MULTICS TECHNICAL BULLETIN MTB-087

TO: DISTRIBUTION

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SUBJECT: MULTICS PERORMANCE GOALS FOR 1974

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This MTB discusses some performance measurements and commitments and outlines the system changes to achieve our performance improvement goals for 1974. Figure 1 summarizes benchmark results for some recently achieved Multics performance fixes. Also indicated are some committed future benchmark performance improvements. These figures have been presented to MIT and to Multics Project Management. They predict a performance improvement of 100% as measured by MIT software assurance benchmark runs between February 1974 and December 1974.

Currently the benchmark performance of the system is quantified as a single number -- the total elapsed time to run 20 absentee processes executing a script of Multics commands on a configuration of 1 cpu, 256K words main memory, and 2 Mwords Bulk Store.

The information at the top of Figure 1 summarizes actual benchmark performance measured against Systems between 20.2 and 23.9 inclusive. Note that System 23.3 was our worst performer; it is being used as the reference point against which all other systems will be measured. Our goal is to reduce the benchmark elapsed time from 104 min. (System 23.3) to 52 min. by year-end. System 23.9 has already reduced the measured elapsed time to 91.8 min. System 23.10 listed below the dotted line in Figure 1 contains scheduler modifications to employ virtual rather than real cpu time as the unit of measure for scheduling quanta and should require an estimated elapsed time of 82 min. to complete the benchmark (an improvement of 11% over 23.9). The next three items on the list are collections of planned software improvements. The final item is a set of hardware performance improvements. All are described in more detail below.

MTS500, initial EIS conversions. By the end of June 1974, the new MTS500 tape software capable of using large records at 1600 bpi will improve tape I/O efficiency; unfortunately tape I/O is not used during the benchmark, so this will enhance real system performance but not benchmark performance. We hope to pick up 1-4% in benchmark performance with the installation, for the first time, of programs compiled with EIS PL/I compiler; the new implementation of edm is particularly important here.

Backup. Planned performance enhancements in the Backup System may improve performance of a heavily loaded Service by around 5%; (a 40% improvement in a facility using 10-15% of the cpu time) however Backup is not run during the benchmark so this improvement will not be apparent.

Page Control/Scheduler, etc. The following changes are expected to reduce the benchmark time by about 20%.

> Page Control/Scheduler: improvements in the bulk store and disk dims, improved page removal algorithm, page pools, and use of working set estimates by scheduler. A 50% reduction in virtual memory management time in a benchmark run previously spending 40% of the cpu time supporting paging will reduce the benchmark time by 20%.
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> tty dim upgrade: initial cleanup of the 6180 tty code to use EIS for character conversions, canonicalization, etc. could improve performance by 1-3% on a heavily loaded system. Unfortunately the benchmark run does not use terminal I/O so this improvement will not be apparent in the benchmark timings. Note that the complete 355 software redo, and attendant additional performance improvements, is scheduled for completion 1Q75.
>
> ring zero cleanup: performance optimization of the Storage System and other ring zero code by restructuring and recoding to take advantage of EIS. A 20-40% performance improvement of ring zero code accounting for 10-20% of the system time will yield a System improvement of around 4%.

Cache and Processor Speedup. Addition of cache to the 6180 cpu and inclusion of speedups primarily to the cpu appending logic have led to measured average processor instruction rate improvements of about 30% while running Multics. Therefore the 20% decrease in benchmark time expected of these hardware modifications appears conservative.

The Benchmark. The use of a benchmark to produce a single number -- benchmark duration -- by which to measure performance change is attractive because of the simple results produced. However, the current benchmark has several serious problems. Most serious is the fact that built-in script delays yield excess zero-idle time; as a result, a recent measurement of the "virtual time quantum system" -- 23.10 -- yielded an elapsed time of 86.8 min. (rather than the predicted 81.6 min.). However the zero-idle time for this run was 12% -- an inaccurate reflection of the usual Service environment in which zero-idle is very rare. Also, typical benchmark runs produce a paging load of around 20% whereas a heavily loaded Service typically spends 40-50% of the cpu time supporting the virtual memory. Moreover, improvements scheduled for Backup, tape I/O and terminal I/O will produce significant performance improvements in the behavior of the Service but will not improve the benchmark time.

Because of shortcomings in the current benchmark, an improved benchmark is being prepared. It will attempt a more accurate simulation of the Service environment primarily by eliminating zero-idle time and by subjecting the system to a heavier, more typical paging load. This new benchmark will then be calibrated against several versions of Multics and against the present benchmark script to establish an equivalence between the two benchmarks. Even the new benchmark will not indicate the effects of all the planned improvements; however by subjecting the system to a full load, it will presumably be more responsive to our efforts then the current benchmark.

Next Step. This MTB discusses only currently planned performance enhancements; other ideas are firming up and will be documented as soon as possible. For example, one of our most serious performance problems -- the large working set required by a process to perform even small tasks -- is just beginning to receive serious attention. In order to coordinate current and future performance improvement tasks, a performance improvement project has been established. Multics Technical Bulletins have already been issued and more are planned. A Multics Task Report summarizing all performance improvement tasks will be issued and updated periodically. Progress against the performance benchmarks will also be reported in MTB's.

Estimates of Performance Improvements Using MIT Benchmark Run

System	Date	Elapsed Time (min)	% of 23.3
20.2	5/12/73	91.4	87.3
22.0a	1/21/74	94.3	90.2
23.3	2/25/74	104.5	100.0
23.7	4/14/74	96.2	92.0
23.9	4/28/74	91.8	87.6

System	Est. Date	Est. Imp.	Elapsed Time (use mean est. imp.)	% of 23.3
Virtual time quantum	5/74	10-12%	81.6	78.2
MTS500 (large records), EIS conversions	6/74	1-4%	79.6	76.2
Backup	3Q74	3-7% (Backup not used during Benchmark)	79.6	76.2
Page Control/Scheduler, tty dim upgrade, ring zero cleanup	4Q74	8-30%	64.5	61.7
Cache and processor speedup	4Q74	20%	51.6	49.4

Figure 1