To: Distribution

From: Steve Webber

Subject: New Storage System Paging Analysis

Date: April 5, 1974

This memo is being written to present some preliminary findings about the possible performance effects alluded to in MTB-055, the new Storage System Overview. The basic problem is that, due to the design, there is the potential for a good deal more paging (or at least disk activity) than with the current design. The numbers below represent approximations to the number of "directory" pages referenced by selected functions within segment and directory control which are most affected.

Here the term "directory page" means just that for the current implementation but includes directory pages, VTOC pages, FSDCT pages and fsmap pages in the new design. Note that the numbers below represent page references which are the worst case of page faults (some pages may be in core for other reasons). Note also that the numbers below are for directory pages only and do not include any code references where in fact the directory faults constitute only about 1/2 of the page faults caused by segment and directory control.

Function	Current Scheme	Proposed Scheme
activation	3	7
deactivation	3	7
updateb	3	6
segfaults	4	6
bound faults	5	8
quota	1	2
make known	6	7
create	6	8

There are two observations which should be made about these figures. First, in both the current and the new design some of the references may be in a page just referenced. It depends on the directory compaction and allocation used. Second, there is

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about a 1.5 to 2 factor of more potential page references with the new scheme. This increase must be weighed to see what effect it will have on total performance.

The entire percentage of system page faults caused by activation, deactivation and bound faults is currently about 4%. If the worst case were realized and we doubled paging for these functions (by far the most frequent of the segment and directory control functions affected) this would mean an increase in the system paging of about 4%; or stated another way the system would be degraded by about 1%-2% (paging costs are currently about 25%-50% of the system).

This increase in paging (4%) must be qualified by realizing two features of the new design:

1. The FSDCT will no longer be wired thereby freeing up about 1/2k core per disk.

2. Depending on the accessing method used for the VTOC, FSMAP, etc. as much as 1k of core might have to be wired per disk. This 1k of core would be for a page table to access the VTOC, etc. with normal virtual methods.

This means that there would be 1/2k less core per disk in the available paging pool. This, of course, will effect system paging as well, but it is hard to estimate the effect (it is a function of the number of disks and the amount of core).

It has been proposed to reference the VTOC's, etc. with explicit disk I/O requests that do not use the virtual memory features of the hardware. This would probably be used in conjunction with an LRU managed buffering scheme of 64 word buffers that keep recently referenced VTOC regions in core in "sticky registers". This implementation has the advantage that it takes considerably less wired core than the page tables required by the virtual scheme and therefore scales to systems with a large number of disks better. It has the disadvantage that it is not as easy to implement other parts of directory control because of lack of virtual accessing techniques.

Note that if a buffering scheme is used many of the page references above would be replaced by explicit requests. These requests are usually for a small amount of data and it would be more efficient to use a buffering scheme that brings in little data that is not needed. This would decrease the 4% figure and place the burden on the directory or segment control modules to do explicit I/O rather than compete for core in the common

pool(s).

In conclusion, then, it seems that the increase in paging is bounded by about 4% and the total system performance may be degraded by 2%. This is to be weighed against the 10% - 20% we hope to gain by the reworking of the backup mechanism. The undertaking appears to be feasible.