Increasing Hard drive Performance – From a Thermal Perspective

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Abstract - The importance of input/output (I/O) performance, hard disks in particular grows over the years. Speed and performance of semiconductor components have grown rapidly and the hard disk I/O sub system cannot cope with that rate. Many have attempted to remove this I/O bottleneck using several techniques such as better cache management, parallelism in the form of RAID, high bandwidth interconnections such as SAN, improved read/write head designs and improved cooling systems. Most of them had not considered the fundamental factor affecting the I/O performance; heat generated within the disk drive from the read/write process. This paper presents a method to increase the hard disk I/O performance by operating the hard drives in a vendor recommended temperature range. Operating the hard drives in the safe temperature range would not only provide performance improvements, it also provide more reliable disk drives by eliminating the off track errors and head crashes. To achieve the above mentioned performance increase, this paper suggests a disk drive model which would work according to the variations of the temperature of the disk drive model.

I. INTRODUCTION

Disk drives lie at the heart of the storage system and are the most significant determinants of both its capacity and performance. Due to the large difference in speed between disks and other levels in the memory hierarchy, I/O performance plays a critical role in many server applications. After all, we also use all the other main components of the system constantly, so aren't they equally important to the performance equation? Well, yes and no. The importance of the CPU, motherboard and other core components are very important. But much as the strength of a chain is equal only to that of its weakest link, in many ways the performance of a system is only equal to that of its poorest performing component. Compared to the solid state components in a computer, hard disks have by far the worst performance. Even though hard drives improve their performance; the performance increasing rate of the hard drives are far less than the performance increasing rate of the semiconductor components. So this once again, widens the performance gap. Thus, hard disks continue to be the bottleneck of overall performance of many systems.

The applications where hard disk performance issues are crucial are obviously those that do a lot of reading and writing to the hard disk, compared to the application do lot of processing. Such tasks are said to be I/O bound. Multimedia editing applications, especially those dealing with large audio and video files, are probably the most affected ones by the speed of the storage subsystem. Initial boot up of a PC is also a very I/O intensive application, as the operating system loads literally hundreds of files. Improving hard disk performance can decrease the boot process time in a very palpable way. On the other hand, if we thought about enterprise; data centric services such as file and e-mail servers and transaction processing within an enterprise, together with Internet based services such as search engines, stock trading, etc., heavily rely on disks for their storage needs. This shows that the performance of storage systems is important for wide variety of users; from PC users to large scale data centric users such as Google.

Disk drive vendors state performance in terms of Internal Data Rates (IDR) and seek times. When we examine the mechanics of drives, it may intuitively appear that we can easily increase the performance by spinning disks faster, making the platters smaller (to reduce seek distances), and usage of better recording technologies whenever possible. However, one of the most fundamental factors affecting disk drive design is the heat generated by some of these actions and its effect on reliable operation. High temperatures can cause off-track errors due to thermal tilt of the disk stack and actuator, or even cause head crashes due to the out-gassing of spindle and voice-coil motor lubricants [2]. Even a fifteen degree Celsius rise from the ambient temperature can double the failure rate of a disk drive [1], and it is important to provide some design margin within the disk to accommodate slight variations in the external temperature. This makes it imperative for the disk to operate below a threshold temperature.

While these traditional techniques have been successful in improving IDR until now, without exceeding the vendor recommended temperature, this is getting to be more difficult because in future:

I. Further density improvements are not as easy since they require high error/noise tolerance and very complex head designs.

II. Stronger error-correcting codes to tolerate errors can consume a significant portion of disk capacity and reduce the effective user data rate.

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