BENCHMARKING THE SAS® SYSTEM, RELEASE 6.03
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Like any good software product, the SAS System has many different uses. Each SAS application makes characteristic demands on the supporting hardware, and a given personal computer platform may be optimal for some applications, but poor for others. Hardware upgrades may not improve overall performance on key applications; in fact, the new hardware may be slower than the old. Application benchmarks are the only reliable tool to help the computing manager decide what works and what doesn't.

Background

Some users rely on SAS software for intensive calculations, as in time series analysis or three-dimensional graphics. For these users, a fast processor and quick memory are a must; a computer can't be too fast. Personal computers (PCs) are within the acceptable speed range, but just barely, and only because they are devoted to just one user.

For users who run full-screen applications or large array problems, the memory space becomes most important. How fast the program runs is secondary to simply getting the whole program loaded. On DOS-based PCs, the search for more memory has meant escaping the 640K address-space limits of the operating system by using the Lotus-Intel-Microsoft (LIM) expanded memory specification (EMS). The SAS System for IBM® PCs and compatibles has supported this paged memory since Release 6.03.

However, many SAS users do not spend the majority of their computing time either crunching numbers or filling memory banks with megabyte-sized arrays. Instead, they rely on the SAS System primarily for data handling. In the Glaxo Inc. Biostatistics department, for example, most SAS programmers use the software to sort, screen, merge, and tabulate information from the corporate database of clinical trials records. This type of application turns out to be nearly independent of processor and memory speed. The key to efficient data handling is the input/output (I/O) capacity of the system. Rapid transfer of data to and from disk storage is everything.

Today, in the spring of 1989, the microcomputer market is in transition. The generation of PCs based on the Intel 80286 microprocessor, and modelled after the IBM PC/AT, seems increasingly slow and outdated compared to the newer 80386-based machines and IBM PS/2 systems. As the older machines depreciate, many sites will be planning to upgrade their PCs to newer and faster technologies.

Unfortunately, this trend presents the buyer with an annoyingly broad range of options. The new hardware falls roughly into two categories: The IBM PS/2 and its eventual clones, and non-IBM PCs built along the "classic" IBM PC/AT design (with or without the upgraded microprocessors). When IBM unveiled the PS/2 line two years ago, many people assumed that the older line would simply fade away. However, the installed base was such that demand for AT-compatible computers continued to grow; indeed, IBM's market share has declined from that day. Makers of classic PC clones have fine-tuned the technology to the point where they can offer reliable machines that equal or exceed the performance of the PS/2s at half the cost or less.

The result is that PC buyers must make hard choices based on price, performance, and obsolescence rates.

One of the most important distinctions between PS/2 architecture and classic PC design is in the system backbone, or "bus." This new bus arrangement does more than change the connection for plug-in cards. Among the largely unexploited benefits are: the potential for co-processors to share the bus, reducing the workload on the CPU; self-configuring add-in cards, a feature that eliminates the need for setting tiny switches; and software-controlled priority and arbitration of devices sharing the bus. In contrast, the classic bus offers a huge supply of peripheral devices at low cost. These circuit boards are relatively easy to design and manufacture, but conflicts between them are usually resolved by service technicians, not software.

Another concern for PC buyers is the operating system. IBM designed the advanced models of the PS/2 line with a new operating system in mind. Because MS-DOS is really designed for the Intel 8088/8086 processors, it never took full advantage of the AT/AT hardware, and does even less well with the 80386. Memory address limitations are a particular problem. OS/2, the new operating system, allows for multitasking and larger memory space.

The SAS System does not currently run under OS/2, and the OS/2 environment has a general shortage of other applications even after a year and a half. But, if the new hardware must serve for five years or more, buyers must weigh the benefits of future operating systems against the need to get the job done today. Since, for the present, users will run SAS software under DOS, buyers should remember that the PS/2 Models 70 and 80 (the Intel 80386-based machines) do not accept LIM expanded memory boards. In other words, the fastest IBM PS/2s can not run large-memory SAS applications at all, without serious tinkering.

Finally, to complete the confusion about operating systems, not all DOS applications designed for the classic PC will run on the PS/2. The problems mostly involve memory-resident programs and graphics. Classic PC models may be able to run OS/2 applications, but some applications may be hardware-specific (as the IBM PC BASIC interpreter was).

Benchmark Tests

For many buyers of computer systems, performance is the main criterion for choosing one machine over another. Both trade journals like Info World and user magazines like PC Magazine publish hardware reviews that include benchmark tests. These tests are not favor any one software advertiser over another; instead, they are "pure" measures of system performance, designed to measure clock speed, disk access times, or the number of null instructions that the computer can perform in a second. Such laboratory
benchmarks usually bear out the manufacturers' implicit claims that bigger or faster is better. Reviewers happily report the percentage by which the new PC is quicker than the reader's old one, and suggest that we all rush out to buy the latest and fastest box.

However, another sort of test exists, the application benchmark, which never seems to find its way into magazine reviews. Instead of taking abstract measures of speed on single tasks, an application benchmark loads a commercial program that people actually use and performs some tasks that people really need. Then, the overall time to get the job done becomes the measure of system performance.

Almost without exception, the industry experts who write the reviews conclude that the latest models are faster and better than the old ones (although they often grumble that the product could have been even better with this or that pet feature added). One rare article, in the September, 1988 issue of PC Tech Journal, compared the discontinued PC/AT Model 339 to current machines based on the 80286 microprocessor. It showed that the IBM PS/2, Models 50 and 80, had no speed advantage over the AT in disk operations. Other than this note, the article was in line with all the other journals' reviews.

At the risk of being called cynical, we in the Biostatistics Department at Glaxo decided to test the new PS/2s from IBM before we planned any migration to the new technology from our installed base of IBM PC/ATs. The primary objective was to test for compatibility, but we were also eager to know how much of a speedup we could expect on our people computing. This machine received the most personal computing. This machine received the most

```
DATA LONG;
LENGTH CHAR1 $200;
DO I=1 TO 10000;
VAR1=UNIFORM(938);
VAR2=UNIFORM(0);
CHAR1 = 'ABC............';
OUTPUT;
END;
RUN;

PROC SORT DATA=LONG;
BY VAR1 VAR2;
RUN;

DATA SHORT;
DO I=1 TO 100;
VAR1=UNIFORM(938);
VAR2=UNIFORM(0);
OUTPUT;
END;
RUN;

PROC SORT DATA=SHORT;
BY VAR1 VAR2;
RUN;
```

This program generates 10,000 records of two random variables each, adds a long text variable for bulk, and sorts the results. Then, it runs a shorter version of the same test. Because we at Glaxo spend so much of our programming time normalizing and sorting arrays of data, this test seemed fair.

We never attempted to create a "perfect" test, only a fair one. Different SAS procedures would have favored different hardware configurations. Graphs, for example, seem to run faster on the Video Graphics Array (VGA) display on IBM PS/2s than on the Enhanced Graphics Adaptor (EGA) installed on our PC/ATs. However, since the SAS System in general is so disk-intensive, any PC that performed poorly on PROC SORT would be likely to be slow on other SAS procedures as well.

**Hardware Tested**

The first PC tested was an IBM PC/AT with a clock speed of 6 MHz. This PC had a 30 megabyte Seagate hard disk, and used the standard-equipment IBM disk controller. It was also fitted with an AST Rampage memory board to provide expanded memory. We tested the PC with and without 384K of EMS. The 80287 math chip was disabled with the $NONDP option in the CONFIG.SAS file.

The next PC tested was an IBM PC/AT Model 339 with a clock speed of 8 MHz. Like the 6 MHz AT, it was equipped with a 30 megabyte Seagate hard disk and a standard IBM disk controller. It was also fitted with an AST Rampage memory board to provide expanded memory, and was tested with and without 384K of EMS. The 80287 math chip was disabled with the $NONDP option in the CONFIG.SAS file.

The PS/2 Model 60 is the top of IBM's 16-bit product line, a Micro Channel PC with an 80256 CPU running at a clock speed of 10 MHz. The test unit had an IBM hard disk and controller, and an Intel AWE Board 2 for expanded memory. We tested it with and without 384K of EMS, and again with EMS and a disk cache. The IBM CACHE program included with the PS/2 was the only cache program tested with this machine. As with the other 16-bit PCs, the 80287 math chip was disabled with the $NONDP option in the CONFIG.SAS file.

When IBM first introduced its PS/2 line, the Model 80-071 was the flagship. With a 16 MHz 80386 microprocessor, 70 megabyte ESDI hard drive, and 32-bit Micro Channel architecture, it represented the state of the art in personal computing. This machine received the most extensive testing. We tried two brands of disk caching software, the DOS FASTOPEN utility, and the 80387 math coprocessor, both active and disabled. We also tested each disk partition separately. The SAS System ran under DOS 3.3, DOS version 4.0 was not tested.

The last PC tested was a PS/2 Model 70-A21. This PC is the current top of the IBM line, with an 80386 processor running at 25 MHz. Disabling the 80387 math chip did not affect the execution time significantly.

The following charts show the times reported for each hardware configuration. These times are the best recorded of several runs. The percentages in the chart express the ratio of the total execution time of each system to the best execution time for the PS/2 Model 80-071.
Results By System

<table>
<thead>
<tr>
<th>Machine Tested</th>
<th>Long Data Time</th>
<th>Long Sort Time</th>
<th>Short Data Time</th>
<th>Short Sort Time</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>6MHz PC/AT 384K EMS</td>
<td>4.50 min.</td>
<td>17.58 sec.</td>
<td>10 min.</td>
<td>6 sec.</td>
<td>22.35 min.</td>
</tr>
<tr>
<td>6MHz PC/AT No EMS</td>
<td>4.18 min.</td>
<td>19.87 sec.</td>
<td>11 min.</td>
<td>8 sec.</td>
<td>24.37 min.</td>
</tr>
<tr>
<td>8MHz PC/AT 384K EMS</td>
<td>4.95 min.</td>
<td>17.58 sec.</td>
<td>10 min.</td>
<td>6 sec.</td>
<td>22.35 min.</td>
</tr>
<tr>
<td>8MHz PC/AT No EMS</td>
<td>4.18 min.</td>
<td>19.87 sec.</td>
<td>11 min.</td>
<td>8 sec.</td>
<td>24.37 min.</td>
</tr>
<tr>
<td>PS/2-60 384K EMS</td>
<td>3.97 min.</td>
<td>17.45 sec.</td>
<td>4 min.</td>
<td>3 sec.</td>
<td>21.54 min.</td>
</tr>
<tr>
<td>PS/2-60 384K EMS plus cache</td>
<td>3.80 min.</td>
<td>15.35 sec.</td>
<td>3 min.</td>
<td>2 sec.</td>
<td>15.55 min.</td>
</tr>
<tr>
<td>PS/2-60 No EMS</td>
<td>3.02 min.</td>
<td>29.95 sec.</td>
<td>9 min.</td>
<td>6 sec.</td>
<td>32.22 min.</td>
</tr>
<tr>
<td>PS/2-70 A21 C:, plain</td>
<td>1.43 min.</td>
<td>13.53 sec.</td>
<td>7 min.</td>
<td>5 sec.</td>
<td>15.16 min.</td>
</tr>
<tr>
<td>PS/2-80 C: partition, plain</td>
<td>1.53 min.</td>
<td>12.28 sec.</td>
<td>8 min.</td>
<td>6 sec.</td>
<td>14.04 min.</td>
</tr>
<tr>
<td>PS/2-80 D: partition, plain</td>
<td>2.92 min.</td>
<td>23.95 sec.</td>
<td>10 min.</td>
<td>7 sec.</td>
<td>24.77 min.</td>
</tr>
<tr>
<td>PS/2-80 E: partition, plain</td>
<td>3.80 min.</td>
<td>15.35 sec.</td>
<td>4 min.</td>
<td>2 sec.</td>
<td>15.55 min.</td>
</tr>
<tr>
<td>PS/2-80 C: IBMCache 1408K</td>
<td>2.83 min.</td>
<td>19.42 sec.</td>
<td>4 min.</td>
<td>3 sec.</td>
<td>22.37 min.</td>
</tr>
<tr>
<td>PS/2-80 C: PC-cache 1408K</td>
<td>2.78 min.</td>
<td>19.30 sec.</td>
<td>4 min.</td>
<td>2 sec.</td>
<td>22.18 min.</td>
</tr>
</tbody>
</table>

Discussion

The fastest time recorded for all PCs tested was 13.72 minutes for a PC/AT Model 339 using 384K of expanded memory. It beat the PS/2 Model 70-A21, although this PS/2 is the fastest PC available from IBM at any price, by nearly a 1.5 minutes. The slowest time was for the PS/2 Model 60 without any speedup options.

Obviously, this result could not have been predicted by any laboratory benchmark. In fact, as of the week before SUGI 14, we have not found a satisfactory explanation for the difference in speed between the Micro Channel and classic PCs. A method for speeding up the SAS System on PS/2 platforms would make a welcome topic for some future SUGI.

We have, by experimentation and with the cooperation of IBM and SAS Institute, ruled out some possible causes. The SAS software is not making any illegal hardware calls; it uses 32-bit buffers, but they can be disabled without affecting execution time. Removing accessory boards from the PS/2 Model 80 sped up the execution of the benchmark program, so the hard disk controller simply may not be getting its share of time on the bus. Adjusting the FILEBUFFERS statement in the CONFIG.SAS can speed up PROC SORT, but reduces the available system memory; whether such a change slows down other PROCs has yet to be tested.

Because the PS/2 was designed for OS/2, not DOS, there is some hope that the SAS System under OS/2 would live up to the potential of the PS/2 hardware. PROC SORT, for example, might be able to do much more in memory, with fewer disk operations. However, OS/2 is known more for the size of the applications it can run than for the speed at which it runs them. And, of course, the SAS System is not currently available under OS/2.

The moral is this: SAS software runs as fast as it runs. No laboratory benchmark is any guarantee of performance in the real world. In fact, the results from real applications might be just the opposite of what the lab tests suggest. Do not assume that any speedup utilities will work as predicted; test them, alone and with other utilities. Above all, don't spend a lot of money on new hardware until you see it run, not just with SAS software, but with your style of SAS application.