White Paper
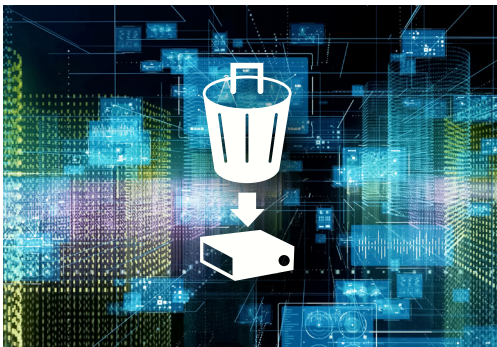
Garbage Collection & TRIM for SSDs

Introduction

Optimizing Data Management with Garbage Collection and Enhancing Drive Longevity and Write Speed through TRIM

This white paper presents solutions to address the challenges associated with solid-state drive's (SSD). SSDs operate differently in how they handle data, which can impact their performance and lifespan. This paper will cover two essential techniques: "Garbage Collection," which helps maintain data consistency and clean up unnecessary data information, and the "TRIM command," which further enhances SSD speed and durability by reducing write operations.
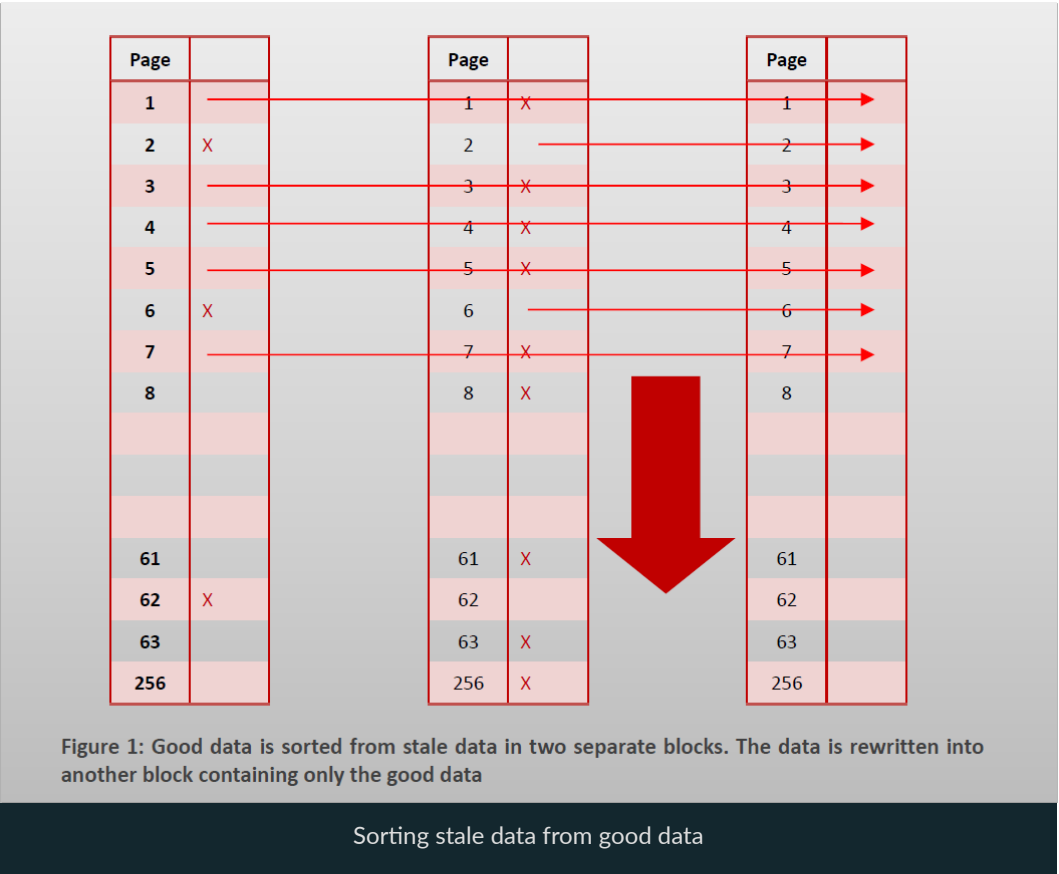
As non-volatile Flash memory becomes more prevalent in demanding environments like factories with severe vibrations, it is crucial to understand how SSDs outperform traditional HDDs in terms of energy efficiency, longevity, access speed, and read performance. However, Flash memory has its unique characteristic, such as being write-once and requiring garbage collection mechanism to manage data storage efficiently.

Innodisk's approach involves employing a linear-access optimized garbage collection method along with the TRIM command. This ensures that read and write operations are optimized for performance and data integrity, addressing the challenges posed by Flash memory's unique traits.

How Innodisk manages garbage collection with TRIM

As stated above, data is written to the Flash memory in units called pages. Pages make up blocks and data can only be erased in entire block-units. Garbage collection involves removing stale data from pages and rewriting the data into newly erased blocks.

The process of garbage collection involves reading and rewriting data to the Flash memory. This means that a new write from the host will first require a read of the whole block, a write of the parts of the block which still include valid data, and then a write of the new data. This can significantly reduce the performance of the system. This is where the TRIM command comes in.

Figure 1: Good data is sorted from stale data in two separate blocks. The data is rewritten into another block containing only the good data

Sorting stale data from good data

TRIM enables the SSD controller to skip invalid data instead of moving it. Naturally, this frees up a significant amount of resources and extends the lifespan of an SSD by reducing erase and write cycles on the SSD. TRIM tells the controller not to waste resources performing garbage collection on data in its logical block addresses (LBA) that has been designated invalid. See Figure 2.

Figure 2: Garbage collection with the TRIM command   Source: thessdreview.com

Garbage Collection with the TRIM command

In the figure above, when file C in column 2 is erased, the old file C space is immediately marked as invalid. During garbage collection this free file C spaced is used to maximize system performance. The controller does not need to move the invalid data to a free block.

Conclusion

While SSD storage solutions offer substantial value added benefits over traditional HDD data storage, data integrity remains a constant challenge for engineers and industry experts. Innodisk's handling of garbage collection along with the TRIM command improves write performance on SSDs. Garbage collection with TRIM eliminates the need for whole block data erasing prior to every write operation, and helps prevent performance degradation and increase SSD life spans.

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