

LC Technology Solid State Doctor™
White Paper
SSD Utility Suite Improves Performance
and Monitors Lifespan

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SSD Utility Suite Improves Performance and Monitors Lifespan

Flash Solid State Drives (SSD) offer great advantages for computing in terms of performance, power consumption and compact size. However, as a replacement for Hard Disk Drives (HDD) it is difficult to compete on price in terms of memory storage per dollar. The need for low power and fast response will drive the penetration rates for SSDs, especially in the enterprise segment.

The enterprise computing segments are most likely to justify the higher GB/\$ of SSDs, but system designers and IT departments need to be convinced of the long term reliability of SSDs. In fact, HDDs also have the probability of failure since these are mechanical devices; however, HDDs have been used successfully for decades and have a long history.

The cost debate between SSD and HDD will be a long running one. Flash memory manufacturers have been able to offer higher density at lower prices, over time. However, the HDD manufacturers have been able to keep pace and thus maintain a wide pricing margin with SSDs based on gigabytes per dollar.

The concern with Flash SSDs has been the limited useable lifespan due to cell wear out from writes to memory. This has hampered higher penetration rates as well. SSD manufacturers use wear leveling as one technique around this problem as well as over-provisioning of the drive. Add in performance issues which frequently emerge due to random write operations to the SSD and the advantages don't look so great anymore.

What is becoming glaringly evident is that SSDs need tools that work with the SSD controller and operating system. LC Technology has developed such a tool which will enable faster performance, data security and provide firmware management.

Solid State Doctor™ offers benefits to SSD manufacturers not only from a technical point of view but also in marketing the product against the competition.

SSD Advantages

Relative to HDDs, the advantages of the SSDs are

- Fast start up and fast random access since there is no spin-up and no “seeking” motion for spinning platters and head actuators.
- Quiet operation since there are no moving parts.
- Lower power consumption and heat dissipation.
- Greater physical resilience to extreme shock, vibration, altitude and temperature variations.
- No mechanical parts that can fail.
- More compact in size and lower weight.

SSD Disadvantages

- Limited lifetimes due to Flash wearing out from too many writes, on the order of:
 - 1 million to 2 million write cycles for MLC
 - 5 million write cycles for SLC
- Wear leveling algorithms and additional spare blocks required in order to spread writes over the entire device and extend the lifetime of the SSD.
- Security and encryption problems with wear leveling.
- Lower GBytes per dollar relative to HDD.

Performance Issues

The SSDs have much faster access times compared to HDDs due in part to the lack of moving parts. In a HDD, files may be broken up across different sectors rather than in one contiguous location. The physical motion of the HDD head slows down this action. This is not an issue for an SSD reading or writing data as fragmentation does not affect

performance. Data can be read faster from an SSD and the “out of the box” write performance is very good.

What has emerged is write performance degradation as an SSD fills up and write combinations quickly slow down overall performance. This occurs because data is stored in an SSD in pages that consist of groups of flash memory cells, typically 4 KB. These pages are then grouped into blocks and typically there are 128 pages or 512 KB per block.

When flash is empty, the memory cells can be written to directly. The nature of flash memory is such that data cannot be overwritten in the same fashion as occurs in a hard disk drive. It must first be erased prior to a write operation for reasons of reliability. Due to hardware limitations in SSDs, a write operation is performed on a page, but an erase operation affects an entire block. As the SSD fills up with data, several read-erase-modify-write cycles occur. Before a block can be erased, the data is stored in the cache and then page data is modified in the cache. The entire block in the cache is then written back to the SSD. This increased number of writes consumes bandwidth and affects the write performance and long-term reliability of the SSD. This phenomenon is known as write amplification.

The SSD controller performs garbage collection as the SSD fills up in an effort to minimize the write amplification effect. This process accumulates blocks that have been previously used and marked for erase as “garbage”. The SSD controller then executes an erase of the whole block in order to reclaim the space for new data writes. This process can occur actively or passively depending on the drive controller, but consumes resources, and can increase costs of the SSD.

Techniques for improving performance and lifespan

Wear leveling is a process by which writes to flash memory are spread around the SSD to minimize the write cycles to each cell. When a flash memory location exceeds its write cycles it will no longer work and the SSD controller swaps in spare blocks as existing ones are depleted. When enough blocks reach end of life, the entire SSD is essentially unusable. Wear leveling algorithms are designed to optimize the overall performance of an SSD by minimizing write amplification, as well as extend the useful life of the flash memory SSD.

TRIM is a recently introduced process that enables the SSD to handle garbage collection overhead. It works with the OS to keep track of the blocks in the SSD that are not in use and that can be wiped during idle

times. TRIM enables the SSD controller to handle the necessary overhead for free space management much more efficiently. The OS and SSD controller firmware need to communicate with each other and the SSD in a coordinated fashion to support wear leveling and TRIM for optimal performance and useable lifespan. For Microsoft OS, only Windows 7 and Windows Server 2008 R2 currently provide TRIM support.

Firmware update issues

Due to its infancy, SSD controller firmware is constantly being optimized to improve performance and efficiency. Therefore, firmware updates are a necessary and vital requirement. Currently, most of the firmware updates require numerous steps which are not exactly user friendly and in some cases take the user “back to the future” by requiring the user to work in DOS mode.

SSD firmware updates can be a complicated, time consuming and frustrating process. Frequently, this tenuous process is confusing and often requires opening multiple task windows. Some procedures require working with command lines in a DOS window and users often need technical support from the SSD manufacturer. In some cases, the user has to make BIOS changes and then remember to go back after the firmware update to reset the BIOS changes. Sometimes the drive itself needs to be removed from the system. Users are warned to backup all data prior to a firmware update and if the procedure is not successful there is the potential for a fatal error and an unusable drive.

These problems are being reported and discussed on SSD tech forums every day. The users performing these updates are mostly tech savvy and understand SSDs better than the general consumer, so clearly an easier and more streamlined procedure is needed in order to attract new customers that are not technical experts, as well as alleviate the frustrations of knowledgeable users.

LC Technology SSD Utility Suite – Solid State Doctor™

LC Technology has developed a utility suite for SSDs, Solid State Doctor™, which addresses the performance issues for SSDs running on any Microsoft OS. In addition to monitoring the useable life of SSDs, Solid State Doctor™ gives users the ability to use the TRIM feature on an OS that does not natively support it, allowing users to easily manage SSDs and perform firmware updates. The utility occupies minimal

space with only a 15-22MB software footprint, depending on the functions selected.

Solid State Doctor™ does not replace the SSD controller firmware but works closely with it and the OS. The utility does not extend the lifetime of the flash memory since flash IC has a finite number of write cycles, but will monitor the health and useable life of the SSD, alerting the user to any issues.

The Solid State Doctor™ can reside on any drive in the system, system or secondary, and can manage one or more drives. An SSD can also be partitioned as a system drive and any number of secondary drive volumes. The utility works on drives formatted in any Windows file system, e.g. NTFS, FAT 32, exFAT, etc. LC Technology provides a simple and intuitive user interface in the utility to allow even novice users the ability to manage the SSD effectively.

SSD Monitoring and Management

The utility monitors all the SSDs in a system. A user can view all pertinent information about an SSD including any special features supported by the drive and will perform monitoring and performance management as a background service, once the service is set up.

The utility monitors various parameters that provide the user with early warning that an SSD is about to fail. This is known as the SMART information (Self-Monitoring Analysis and Reporting Technology). SMART technology has been a standard on HDDs since the mid-1990's, but is a relatively new addition to SSDs. The drive keeps an internal list of Attributes which are associated with different measurements of reliability and performance. In an SSD, there can be around 20 Attributes or more. The results presented to the user are raw values. The purpose of SMART is to warn a user or an IT administrator of impending drive failure while there is still time to take action, such as copying the data to a replacement device. The main shortcoming of SMART is that there is no mechanism in the standard for informing the OS or the user of problems. The drive's SMART status needs to be frequently monitored, otherwise a problem could go undetected that leads to a catastrophic failure. Solid State Doctor™ monitors SMART, thereby eliminating that worry for the user. The utility includes an email alerting option to notify the user of a SMART failure. Additional detail on the health of each SSD drive can be obtained by examining the individual SMART attributes displayed by the utility.

A limitation of SMART is that while it provides diagnostic results which can be used as clues that there is a problem with an SSD, there is no actual failure prediction presented. On several tech forums one can find that even knowledgeable users have difficulty interpreting the raw values of the Attributes. Solid State Doctor™ monitors in real time the SMART status and provides advanced warning of a potential disk failure, as well as monitoring the SSD for end of life. With this information the user has time to back up data and replace the drive.

What is important to note is that the SMART Attributes and raw values are vendor specific. The interpretation of these results is also vendor specific. LC Technology works closely with all the SSDs it supports, eliminating the burden for the user to interpret the results from one SSD manufacturer and another.

Solid State Doctor™ also allows the user to execute the SSD's built in diagnostics if the SSD supports it. A user can select to execute simple quick tests or more exhaustive read and write tests, as required.

The utility also offers a Security Wipe. This feature does not do encryption nor can it block unauthorized access of the SSD, but it will completely delete all information on the SSD, writing zeros to every cell, back to its original raw state. This function is intended for a secondary or data drive as well. There is a safety feature which prevents the user from accidentally wiping the system drive.

Solid State Doctor™ and TRIM

As noted previously, only Windows 7 and Windows Server 2008 R2 support TRIM. One of the key features of Solid State Doctor™ is that it also provides TRIM support for all other Microsoft OS's starting with Windows XP. TRIM is still a relatively new function to the SSD industry and there is still room for improvement for how the OS works with TRIM. The utility provides additional user control where Windows 7 and Windows Server 2008 do not, by allowing users to either run TRIM manually or schedule the service to run daily or weekly at scheduled times.

In the installed base of SSDs, in addition to systems with older OS that have no TRIM support, there are older SSDs that do not yet have this feature. Many of these drives need firmware updates to enable TRIM support. LC Technology's utility easily enables bringing these systems up to current firmware features in order to improve write performance.

Firmware Wizard

LC Technology provides easy firmware management with a feature called Firmware Wizard. A user can easily update the SSD firmware on any SSD with a few button clicks. There are several options available for applying firmware updates – either directly downloading from within the application or manually selecting one from a particular device or location. The utility will create a bootable USB stick or file for a bootable CD. On reboot there is the option to update the firmware with no need to use a command line, modify the BIOS or remove the SSD from the system.

Due to the complexities of firmware management, Solid State Doctor™ is customized to the specific needs of each SSD manufacturer allowing for a streamlined firmware update, making the process incredibly easy for the user.

Advantages for SSD Manufacturers

There are over 150 manufacturers of SSDs in the market today. Most SSD makers do not have the software expertise and resources to make a utility like Solid State Doctor™. Intel does make a utility but only for its own SSDs.

LC Technology has extensive knowledge of firmware and file systems. This allows an SSD maker to be able to get a product to market quickly with the utilities to manage it. An SSD maker can license the utility and deliver it on a CD with the SSD. Additionally, the utility can be customized for a specific manufacturer. LC Technology can deliver a custom GUI, whereby features can be added or removed. A custom version of Solid State Doctor™ gives the SSD manufacturer or system integrator added value to stand out from its competitors.

Solid State Doctor™ also works with external SSDs via USB and FireWire if SAT-ATA pass-through is supported. In addition, other flash based devices can benefit from some of the features of this utility, for example, industrial grade Compact Flash.

Currently, the largest market for SSDs is the enterprise segment. However, SSDs are likely to grow exponentially in other markets. As SSDs increase penetration in high volume PC client and consumer markets, SSD makers will need to deliver user friendly utilities. LC Technology provides this with Solid State Doctor™.

About Semico

Semico is a semiconductor marketing & consulting research company located in Phoenix, Arizona. Semico was founded in 1994 by a group of semiconductor industry experts. We have improved the validity of semiconductor product forecasts via technology roadmaps in end-use markets. Semico offers custom consulting, technology white papers, portfolio packages, individual market research studies and premier industry conferences.