O&O Defrag and Solid State Drives

Summary

Solid State Drives (SSD or "flash drives") have become increasingly popular in recent years and have come to compete with traditional hard drives as very fast storage media. The sole use of memory chips accounts for all moving mechanical parts of a hard disk, resulting in lower power consumption and less heat. In addition, SSDs operate silently and are insensitive to shock or vibration. However, the main disadvantages of SSDs when compared to conventional hard drives is still their very high price and, unfortunately, limited life span since the used memory chips allow only a finite number of write cycles.[1]

The question about defragmenting such drives is often asked in connection with the overall performance of an SSD. In addition to answering this question, this paper will also consider SSDs in connection with O&O Defrag under all current Windows versions.[2]

Physical degradation

The SSDs for the mainstream market are made up of non-volatile flash memory which retains written data without a permanent electrical supply. Due to their special construction, flash drives are physically worn out bit by bit every time they are write-accessed. This, of course, limits their life span considerably.

Each flash cell stores a single bit (SLC - single-level cell) or multiple bits (MLC - multi-level cell) through the concentration of charge carriers in certain semiconductor layers. In order to maximize the storage density per area, several thousand flash cells are organized into a flash block. While it is possible to read individual cells in a flash block, they cannot be written on individually. If a single bit is changed, the entire flash block needs to be deleted and rewritten completely.

In each of these delete-rewrite cycles, higher voltage is used to move charge carriers between the semiconductor layers so that the semiconductor crystal is gradually damaged over time. Depending on the design, a flash block may perform a maximum of either 5000-10000 (MLC) or 100,000 (SLC) delete cycles. From that time on, there is no guarantee for saving future data, and so data loss is imminent.[1]

The SSD controller intelligently redistributes the write access to counteract such effects. New incoming data is written on the less frequently used flash blocks with help of complex algorithms. Though physical degradation will not be prevented completely, it will be effectively limited. Only as a result of these measures can flash devices be used as replacements for hard disks. Any current SSD disposes of significantly more memory than designated in order to evenly distribute write accesses.

Defragmentation shortens life span
In contrast to 1:1 mapping of file system sectors to media sectors, as was the case with hard disks, the internal data management of SSDs leads to a completely different assignment of sectors to flash blocks. It may well be that a large file that isn't fragmented in the file system can be distributed by the SSD controller across thousands of different flash blocks - without any adverse effects in performance. Defragmentation would not cause any measurable increase in acceleration. On the contrary, due to the many short write accesses, it would only produce unnecessary delete-write cycles.

Defragmentation of SSDs is not only unnecessary, if done frequently it may even significantly reduce their life span !

Extend life span of SSDs through TRIM

So far, hard drives have always been content agnostic - they store all sectors of a file system 1:1. In addition, areas marked as free by the operating system, and which the user sees as containing no data, will be saved. If the user deletes files or formats a drive, the actual contents will remain stored on the drive even though data is discarded from the perspective of the operating system. SSDs also keep this useless sector content until they're overwritten by new data. And that's where considerable room for the support of the wear-leveling algorithms opens up: If drives were somehow told which memory areas do not contain useful data, they'd be able to release these flash blocks so that they could be re-used for new data.

This is exactly the optimization approach that's implemented in the latest ATA standards with the TRIM command. Drives that support TRIM can improve their internal data management and wear leveling. Software is needed for transmitting the TRIM command to the SSDs in order for this optimization to take place at all.

SSDs under Microsoft Windows

TRIM command from Windows 7 on
Native support for the TRIM command was integrated with the introduction of Windows 7 and Windows 2008 R2. Each file deletion is accompanied by this command, which is sent from the operating system to the SSD, provided that it supports this command.

Older versions of Windows cannot do this, so the user has to rely on applications made by various manufacturers. These applications all follow the same standardized procedures internally, but they artificially lock out drives from other manufacturers.

Using these tools manually requires some knowledge on the part of the user and are time-consuming – which would make fully automated optimization of SSDs something very desirable.

Defragmentation programs
Another problem in the interaction between Windows and SSDs are defragmentation programs, including Windows' own Disk Defragmenter. If SSDs are not recognized as such, a defragmentation will be run: this not only fails to improve performance, but also shortens the life span of the drive due to overloading of the wear-leveling mechanism. That's why it's absolutely necessary to avoid the defragmentation of SSDs.

Neither Windows XP nor Windows Vista can distinguish SSDs from hard drives. For this reason, the built-in Windows defragmenter[3], as well as other defragmentation programs that preform similarly, will try to unnecessarily rearrange files on SSDs at regular intervals. Every defragmentation that's run will thereby reduce the life span of your SSD.

O&O Defrag supports SSDs under all current Windows Versions

O&O Defrag,[4] implements the optimization of SSDs using the TRIM functionality according to the ATA standard[5]. For the first time, O&O Defrag allows a user-friendly solution for optimizing all the drives on a computer - regardless of their manufacturer, or whether they are SSDs or mechanical hard disks.

Automatic Optimization
Thanks to the new automatic optimization, it is no longer necessary to set up a defragmentation manually. It is enabled by default after installation and optimizes the disks in the background without affecting the computer negatively during operation.

Automatic optimization was extended for SSDs to allow for the regular implementation of the TRIM command. O&O Defrag detects SSDs and prevents any attempt at defragmentation. In addition, the Windows Disk Defragmenter is switched off to prevent automatic (and damaging) defragmentation of the SSD.

The default configuration of O&O Defrag was prepared on the basis of a broad survey of personal and corporate customers. It is optimized for the vast majority of computer user scenarios and also takes into account all combinations of conventional hard drives and SSDs in a computer.

Note
O&O Defrag recognizes SSDs and will never subject them to an automatic defragmentation, regardless of the settings. The automatic TRIM command for SSDs will be prevented if automatic optimization is disabled by the user. Consequently, automatic optimization should be enabled all the time.

Run TRIM manually
O&O Defrag runs TRIM independently when automatic optimization is enabled for SSDs. In addition, a manual execution of TRIM is also possible via the integrated command line application. The syntax is as follows:

oodcmd.exe /TRIM:<Drive letter (A-Z)>

This command line tool is located in the O&O Defrag installation folder.

Requirements and restrictions
In principle, the O&O Defrag TRIM functionality works independently of the operating system. Unlike most manufacturers, all standard file systems of Windows are supported: not only NTFS, but also FAT/FAT32, and exFAT (available since Windows Vista). However, the following requirements for hardware and drivers must be met:

- The SSD supports the TRIM command. This should be given to all current drives with the latest firmware. At the time of publication of this white paper, the following SSDs or SSD controllers support the TRIM command:
  - Intel X25-M and X18-M G2 G2 ("Postville")
  - SSDs with Indilinx Barefoot (e.g. OCZ Vertex)
  - SSDs with SandForce SF1200 or SF1500 Force (e.g. OCZ Vertex 2)
  - SSDs with Samsung RBB (e.g. OCZ Apex, Samsung PB22-J)
  - Samsung 470
  - SSDs with the latest controllers from Toshiba
  - SSDs with the latest controllers from Marvell (e.g. Crucial RealSSD C300)
  - And much more! If in doubt, please contact the manufacturer!
- SSD is attached to a SATA controller which runs in AHCI mode
  - Technically speaking, TRIM commands can also be run in the IDE mode, however, they will block all the read and write commands of the system. Without AHCI, the system will literally stop still during the implementation of TRIM for several seconds to minutes – and this is unacceptable for our customers in our view.
  - Drives attached to RAID or SAS controllers are not supported
  - SSDs in RAID arrays are not supported
- SATA drivers must be able to pass on TRIM commands to SSDs (ask the manufacturer if necessary)
  - Currently, only the latest drivers from Intel (iaStor) and the Windows native AHCI driver from Microsoft (msahci) can pass on TRIM commands

Conclusion

The defragmentation of SSDs leads to no improvement in their performance, and may even negatively influence their life expectancy. As a result, such defragmentation must be avoided through the automatic detection of SSDs by the operating system or the defragmentaion software. On the other hand, the automatic and regular execution of the TRIM command increases SSD performance and significantly extends its life span.

O&O Defrag provides both. It is therefore the optimization tool of choice - both for traditional hard disks, as well as for SSDs. With O&O Defrag, you get an intuitive tool that optimizes all the drives on your system and provides a sustained increase in the overall performance of any PC or server.

About O&O Software GmbH

O&O develops solutions for corporate clients to assist them in their daily work and reduce their costs. Our products for system optimization, data imaging, restoration and the secure deletion of data, as well as company-wide administration are pioneers in the Windows area. With our worldwide network of partners, we support companies, corporations, public institutions and private clients in more than 140 countries from our headquarters in Berlin.

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