

# Apacer® and Diskeeper Corporation®

## The Best Gets Better

## Table of Contents

Overview	1
The Problem	1
Problem Analysis	1
The Software Solution: HyperFast™	2
Summary	7

## Overview

This paper details the purpose and benefits of a ground-breaking technology alliance between NAND Flash hardware leader Apacer Technology Inc, and storage performance technology innovator Diskeeper Corporation.

## The Problem

Solid State Drives (SSD) have several issues that come into play when used as the primary storage medium in place of traditional magnetic Hard Disk Drives (HDD); specifically regarding the operating system's logical file system. To date, file systems have been designed under the pretext of HDDs, and do not properly account for new NAND Flash / SSD technology.

This leads to issues that negatively impact mass market adoption of NAND Flash memory into the consumer, small/medium businesses, and enterprise markets where legacy file systems, designed for HDDs, will dominate the landscape for many years.

## Problem Analysis

The principle issue is write speed degradation due to free space fragmentation. Small free spaces scattered throughout a volume at the logical level cause the file system to write a file in fragments to those small free spaces. This will degrade write performance as much as 80% to that solid state storage device. Fragmented free space forces the writing of blocks that are not advantageous to write or erase block boundaries, even if the application software would otherwise use large buffers.

Diskeeper Corporation has tested many current SSDs, from many manufacturers for file write speed degradation as a function of free space fragmentation. NTFS, the most common Windows® file system by far, is shown to fragment free space rather aggressively over a few months and then grows slowly thereafter when not maintained (figure 1).

**FRAGMENTATION LEVELS**  
(Free Space)



Figure 1: Accumulation of free space fragmentation through normal system use.

Write performance decreases proportionately as free space fragmentation increases. The graph below (Figure 2) shows the resultant 80% write speed reduction on a variety of drives due to this effect. The test included copying a 1GB file on to an SSD with fragmented free space. The graph axis depicts the I/O write throughput in megabytes per second (MB/s) in relation to the number of file fragments the file is forced to be written in due to non-contiguous free space clusters. While a brand new SSD device may offer write performance in the 80 MB/s range to start, after a few weeks of use, performance will quickly deteriorate to 35 MB/s. Over the span of a few months, write speed becomes painstakingly slow at an abysmal 10 MB /s.

### 1GB FILE WRITE TEST

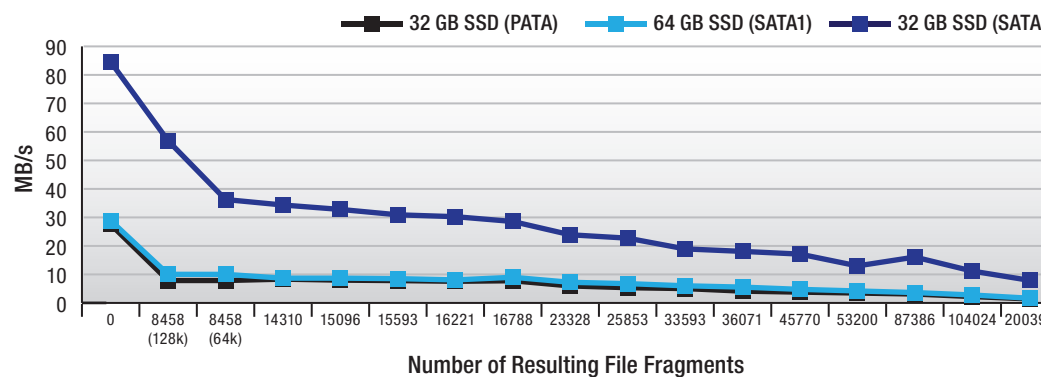


Figure 2: Write I/O throughput degradation due to fragmented free space.

It is important to note that the performance loss due to fragmented free space affects all NAND Flash memory drives shipping today. The issue is not relegated to one specific vendor or other. The results depicted in Figure 2, for example, are non-Apacer devices.

## The Software Solution: HyperFast™

As described, the issue originates with how an operating system interacts with the storage hardware. The nature of modern operating systems, their regular updates, and the applications which run on them, have been designed with no forethought to the effect of free space fragmentation and its unique impact on SSD NAND flash. While moderately immune to effects on read-based file fragmentation, NAND flash is extremely susceptible, based on the empirical evidence, to write speed degradation when the free space is moderately to heavily fragmented.

HyperFast delivers automatic maintenance of the file system, keeping a low level of free space fragmentation through specific optimization techniques which preemptively force the file system to write sequentially rather than randomly.

This technology dramatically improves SSD performance. Specific tests were performed to demonstrate the improvement. The test depicts an environment with free space fragmentation in a range as might be expected from about 6 months of typical system use.

### HDBENCH SCORES APACER 8GB SATA SSD (higher scores are better)

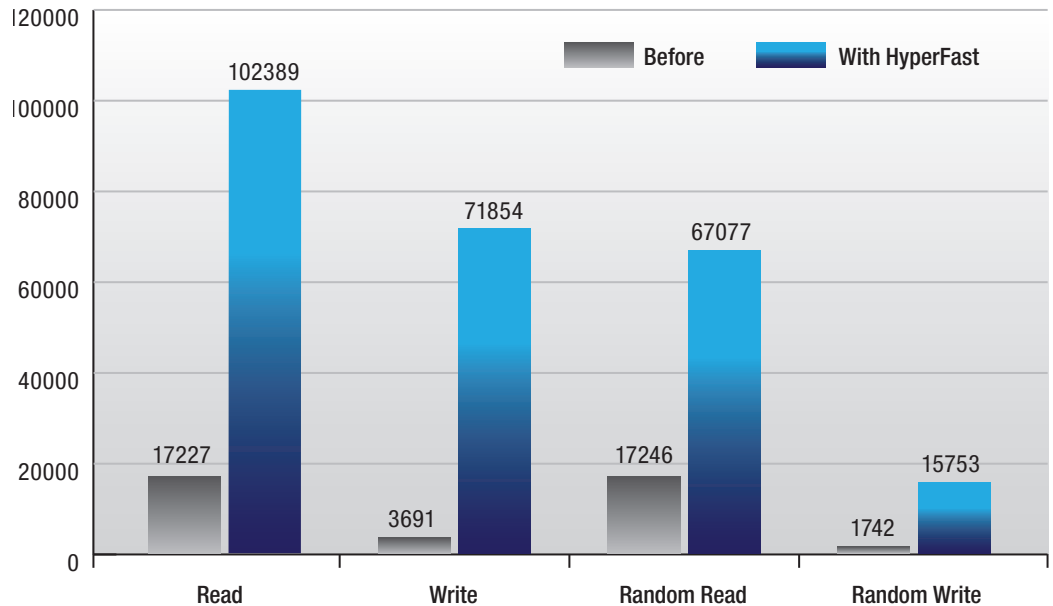


Figure 3: Benchmark scores on Apacer 8GB SATA SSD with HDBench™ software.

The results on an Apacer 8GB SSD (SATA) device record performance improvements of 5.9x faster reads, 19.5 faster writes, 3.9 faster random reads, and 9.0 faster random writes.

### HDBENCH SCORES APACER 8GB PATA SSD (higher scores are better)

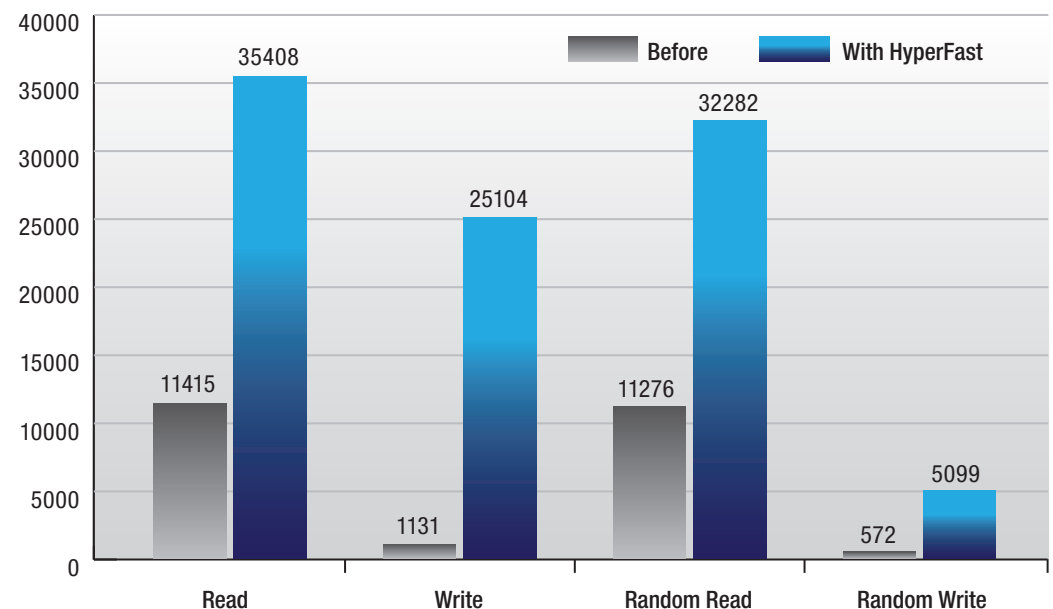


Figure 4: Benchmark scores on Apacer 8GB PATA SSD with HDBench software.

The results on an Apacer 8GB SSD (PATA) device record performance improvements of 3.1x faster reads, 22.1 faster writes, 2.8 faster random reads, and 8.9 faster random writes.

NAND flash drives have limited erase-write cycles. This fact mandates that any optimization program that may seek to increase performance cannot acceptably do so at the expense of wearing out the drive faster. A tool, specially provided to Apacer, from BinarySense Inc. called SSDLife™, was used to measure the average erase-write activity on the Apacer SSD device from various actions.

#### SSD LIFE™ ERASE COUNT RAW AVERAGE

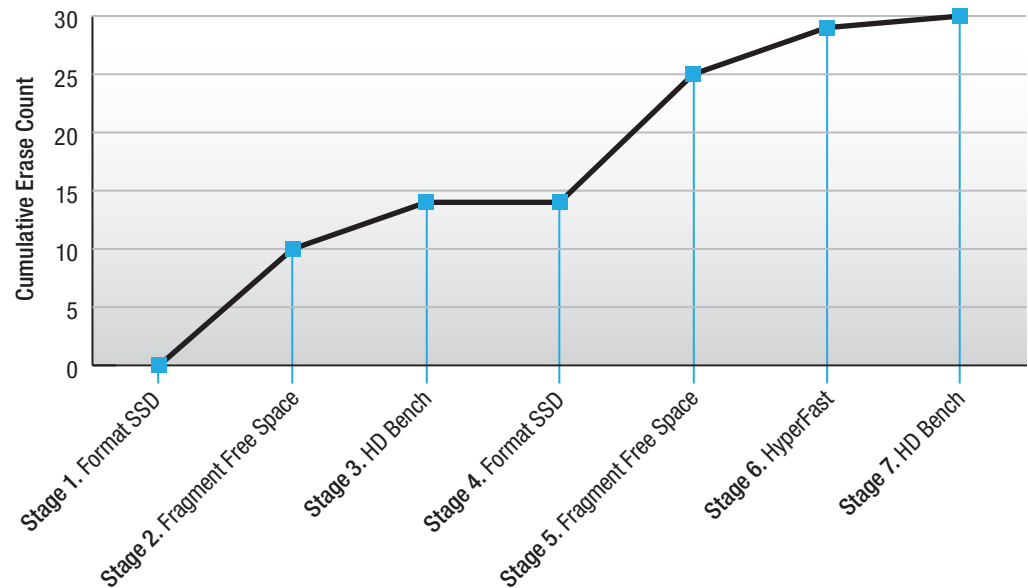


Figure 5: Cumulative Erase activity on Apacer 8GB PATA SSD as measured by SSDlife software.

Starting from a freshly Windows' formatted drive (stage 1), fragmenting the free space (stage 2) generates a score of 10 from SSDLife's proprietary scoring system. Then running the HDBench program (stage 3), which creates and reads files to measure hardware performance, generated a count of 4. A reformat (stage 4) incurred no change. A second run of the free space fragmentation routine (stage 5) averaged an Erase count of 9. HyperFast was then run (stage 6) to optimize the SSD. It created Erase activity at an average count of 4 (identical to HDBench in stage 3). HDBench was then run on the optimized SSD (stage 7), and this time only incurred an average Erase count of 1.

This test indicates that, while the SSD optimization techniques employed by HyperFast do incur the occasional increase in erase-write activity, the result of its operation reduces the erase write activity of typical day to day use of the SSD. The net result of using HyperFast will be less erase-write activity on the Flash drive, thereby increasing its longevity.

It should also be noted that in the test case above, the effort required from HyperFast (in stage 6) was the reparation of many months worth of accumulated free space fragmentation. The intelligent algorithms employed by HyperFast are designed to optimize the drive's performance and maximize its useful life.

## Summary

With typical system use, the out of the box performance of computer systems shipping with solid state storage devices will not be maintained. This is not due to quality or design of the hardware, but rather the fact that inherent attributes of file systems will manifest over time.

Fragmentation, in this case primarily of free space, is a natural side effect that will occur and accumulate over time with all file systems. As free space becomes increasingly fragmented, performance will suffer proportionately. This leads to increased, excess write activity on the NAND Flash device, diminishing the device's longevity and reducing its performance dramatically, especially with write speed.

Apacer NAND Flash devices with HyperFast will out perform competitive solutions. As a result of this revolutionary technology alliance, users of Apacer solutions will enjoy greater performance which will be maintained for the full, extended life of the storage device.