing an associated status byte.

When two Computing Elements simultaneously request access to storage, a tie-breaking priority circuit in the accessed Storage Element grants access to one of the Computing Elements, then gives the next cycle to the other one. Should a Computing Element find a table unavailable, it is often desirable to program a short delay before testing again. The instruction DELAY offers a means of doing this without making nuisance main-storage references, which tend to degrade the overall effectiveness of a multisystem.

In a multisystem, it is often useful for a program to be able to identify the Computing Element that is executing a program or updating a table of interest. The instruction LOAD IDENTITY provides a handy way for a Computing Element to load its name into a general-purpose register (for subsequent placement in an agreed-upon identifying location). Computing Elements CE1, CE2, CE3, and CE4 are designated by the positive fixed-point integers 0, 1, 2, and 3, respectively.

preferential storage area

Certain permanent storage assignments, grouped together in a preferential-storage area within the first 4,096 bytes of storage, are provided in SYSTEM/360 for such activities as initial program loading, interruption handling, initiating I/O channel operations, interval timer updating, and diagnostic logouts. When two or more Computing Elements share main storage, these special areas are automatically relocated by program-specified base addresses. The relocation is accomplished by inserting a 12-bit preferential-storage base address (prefix) into each address whose twelve high-order bits are 0. Each Computing Element can have a preferential-storage area on any 4,096-byte boundary in main storage. The privileged instructions LOAD PREFERENTIAL-STORAGE BASE ADDRESS and STORE PREFERENTIAL-STORAGE BASE ADDRESS are used to manipulate the contents of the preferential-storage base address register.

If a faulty Storage Element contains the preferential-storage area, equipment automatically provides an alternate preferential-storage area by placing an alternate preferential-storage base address (alternate prefix) in the Computing Element's base address register. The alternate preferential-storage base address is automatically developed by an algorithm which successively modifies the contents of the preferential-storage base address register in increments of 131,072. This process terminates upon reaching the first configured Storage Element whose identifier also appears in the I/O Control Element's address translator.

partitioning and logical addressing

Although the 9020 system places the partitioning of main storage under configuration control by use of configuration control registers, some applications assigned to two or more independently working subsystems (each having its own Storage Elements) require access to consecutive storage locations starting at address *logical* zero. Storage address translation is therefore provided in each Computing Element and I/O Control Element to control the logical assignment of addresses to each *physical* Storage Element.

Each Computing Element and I/O Control Element is inherently capable of accessing all storage. When a logical address is developed by a program, equipment directs the access request to the physical Storage Element determined by the content of a twelve-position storage address translator in the accessing element. To achieve this, each Storage Element (SE1, SE2, . . ., SE12) is assigned an identifier (1, 2, . . ., C hexadecimal). Each position in a storage address translator is associated with a block of addresses set on a 131,072-byte boundary. The privileged instruction SET ADDRESS TRANSLATOR assigns a physical Storage Element to a block of logical addresses by setting the element's identifier into the desired position in the storage address translator. Unassigned positions are set to 0. The instruction INSERT ADDRESS TRANSLATOR allows a Computing Element to place the contents of its storage address translator into a pair of general-purpose registers.

inter-element signaling

Each Computing Element responds to inter-element signals by means of an external interruption. The two categories of particular interest in the 9020 system are associated with a direct-control feature and with malfunction alerts via the diagnose-accessible register. The source of interruption is identified by the code stored in the "old" external interruption program status word and defined in Table 3.

direct control

The privileged instructions WRITE DIRECT and READ DIRECT are provided in SYSTEM/360 for the transfer of a single byte of information between a Computing Element and an external device. These may be used in the 9020 system for the transfer of a data byte between two Computing Elements in the absence of shared storage, or for the transfer of a control byte when shared storage obviates the need for data transfer. WRITE DIRECT places the byte at the location designated by the operand address on a set of direct-out lines to the Computing Element selected by the instruction. An interruption is caused in the receiving Computing Element, where a code is stored to identify the sending Computing Element. Conversely, READ DIRECT accepts a byte of data via a set of direct-in lines from the selected Computing Element and stores the byte at the location designated by the operand address. An interruption is returned to the selected Computing Element where the stored code identifies the Computing Element executing the READ DIRECT.

The 9020 system also uses WRITE DIRECT to initiate certain operations required in multisystem operation. A designated Computing Element may be directed to perform an external start or a diagnostic "logout"; similarly, an I/O Control Element may also be requested to log out. None of these actions is accompanied by an external interruption.

A Computing Element receiving an external start resets and fetches a new program status word from a main-storage location determined by an equipment algorithm.

A logout preserves critical environmental information in the logout area of the preferential-storage area. Provided machine-check interruptions are not masked in a receiving Computing Element or in a Computing Element controlling a receiving I/O Control Element, a logout may be initiated by the WRITE DIRECT instruction.

malfunction alerting

A multisystem must not only provide redundant elements, but it must be able to determine when redundant elements should become active. In other words, a modular system must monitor the status of its major elements and distinguish between self-clearing transient errors (which do not require active-element elimination) and non-clearing failures (which require elimination of an element and its replacement by a redundant element, if available).

The *abnormal-condition* interruption is the means by which the Computing Element responds to certain hardware-generated malfunction alerts from another Computing Element, an I/O Control Element, Storage Element, Tape Control Unit, or Peripheral

Table 3 Interruption codes

Interruption code bit	*External interruption cause*
20	CE1 read direct
21	CE1 write direct
22	CE2 read direct
23	CE2 write direct
24	Timer
25	Interrupt switch
26	CE3 read direct
27	CE3 write direct
28	CE4 read direct
29	CE4 write direct
30	Spare
31	Diagnose-accessible register

Legend: CE Computing Element

Adapter Module. Three categories of malfunction alerts are recognized: *element check*, *out-of-tolerance check*, and *on-battery signal*. Each of these alerts, when generated by a Computing Element or an I/O Control Element, sets a bit in the diagnose-accessible register provided in each Computing Element. The Storage Element, Tape Control Unit, and Peripheral Adapter Module generate only an element check. If not masked off by this register's mask or by the external interruption mask, an external interruption takes place. Abnormal condition interruption action is shown in Table 4.

The out-of-tolerance check alert indicates that a rise in temperature above the normal operating range for the element has been detected. The on-battery signal alert indicates that the element has switched from its normal power supply to its battery back-up supply. The element-check alert indicates that an element failure has been detected whose precise interpretation depends upon the particular element presenting the alert.

An out-of-tolerance check condition or an on-battery signal condition in a Computing Element causes that element to take an abnormal condition interruption, but does not cause an alert to be broadcast to other Computing Elements in the system. It is expected that each Computing Element can handle its own out-of-tolerance checks and on-battery signal checks as they do not indicate an error environment, but instead provide warning of an environment that could soon become critical.

Summary comment

The 9020 system is designed to meet FAA requirements for a large-scale, high-availability multisystem. SYSTEM/360 design concepts are utilized and significantly extended in the areas of configuration control, shared storage, inter-element signaling, and malfunction alerting.

Table 4 Abnormal condition interruption action

Interruption source identification	*Diagnose-accessible register code bit*	*Diagnose-accessible register mask bit*
IOCE1a*	0	0
IOCE1b	1	
IOCE2a	2	2
IOCE2b	3	
IOCE3a	4	4
IOCE3b	5	
SE1 ELC	6	6
SE2 ELC	7	7
SE3 ELC	8	8
SE4 ELC	9	9
SE5 ELC	10	10
SE6 ELC	11	11
SE7 ELC	12	12
SE8 ELC	13	13
SE9 ELC	14	14
SE10 ELC	15	15
SE11 ELC	16	16
SE12 ELC	17	17
PAM1 ELC	18	18
PAM2 ELC	19	19
PAM3 ELC	20	20
TCU1 ELC	21	21
TCU2 ELC	22	22
TCU3 ELC	23	23
CE (own) OTC	24	24
CE (own) OBS	25	25
Spare	26	26
CE1 ELC	27	27
CE2 ELC	28	28
CE3 ELC	29	29
CE4 ELC	30	30
Spare	31	31

Legend

IOCE	I/O Control Element
SE	Storage Element
PAM	Peripheral Adapter Module
TCU	Tape Control Unit
CE	Computing Element
ELC	Element check
OTC	Out of tolerance
OBS	On battery supply
*	External signals from IOCE's are encoded as a two-bit field, designated *a* and *b* as follows:

Interruption Source Identification	*Bit Setting* *a*	*b*
Normal Operation	0	0
OBS	0	1
OTC	1	0
ELC	1	1

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Appendix — SYSTEM/360 compatibility

The requirement for eleven I/O channels available at the same time to a single Computing Element obviously precludes complete 9020 system compatibility with SYSTEM/360. The areas of incompatibility are manifest in the program status words (PSW) and channel addressing as follows:

Program status words

BITS	9020 PSW	SYSTEM/360 PSW
0–7	System mask	
0	Multiplexor Channel A mask	Multiplexor Channel mask
1	Selector Channel 1A mask	Selector Channel 1 mask
2	Selector Channel 2A mask	Selector Channel 2 mask
3	Selector Channel 3A mask	Selector Channel 3 mask
4	Multiplexor Channel B mask	Selector Channel 4 mask
5	Selector Channel 1B mask	Selector Channel 5 mask
6	Selector Channel 2B mask	Selector Channel 6 mask
7	External mask	External mask
8–11	Protection key	
12	ASCII mode (A)	
13	Machine check mask (M)	
14	Wait state (W)	
15	Problem state (P)	
16–19	System mask	Interruption Code
16	Selector Channel 3B mask	
17	Multiplexor Channel C mask	
18	Selector Channel 1C mask	
19	Selector Channel 2C mask	
20–31	Interruption code	
32–33	Instruction length code (ILC)	
34–35	Condition code (CC)	
36–39	Program mask	
36	Fixed-point overflow mask	
37	Decimal overflow mask	
38	Exponent underflow mask	
39	Significance mask	
40–63	Instruction address	

Channel Addressing

Channel address	9020 *interpretation*	SYSTEM/360 *interpretation*
0000 0000	Multiplexor Channel A	Multiplexor Channel
0000 0001	Selector Channel 1A	Selector Channel 1
0000 0010	Selector Channel 2A	Selector Channel 2
0000 0011	Selector Channel 3A	Selector Channel 3
0000 0100	Multiplexor Channel B	
0000 0101	Selector Channel 1B	Not operational
0000 0110	Selector Channel 2B	
0000 0111	Selector Channel 3B	
0000 1000	Multiplexor Channel C	
0000 1001	Selector Channel 1C	
0000 1010	Selector Channel 2C	Invalid
0000 1011		
	Invalid	
1111 1111		

A simplex subsystem whose operation is compatible with SYSTEM/360 may be configured from any 9020 system. It consists of one Computing Element, I/O Control Element 1 (IOCE1), and one or more Storage Elements. The subsystem may include the following peripheral elements, assigned to IOCE1 through the System Console: unit-record control unit, card read/punch, printer, and system console printer keyboard. A subsystem may also include the available tape control units and magnetic tape units. Large-capacity Storage Elements may be used in such a subsystem if provided in an installation.

Any Computing Element in state 1 or 0 may be switched from 9020-mode operation to 360-mode by pressing a mode-change switch provided on its control panel. A Computing Element in 360-mode is returned to 9020-mode by pressing the mode-change switch, by a power-on reset, by receipt of an external start signal from another Computing Element, or by placing it in state 2 or 3.