A DESCRIPTION OF THE IBM 7074 SYSTEM

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Summary

A new data processing system, the IBM 7070\textsuperscript{1}, was described at the 1958 Eastern Joint Computer Conference. Recent progress has resulted in the creation of an expanded family of 7070 systems, exemplified by the announcement of the IBM 7074 system.

The 7074 represents a dramatic new approach to data processing system growth, and is the second major step in the 7070 data system family. It is not an entirely new system, but rather an improvement within the 7070 framework. It enables a customer whose workload has outgrown his 7070 equipment to upgrade his system over a weekend, thus achieving multiplied performance without reprogramming and without excessive disruption of his operation.

Specifically, the increased performance is achieved by use of:

1. A new, high-performance arithmetic and program unit called the 7104 high-speed processor.
2. Improved-performance storage units, the 7301 models 3 and 4, which operate on a four-\(\mu\)sec cycle instead of the six-\(\mu\)sec cycle used with the basic 7070.

These units are substituted for their counterparts in the 7070 system.

Compared to a two-channel 7070 system using 729 IV tape drives, a 7074 of the same configuration has the following performance characteristics:

| Internal performance on commercial work | 6 x 7070 |
| Thruput or job performance on commercial work | 2 x 7070 |
| Floating point performance on scientific work | 10 x 7070 |

Internal performance is a measure of instruction-execution time. It is measured on the basis of the mix of instructions executed in a group of programs considered typical of commercial applications.

Thruput or job performance considers, in addition to instruction-execution time, the time expended in magnetic-tape input/output operations. A typical mix of commercial jobs--including sorting, merging, high and low activity-file maintenance, and editing--provides the basis for this comparison.

Floating point performance is measured on the basis of a typical group of arithmetic and logical instructions encountered in many scientific problems. It is essentially a measure of internal speed.

Functional Units

Physically, the 7070 family is made up of the following functional units which are packaged in IBM standard modular system (SMS) frames:

<table>
<thead>
<tr>
<th>7070</th>
<th>7074</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic &amp; processing unit</td>
<td>7601 (2 modules)</td>
</tr>
<tr>
<td>High-speed processor</td>
<td>7104</td>
</tr>
<tr>
<td>Storage, 6-(\mu)sec</td>
<td>7301, 1 &amp; 2</td>
</tr>
<tr>
<td>Storage, 4-(\mu)sec</td>
<td>7301, 3 &amp; 4</td>
</tr>
<tr>
<td>Core control and power distribution</td>
<td>7602</td>
</tr>
<tr>
<td>Basic timing &amp; control</td>
<td>7600</td>
</tr>
<tr>
<td>Tape control unit</td>
<td>7604</td>
</tr>
<tr>
<td>Tape transports</td>
<td>729 II or IV</td>
</tr>
</tbody>
</table>

The 7601 arithmetic and processing unit and the 7104 high-speed processor perform arithmetic, logical, and other stored-program operations under the control of a single-address type of instruction. Some other features are: ninety-nine indexing words; variable field length by the use of field definition; automatic block transmission of data within core storage; automatic priority processing; extensive checking; and simultaneous read, write, and compute.
The 7301 storage units are available in models of 5000 or 9990 words. They provide parallel access to ten digits (one computer word) at each storage reference.

The 7604 tape-control units provide for transmission of data between tape storage units and core storage. Two independent data channels can be provided by each 7604 unit.

The 729 tape transports are available in two models. Model II can operate at data rates of 15,000 and 41,000 six-bit characters per second. Model IV can operate at data rates of 22,000 and 62,500 six-bit characters per second. Up to forty tape transports, in any combination of models, are available on the system.

The above listing is by no means exhaustive. Many other devices -- including punched-card devices, printers, and manual inquiry stations -- are also available.

These units are the building blocks of the IBM 7070 family. Proper selection of processor, memory, and tape drives provides the ability to tailor a data processing system to a wider variety of customer requirements (both commercial and scientific) than ever before possible.

**System Growth**

The IBM 7074 system may be ordered directly from the factory, or it may be "grown" from a 7070 in the customer's office. The necessary changes can be made by a team of field engineers over a weekend.

Referring to Figure 1, the 7104 high-speed processor is substituted for the two 7601 modules which are removed and returned to the factory.

The 7301 storage unit is converted from a six-μsec cycle to a four-μsec cycle by a change to high-speed circuitry.

One slide, containing storage controls, is removed from the 7602 core control unit and returned to the factory. New storage-control circuits are provided in the high-speed processor.

**Program Compatibility**

The 7104 high-speed processor uses the same instruction set as the 7601, although it processes individual instructions three to twenty times faster. Some examples are:

<table>
<thead>
<tr>
<th>Operation</th>
<th>7070</th>
<th>7074</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-digit true add</td>
<td>48 μsec</td>
<td>10 μsec</td>
</tr>
<tr>
<td>Ten-digit true add</td>
<td>72 μsec</td>
<td>10 μsec</td>
</tr>
<tr>
<td>Multiply (10-digit multiplier)</td>
<td>924 μsec</td>
<td>56 μsec</td>
</tr>
<tr>
<td>Conditional branch</td>
<td>36 μsec</td>
<td>6 μsec</td>
</tr>
<tr>
<td>Unconditional branch</td>
<td>24 μsec</td>
<td>4 μsec</td>
</tr>
<tr>
<td>Floating add</td>
<td>212 μsec</td>
<td>16 μsec</td>
</tr>
<tr>
<td>Floating multiply</td>
<td>1019 μsec</td>
<td>60 μsec</td>
</tr>
</tbody>
</table>

Since the instruction formats are identical, programs written for the 7070 may be used on the 7074 without change. Furthermore, they will operate at full efficiency on the 7074.

This compatibility is important for rapid and simple change-over from 7070 to 7074. In addition, all 7074 customers -- newcomers as well as those changing over from the 7070 -- have at their disposal the entire 7070 program library of the GUIDE organization, and IBM applied programs for the 7070.

**Processor Organization**

The 7104 high-speed processor, like the 7601 arithmetic and processing unit, operates on the basis of a word of ten decimal digits and sign. Coding is 2 of 5, so that a word consists of 53 bits. Sign is plus, minus, or alpha and is represented by three bits in 2 of 3 code. Alphanumeric information is represented by two decimal digits, so that an alphanumeric word contains five characters, while a numeric word contains ten digits.

When written on magnetic tape, an alphanumeric word fills five six-bit characters. Numeric words are written as ten six-bit characters except that up to five high-order zeros are eliminated. This makes for very high tape efficiency.

The 7104 high-speed processor differs from the 7601 arithmetic and processing unit in that the 7601 performs arithmetic operations in a serial-by-decimal-digit manner while the 7104 performs full-word parallel arithmetic.
In the 7601 (see Figure 2) each digit is moved through the adder in one four-µsec cycle and is stored back in the arithmetic register on the following cycle, during which the next digit is moved through the adder. A full ten-digit add requires eleven cycles or 44 µsec for completion (assuming that recomplementing is not required). To this must be added instruction and operand access time as well as indexing time if required. Total time for a ten-digit true add (not indexed) is 72 µsec.

In the 7104 (see Figure 3) the full-word adder cycle requires two µsec for completion. Instruction and operand access time results in a total time of ten µsec for the nonindexed add instruction. This time is valid for any field size up to ten digits. Thus, add speed has been improved from three to seven times, depending upon field size.

Items of interest are:

1. Skew registers which provide the functions of field control and shift.
2. Three accumulators which provide speed in floating point operations.
3. Validity checking on all buses.
4. Complete program compatibility with 7070 (uses 7070 instruction set).

The information bus is one computer-word wide (ten decimal digits and sign = 53 bits). The address bus is four digits (20 bits) wide, and the arithmetic buses are eleven decimal digits wide.

Circuits and Packaging

The high arithmetic speeds are made possible by the use of saturating-drift-transistor NOR circuits. Packaging is accomplished in a new package known as the SMS twin card, which provides over three times the density of logical elements achieved in the 7601 processor of the IBM 7070. This density permits the 7104 to contain in one module all of the logic previously packaged in two and one-half modules.

Figure 4 compares the new SMS twin card with the SMS single card used in the 7601. Up to 44 transistors may be packaged on one twin card as compared to a maximum of eleven on the single card. The use of NOR circuits further increases the logical density in the SMS twin-card system. Vertically mounted components of the twin cards provide more efficient cooling. The component tips are welded to the bronze support clips at the upper end, and are soldered to the printed wiring of the card at the lower end. The bronze support clips contribute to cooling by providing a heat-sink effect; these clips also provide an additional dimension of modularity for automated production and for field repair of cards. Support-clip sections can be stocked and card repairs made in the field by replacement of clips, thus contributing to more economical maintenance.

Figure 5 shows additional details of the SMS twin card.

Cards are mounted in an IBM standard modular system (SMS) frame, which contains two slides, each composed of two pages. Each page contains four chassis, each of which in turn can contain 100 SMS twin cards.

Figure 6 shows an SMS sliding-gate module, covered. One such module contains the 7104 high-speed processing unit, and measures 29 1/2 in. wide by 56 in. deep by 69 in. tall.

The sliding gates pull out toward the front as shown in Figure 7.

Each gate opens into two pages in which are mounted the SMS single or double cards. The pages or gates are accessible for service from both sides. Covers over the cards contain the flow of cooling air.

Figure 8 depicts the organization of a page or gate of the module. The four chassis, each of which can contain 100 SMS double or 200 SMS single cards and a number of edge connectors, are shown from the rear or panel-wiring side.

It is the SMS system which makes possible the modular growth from the 7070 to the 7074. Replacement of one or more of these frames with functionally similar units of higher performance is possible without re-engineering every unit of the system.

References


From the collection of the Computer History Museum (www.computerhistory.org)
Fig. 1. System growth.
Fig. 2. 7070 information flow.
Fig. 3. 7074 information flow.
Fig. 4. SMS twin card and SMS single card.
Fig. 5. SMS twin card detail.
Fig. 6. SMS functional module.
Fig. 7. SMS module with slide out.
Fig. 8. SMS module page — rear view.