

**Name:** \_\_\_\_\_

### Instructions

There are three (3) sets of questions on the exam. You may find questions that could have several answers and require an explanation or a justification. As we've said, many answers in storage systems are "It depends!". In these cases, we are more interested in your justification, so make sure you're clear. Good luck!

If you have several calculations leading to a single answer, please place a 

box around your answer
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### Problem 1 : Short and concise answers. [55 points]

- (a) Dr. Dimwit was thrilled to learn that his new disk drive has a MTBF of 1,000,000 hours. He immediately sold his backup devices, feeling confident that he is guaranteed years of fault-free storage. Why should he be nervous?
  
  
  
  
  
  
  
  
  
  
- (b) Bob, inspired by Greg's lectures about how large requests amortize overheads, proposes to use 20 MB requests whenever possible. Explain one difficulty he will face and one performance problem that may arise.
  
  
  
  
  
  
  
  
  
  
- (c) Give two advantages of zoned recording?
  
  
  
  
  
  
  
  
  
  
- (d) Although the C-LOOK scheduling policy gives slightly higher average response times than SSTF, it is still used in some application domains. Why does C-LOOK give higher response times and why is it still used sometimes, despite that?

- (e) Upon coming home from a fun trip to Albania, Greg suddenly realizes that many of the pictures he took there will be hard to find in the future if he stores them in his hierarchical directory-based file system. Greg then contacts Eno to ask for a solution, and Eno tells him to install a database and store the pictures in that database. (1) Why would a database help in finding files? (2) What does Greg still need to do, even with a database, to ensure he'll find his files easily in the future? (3) Finally, why don't we get rid of file systems altogether, and use an off-the-shelf database to store files?
- (f) In POSIX systems, how can an application quickly read byte #1,234,567,890 in a newly opened file?
- (g) Heated discussions often arise when the log-structured file system is compared to shadow paging, as a mechanism for ensuring consistent updates to persistent storage. Briefly describe why log-structuring can be thought of as a form of shadow-paging or argue why it should not.
- (h) Prof. SmartyPants has invented a new storage interconnect technology that can transfer 100 GB/second. But, he is worried that it will take years for people to agree on a storage protocol for it. Why should he not worry?

**Problem 2 : Analyzing disk characteristics – the Skippy experiment. [25 points]**

Raja has just come up with a brilliant idea (this is a very common occurrence). He is going to start a web-site devoted to the analysis of hard disks. Having just taken Greg's storage systems class, he decides that he will start by posting the results of the project one Skippy-based experiments for various disks on his web-site. Unfortunately, having not paid much attention in class, Raja is unsure as to how to run these experiments or interpret their results. Please help him out by answering the following questions.

(a) What three things must Raja remember to do on his lab machine before running the Skippy-based experiments? What will happen if he forgets to do these three things?

(b) Raja runs read-based Skippy and obtains the graph shown at the end of this handout.

(a) How many heads does this disk have? Label all of the head switches and cylinder switches on the graph.

(b) What is the rotational latency of this disk?

(c) What are the MTM and STM values for this disk? Label the point on the graph that corresponds to MTM and STM.

- (c) Raja now runs write-based Skippy (same as read-based Skippy, but reads are replaced with writes), but forgets to disable the disk's write-back cache. How would the graph differ from the correct output? How can Raja tell that he forgot to disable the write-back cache by looking at the graph?

**Note:** When answering this question, assume that the disk cache uses a FIFO replacement policy and does not coalesce multiple writes to the same sector.

- (d) Raja is almost done running experiments! Thanks to your input, he re-runs write-based Skippy with the hard disk write-back cache disabled. However, he is confused by the fact that the MTM and STM values obtained from the write-based Skippy experiment are different from those that he obtained from the read-based Skippy experiment. Explain why you think these values should or should not be different. If you think they should be different, should the write-based Skippy MTM and STM values be higher or lower than the read-based Skippy MTM and STM values?

### **Problem 3 : File system layout. [21 points]**

Many filesystem benchmarks specify strict rules that must be followed when the benchmark is run in order for the results to be considered valid. One such rule specifies that the underlying filesystem must be freshly formatted and empty before the benchmark is run. In a paper entitled *File System aging – Increasing the Relevance of File System Aging*, Keith Smith and Margo Seltzer argue that the results obtained from any benchmark that mandates this “fresh format rule” will show results that are atypical of real-world scenarios.

- (a) Consider two identical Servers A and B that differ in only the age of their filesystems. Server A uses a FFS filesystem that has been freshly formatted, whereas Server B’s FFS filesystem is six-months old and has seen steady usage during this time period. If the ACME benchmark is run against both, which will perform better? Explain your answer.

- (b) If the two servers use LFS filesystems, instead of FFS, which would perform better? Explain your answer.

- (c) Raja is running the ACME benchmark against his server which uses FFS. While doing so, he realizes that all of the files read and written by the ACME benchmark are 128KB in size. Raja knows that FFS uses a 8KB block size and inodes that contain 12 direct blocks references. Raja also knows that FFS changes the cylinder group in which a file's data is placed every time an extra indirect block is allocated. Suggest a change that Raja can make to FFS to potentially increase his server's performance on the ACME benchmark. Why will this change increase performance? Are there any potential disadvantages to this change?



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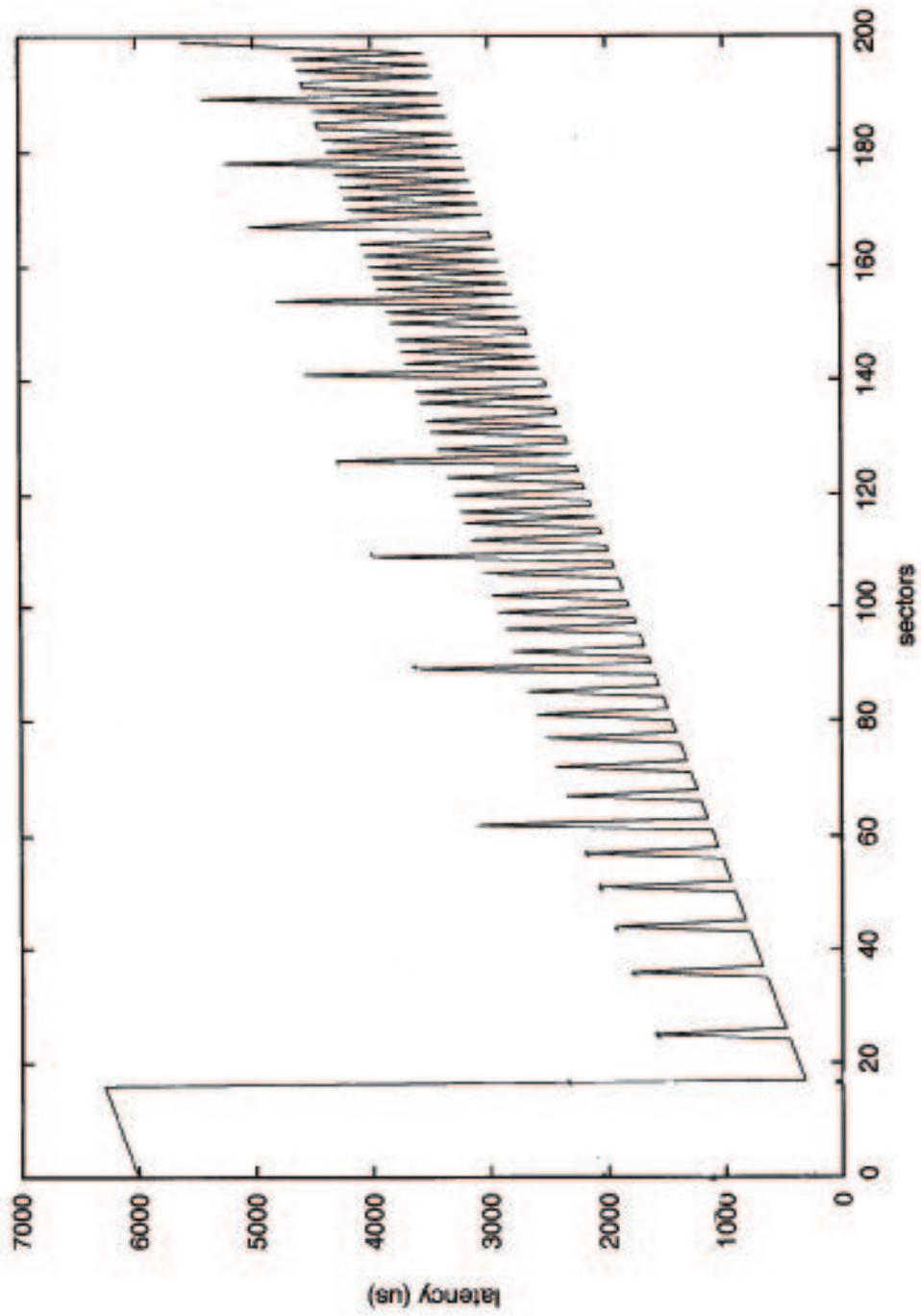


Figure 1: Raja's Read-based Skippy results