An evaluation of the East German RYAD 1040 system

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ABSTRACT
In the early 1970's, several East European countries and the USSR developed a compatible computer family called the Unified System, or RYAD. In 1975, Control Data purchased the ES-1040, a member of the RYAD family for testing and evaluation. Performance and compatibility tests were made and the technology was assessed. Tests determined that the ES-1040 is compatible with IBM 360 instruction set. Benchmark programs show the ES-1040 to be twice as powerful as the IBM 370/145 in scientific/engineering applications, and at least as powerful in BDP work. The processor, using TTL IC's lags the U.S. by three years, the core memory shows a lag of about eight years, while peripheral equipment is eight to ten years behind the U.S.

INTRODUCTION
My purpose is to present an evaluation of the East European RYAD 1040 Computer System, and to share with you some of the significant results. Before we go into the details, some background is necessary to set the stage for further remarks.

In 1969, the five year plan for the CMEA (Council for Mutual Economic Assistance) countries specified the development of a computer family called the Unified System of Electronic Computing Techniques. This family is commonly referred to as the RYAD which is the Russian word for series. The CMEA countries consist of Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland and the USSR. The development and production of the various models were delegated to the different countries, as was the peripheral equipment. In some cases, variants of a single model are produced in more than one country.

The family consists of six processors, numbered from 1010 to 1060, and a complement of peripheral equipment. The family uses an instruction set compatible with that of the IBM 360, and has common peripheral interfaces at the I/O channels. Because of the strong resemblance to the IBM 360/370, much of the evaluation is couched in terms of comparison to the IBM products.

In early 1975, Control Data purchased the largest available member of the RYAD family, an ES-1040 system made by the Robotron organization of the GDR. The system was received and installed at our Plymouth, Minnesota facility in July, and later moved to Washington, D.C. It is now installed in a CDC facility in Vienna.

THE ES-1040 SYSTEM
The system we received consisted of the hardware shown in Figure 1, together with operating software. The computer hardware consists of the central processor, an operator console, a main memory of 256 kilobytes of core storage, a byte multiplexer channel, and one selector channel. The peripheral equipment consisted of a card reader, card punch, line printer, two 7.25 MB disk drives, and two 79 IPS tape drives. I will discuss the hardware characteristics somewhat later.

We augmented the system by attaching some CDC peripheral subsystems normally offered in the plug-compatible market. The augmented system is shown in Figure 2. The specific items we attached, and used
DESCRIPTION OF THE ES-1040

In general terms, the ES-1040 processor can be classified as a medium to large machine, falling between the IBM 360/50 and 360/65 in terms of computer power. It is an integrated circuit machine constructed from TTL devices produced in East Germany. These devices are mounted on 72-pack multilayer boards which average four to five layers. The back-panel is wirewrapped, although fully automatic techniques are not used in production. The general workmanship in the processor was very good, and the reliability extremely high. We experienced one hour of CPU downtime during five months of operation, and had no CPU card failures. It is the routine practice to turn off power at the end of each day, turning it on again the following day.

The operation of the processor is based on the use of microprogram control. The microprograms are stored in a ROM core memory containing 3K words of 130 bits each. This memory has an access time of 100 nanoseconds and a full cycle of 450 nanoseconds, the latter constituting a major timing cycle.

Insofar as registers are concerned, the ES-1040 looks very much like an IBM 360. For example, it has 16 general purpose and four floating point registers. Because of its compatibility with the 360, an instruction may consist of two, four, or six bytes. The repertoire contains 143 commands, of which 87 are basic, eight deal with decimal arithmetic, 44 are for floating point operations, two are for storage keys, and the other two are used for direct control.

There are some important differences between the ES-1040 and IBM 360 models as far as the internal design is concerned. As I will bring up later, the 1040 performance is hampered by a relatively slow memory. However, this is masked to a large extent by an instruction lookahead feature. This allows memory accessing, address modification, and instruction execution to be overlapped. When considering the basic TTL circuit speeds and the major timing cycle of 450 nanoseconds, the execution times of complex operations, such as divide, indicate that some rather sophisticated algorithms have been employed.

ES-1040 MEMORY

The ES-1040 uses a main memory constructed from 21 mil cores. It has an access time of 450 nanoseconds, and a cycle time of 1200 nanoseconds, although the effective systems-level time is three CPU cycles, or 1350 nanoseconds. In our machine, the memory is composed of two 128K independent modules. In a maximum system of one megabyte, four modules are used. The access path to memory is eight bytes, with a theoretical bandwidth of 142 megabits per second possible when three or more modules are used. The memory uses a single parity bit for each 8-bit byte.
I/O CHANNELS

As I mentioned earlier, the ES-1040 we received had one byte mux channel for attachment of low-speed devices and one selector channel. The I/O structure can be expanded to include one byte mux and up to six selector channels. The first selector channel has a speed of 1300 kilobytes per second. Channels 2 and 3 comprise Group 2 and have an aggregate rate of 1100 KBS, assignable to a single channel if only one is used, or split evenly between the two when both are installed. Similarly, channels 4, 5, and 6 have a total rate of 900 KBS, which can be used on one channel, or divided into 300 KBS increments, if more than one is used. These rates apply when all channels are active.

In general, the channel rates far exceed the capabilities of the peripheral equipment used with the system.

PERFORMANCE EVALUATION

I would now like to discuss some of the evaluation results. We concentrated most of our efforts in evaluating the performance of the processor, since I/O-bound jobs would be highly affected by the restrictions of a single selector channel and by the peripheral configuration. One of the first things we did was a Gibson mix analysis. As you are probably aware, this analysis evaluates CPU performance primarily in a scientific and engineering environment. The results are displayed in Figure 3 using 64 bits as the floating point mode. As can be seen, the ES-1040 is about twice as fast as the IBM 370/145, two-thirds the speed of the IBM 370/155, and about half the speed of a CDC CYBER 73.

We also wrote some FORTRAN programs designed to test the speed of the 1040 versus the IBM 370/145. The pure floating point arithmetic tests showed that the ES-1040 is three to four times faster than the 370/145. On the other hand, a FORTRAN program stressing memory speed, and using only integer arithmetic showed that the 370/145 ran that program at twice the speed of the 1040. This result confirmed what we expected from comparing specified memory speeds. We also ran a comprehensive FORTRAN test program submitted by a customer to our benchmark center. Neither the 370/145 nor the 1040 could successfully execute this program using single precision REAL variables. When converted to double precision, the 370/145 ran the program in 41 minutes, as compared to 20.3 minutes on the ES-1040, a ratio closely approximating the 2:1 obtained in the Gibson Mix.

We were not nearly as successful in testing the 1040 in BDP applications for several reasons. First, we did not have a COBOL compiler in the Robotron software product set, and secondly, we had only a single channel to service both tape and disk. We did write some assembly language programs using the variable length instructions. The results of these indicate that the ES-1040 will be at least as fast as the IBM 370/145 in BDP applications, provided it were similarly configured.

I should note that our evaluation would have been easier if we could have had a manual fully defining instruction timing. As far as we know, no such manual exists either in English or German.

SOFTWARE AND DOCUMENTATION

At the time we procured the ES-1040, we also purchased a set of operating software known as DOS/ES. This bears striking resemblance to IBM DOS. The product set under DOS/ES included a FORTRAN IV compiler, an assembler, RPG, and PL/1. Notably lacking was a COBOL compiler. It is interesting to note that all compiler diagnostics were printed in English, although certain systems messages and diagnostics were in German.

In addition to DOS/ES, a more advanced system, called OS/ES, is also offered. From the information offered, it appears to be very similar to IBM OS, offering MFT and MVT options. To our knowledge, no ES-1040 systems are using OS/ES, probably because of the lack of adequate mass storage.

The documentation was very mixed in quality. The programmer manuals available in English were inadequate to the point that we used IBM manuals in that area. The German language manuals were better, but still less than what one receives from a domestic manufacturer. The hardware manuals, primarily for CE use, were very thorough and complete, but exclusively in German. This was of little concern to us, since we had Robotron field engineers on-site to supply maintenance.

COMPARISONS WITH WESTERN TECHNOLOGY

There is a great deal of interest in comparing the State-of-the-art of Eastern Europe technology with that of our own. Based on our examination of the ES-1040 equipment, no single statement can be applied across the board. Quite clearly, the CPU is the most advanced element of the system. As I mentioned it is constructed from TTL devices with an U.S.-type numbering scheme. The devices used in the ES-1040 are

<table>
<thead>
<tr>
<th>MODEL</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM 360/50</td>
<td>6.50</td>
</tr>
<tr>
<td>IBM 370/145</td>
<td>4.95</td>
</tr>
<tr>
<td>ES 1040</td>
<td>2.40</td>
</tr>
<tr>
<td>IBM 370/155</td>
<td>1.77</td>
</tr>
<tr>
<td>CDC CYBER 73</td>
<td>1.23</td>
</tr>
<tr>
<td>CDC CYBER 173</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Figure 3—Gibson Mix Values
relatively simple members of the family. By knowing when the equivalent devices were available in the U.S., we estimate that an American company could have completed a 1040 equivalent in 1968 or 1969. Since the first 1040 appeared in late 1972, we conclude that a time lag of three to four years exists in processor area.

The core memory attached to the 1040 is not a good match considering the power of the CPU. The technology is about eight years behind ours. The power consumption is about twice that of comparable memories used on domestic machines. The deficiencies of memory performance were apparently recognized early in the design cycle, and are effectively masked by the use of the instruction lookahead and memory interleaving features.

The peripheral area in general lags the U.S. by eight to ten years. The significance of the lag on general systems performance varies, of course, with the device. The one of most importance is that of disk drives. The two disks and the packs we received were made in Bulgaria, presently the only source of drives and packs in the CMEA countries. Although Bulgaria is also the primary disk controller supplier, the disk controller with the ES-1040 was produced in the GDR. The disks have 2311 characteristics. Its capacity is 7.25 MB, the transfer rate is 156 KBS, the rotational speed is 2400 RPM, and the average access time is about 65 milliseconds, even though a voice coil actuator is used.

Disk drives of the 2311 class went into production in the U.S. over 10 years ago, and since that time we have seen three new generations evolve. As far as the 1040 is concerned, the disks are clearly inadequate, not only for the obvious reason of capacity, but also the other performance parameters.

The ES-1040 tape subsystem, built in the GDR consisted of a controller and two 79 IPS drives, using 800 BPI nine-track format. The tape drives used dual capstans with pinch rollers, an old design approach. The tape loading process was very tedious and required considerable manual dexterity. The U.S. was producing comparable tape units over 10 years ago, and since then we have increased the bit density by a factor of eight and the tape speed by a factor of 2.5.

The line printer and associated controller were built in the GDR. It uses drum printer technology, operates at 900 LPM, and has 156 columns. It contains a unique feature; in effect a split platen, which allows two separate forms to be controlled independently. Thus, the printer can appear as two logical units to a programmer. This feature is supported by the Robotron software. Despite the technological drawbacks of the printer, it is adequate for most uses.

The card I/O equipment was made in the USSR, apparently having been in production for 10 to 15 years. The card reader reads 500 CPM, photoelectrically, while the card punch operates at 100 CPM, punching a row at a time. With the de-emphasis on card I/O, these units are adequate for most cases.

In examining the equipment, one quickly becomes impressed by its ruggedness, and high labor and material content. Workmanship ranges from good to excellent. Despite some old engineering designs, the equipment was very reliable. Preventive maintenance consisted of a daily PM of one to two hours and one weekly PM of four hours. Included in the daily PM was checking the adjustment of the positioners on the disk drive. All PM and EM work was performed by Robotron field engineers assigned to our system in accordance with their normal practices.

SUMMARY

I would like to conclude my remarks by making the following points:

- First, the ES-1040 demonstrated instruction set compatibility with the IBM 360 line.
- Second, the ES-1040 processor is about twice as powerful as the IBM 370/145 in scientific and engineering applications and at least equivalent to the 370/145 in BDP applications.
- Third, general processor technology seems to lag the U.S. by three or four years.
- Fourth, the core memory is about eight years behind.
- Finally, there is a significant lag in peripheral capability, which we estimate at eight to ten years.