Real-Time Fragmentation Prevention with OptiWrite™

What is OptiWrite™?

OptiWrite™ is a new file system filter that eliminates fragmentation in real-time by ensuring that up to 100% of files are written to the file system in a single continuous stream. In addition to saving the resources normally required to analyze and defragment files, it ensures maximum sequential write performance for storage devices, effectively eliminating slow random write behavior. OptiWrite performs above and beyond its competition because it was designed to prevent file fragmentation in a way that does not negatively impact the performance of subsequent reads.

Why Prevent Fragments?

The negative performance impact of file and free space fragmentation on mechanical drives is a well-known element in modern computers. The tests in this paper alone demonstrate how even with a fast processor, lots of RAM and the latest virtualized operating systems, simple tasks that you would expect to occur quickly (like copying files) can be hindered by fragmentation. The primary cause of this phenomenon is the fact that while disk capacity has grown greatly over the past 15 years, disk performance has not. Seek times for disks are still incredibly slow when compared to RAM speeds and modern multicore processors waste hundreds of millions of cycles or more while waiting for seeks to complete. This is why it is more important than ever to defragment disks in order to get the most out of your hardware, but the lack of increase in performance relative to capacity has created another problem: energy consumption. As larger capacity disks are filled with data, it takes longer to optimize them for peak performance and that means paying more for power. Preventing fragmentation before it occurs doesn't just cut down on the time it takes to perform optimizations; it can eliminates the need to do so for extended periods of time depending on disk usage. Preventing fragmentation in real time saves you real money, and in today's economy, any solution that both maximizes performance and reduces costs is a real winner.

There are various other benefits as well. There is a significantly lower impact on system resource usage for preventing fragments up front than there is for defragmenting them after the fact. In addition, random write behavior, a common type of disk activity for which disks perform poorly, is significantly reduced or eliminated while preventing fragments in real time.

Competitive Performance

OptiWrite out performs its leading competitor, in both performance and energy savings. The following tests demonstrate how even non-fragmented files can perform poorly when their physical locality to each other is not optimized.

Methodology

A simple apples-to-apples test comprised of writing out 10,000 files to a freshly formatted volume shows the dramatic benefits of using OptiWrite. The test proves that files optimized with OptiWrite read and write significantly faster than with its nearest competitor. The test shows that the key factor in preserving performance and reducing energy costs is the amount and type of free space fragmentation created in exchange of preventing fragments. The same hardware is used to perform this test multiple times to ensure fairness.

Pertinent Hardware specifications:
Machine Type: Virtual Machine (Microsoft Hyper-V)
Backing CPU: Intel Xeon E5620 Westmere 2.4GHz 12MB L3 Cache
System RAM: 4GB
System OS: Windows Server 2008 R2
Backing Disk: 300GB Western Digital VelociRaptor 16MB Cache
VHD Format: NTFS @ 4K Clusters

Methodology
The test is performed as follows:
With OptiWrite enabled, 10,000 files, each just 4K in size, are programmatically written to a folder on the volume in question. It is important to note, that at 4K each, the total amount of data written is just 39MB on disk. An analysis of the volume is performed to determine the amount of fragmentation created as a result. *(Phase 1: Writing Out)*

Because both utilities create some free space fragmentation as a side effect of preventing file fragmentation, the following additional tests are performed and data gathered:

- After each run, a diagnostic utility is used to read out each file as fast as possible for 10 iterations in order to determine the average access time of all 10,000 files. The diagnostic utility shows whether or not the 39MB worth of data can be read back as quickly as is expected. (*Phase 2: Reading In*)

- Subsequently, the folder in question is copied to the same volume using Windows Explorer. The process is timed in order to corroborate the findings of the diagnostic utility. (*Phase 3: Copying out*)

- Defragmentation of the free space on the volume is performed in order to clean up any free space fragmentation. The time it takes to complete the process is also logged. (*Phase 4: Consolidating Free Space*)

After collecting data, the volume is reformatted and the test rerun for a total of 10 times in order to determine averages.

In addition, all phases are monitored using a professional Watt's Up?™ meter to log energy consumption in Watts per second and used to average watt consumption over the course of all 10 iterations of each phase.

Test Results

Phases 1 & 2: (Writing out, Reading In)

The following data in *Figure 1* shows that while both solutions are able to prevent 100% of fragments, the amount of Free Space Fragmentation created as a result is dramatically different. The performance impact of Free Space Fragmentation is highly evident when the diagnostic File Access Timer is run. Since the diagnostic reads all 10,000 files, the physical locality of each file becomes crucial in avoiding disk thrashing and excessive seeking. The results with OptiWrite are exponentially faster because it avoids the creation of excessive free space fragmentation.

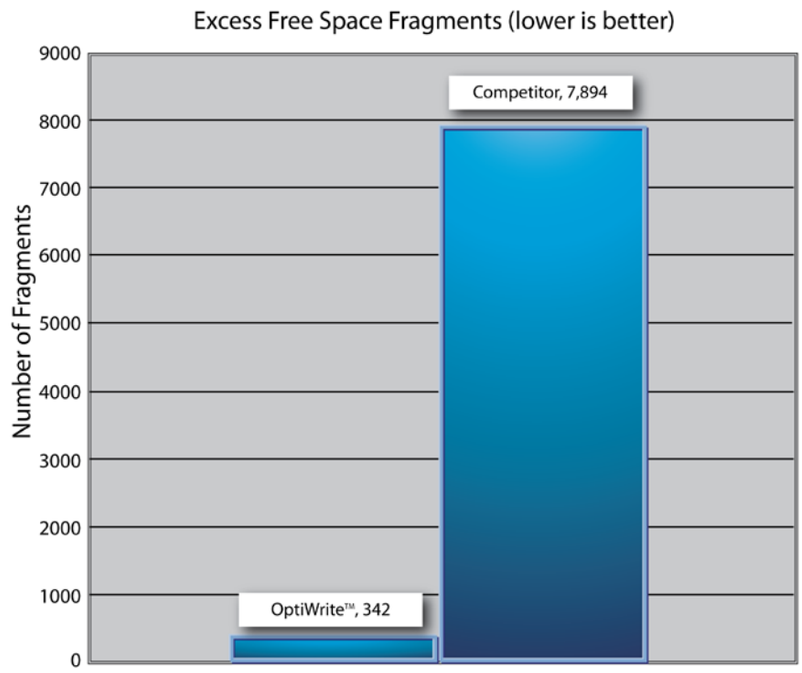


Figure 1. Preventing File Fragmentation while creating Free Space Fragmentation

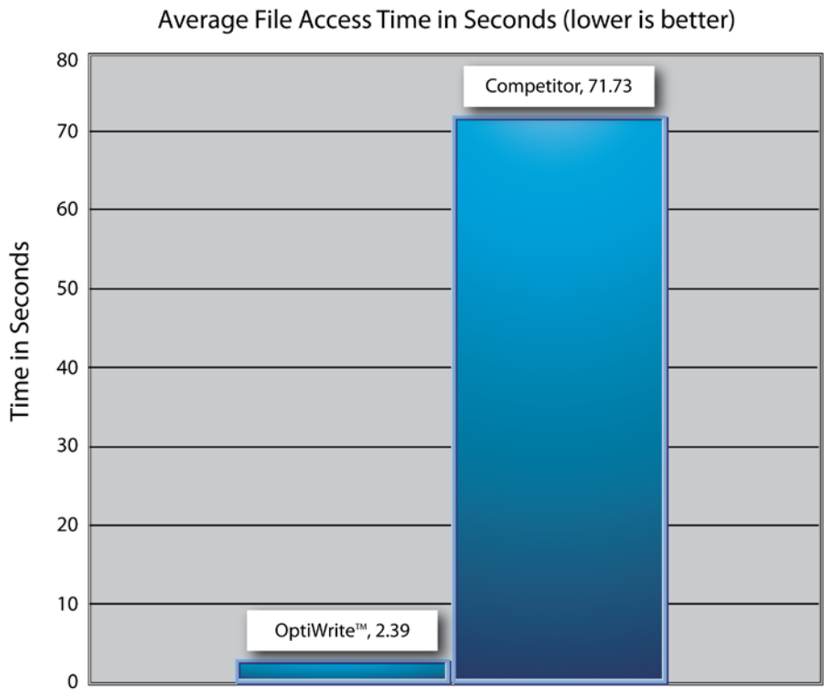


Figure 2 Free Space fragmentation impacts file access time

During Phase 1, differences in energy consumption are mostly negligible, with results showing a savings of just 13.36 Watts per second with OptiWrite versus the competition. However, phase 2 shows a dramatic difference in energy consumption as shown in Figures 5 & 6 below. The operation is so slow with the competitor solution, that the average measurement per second is negligibly higher than nominal – but the overall energy cost is significantly higher at an average of 122,791 watts. The key difference in phase 2 is simply the amount of time it took the competitor to complete the operation.

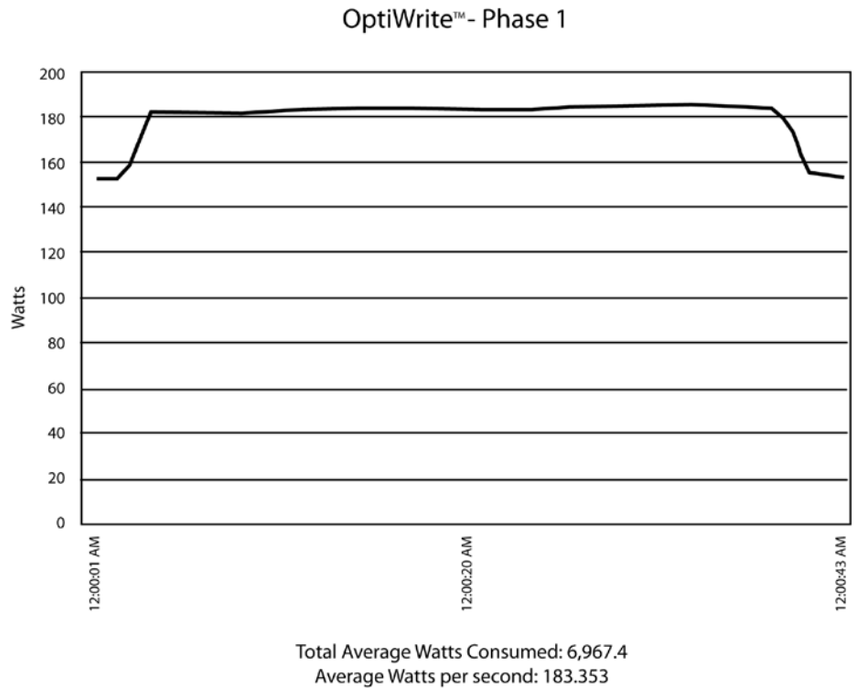


Figure 3 Writing out files with OptiWrite enabled

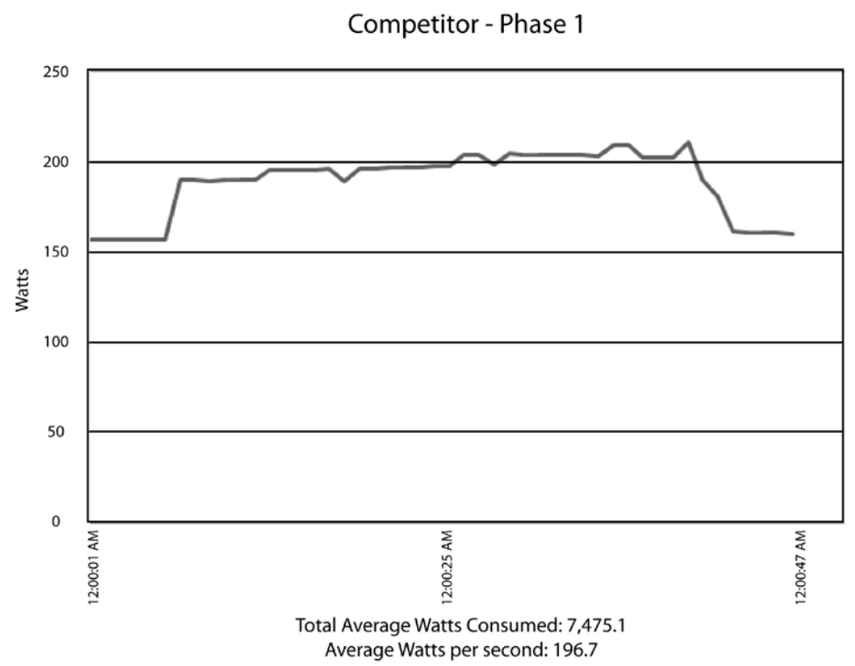


Figure 4 Writing out files with Competitor enabled

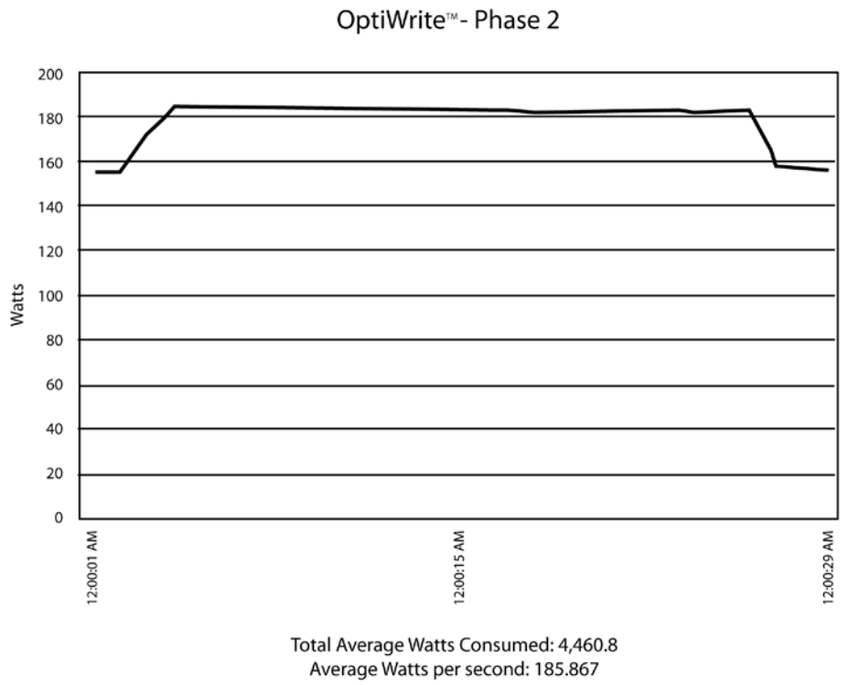


Figure 5 Read File performance with OptiWrite

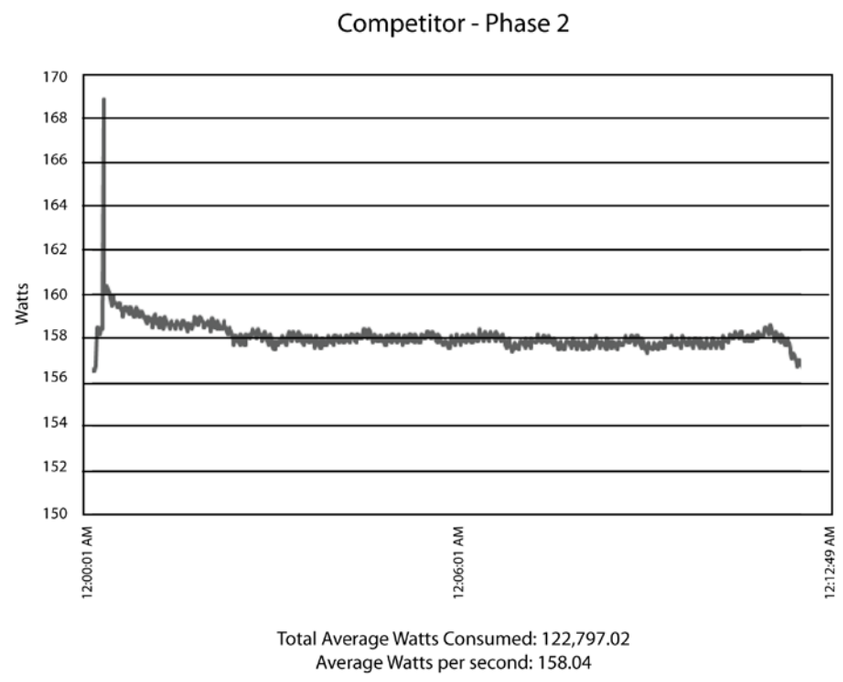


Figure 6 Read File performance with competitor

Phases 3 & 4: (Copying Out, Consolidating Free Space)

To corroborate the findings in phases 1 & 2, a simple copy operation is performed with Windows Explorer to the same volume and timed. This test distinctively shows how Free Space Fragmentation can dramatically impact the performance of the file system. It is important to keep in mind that at 4K per file, this test is a simple matter of copying a folder that contains only 39MB of data, but which requires thousands of IO transactions. Simply stated, it is the number of files and their physical locality to each other that matters most in this test. As *Figure 7* shows, on average the files optimized with OptiWrite could be copied over 2.5 times faster than with its nearest competitor.

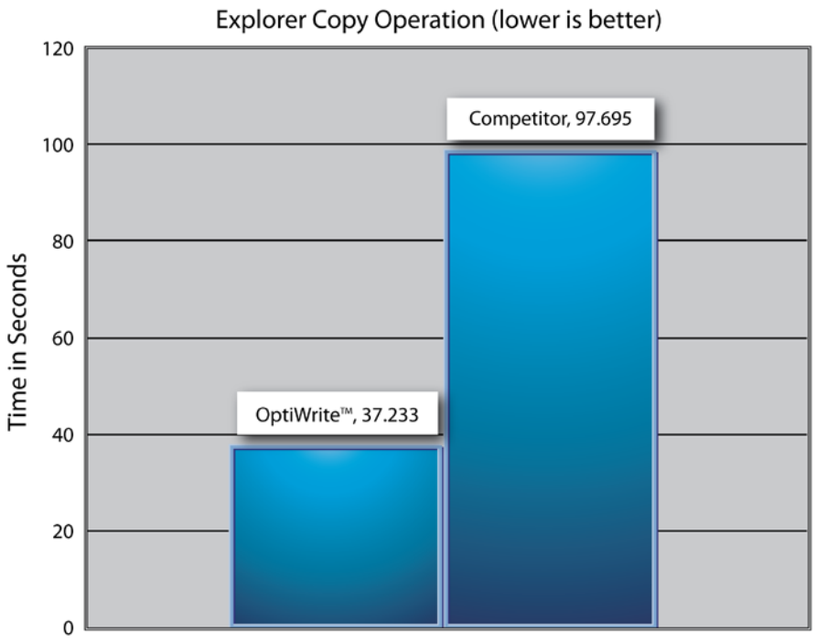


Figure 7 Copying files with Explorer.exe

To further corroborate these findings, a Free Space Consolidation pass was run on the volume at maximum priority for best speed. This test shows how much work is required to clean up after either solution and involves physically relocating all 10,000 files. The results show that due to excessive seeking, the competitor tests averaged nearly 5 times longer than those with OptiWrite. The tests show conclusively that preventing file fragmentation is not enough to ensure maximum performance and energy savings. It is just as important to factor in where and how files are written – as it is to prevent fragmentation.

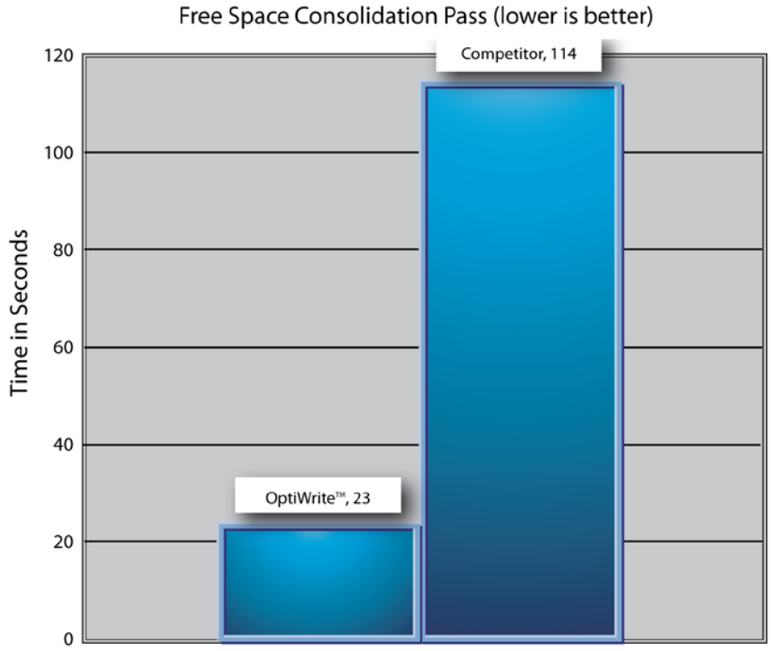
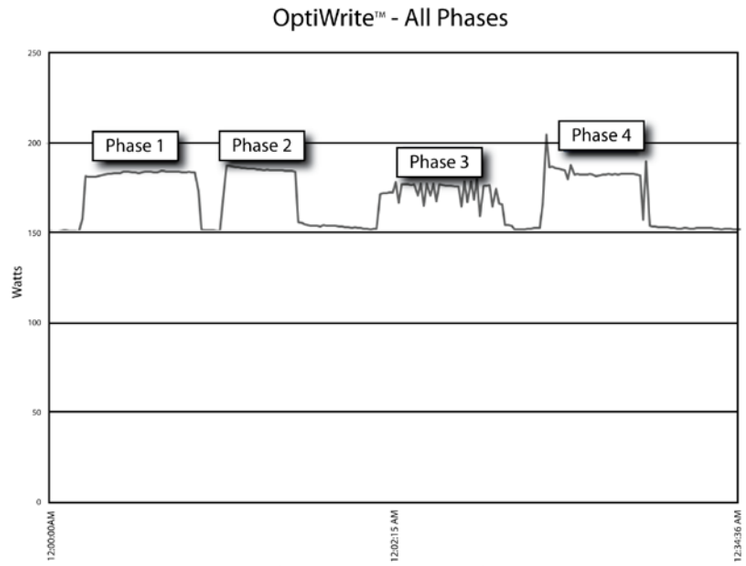
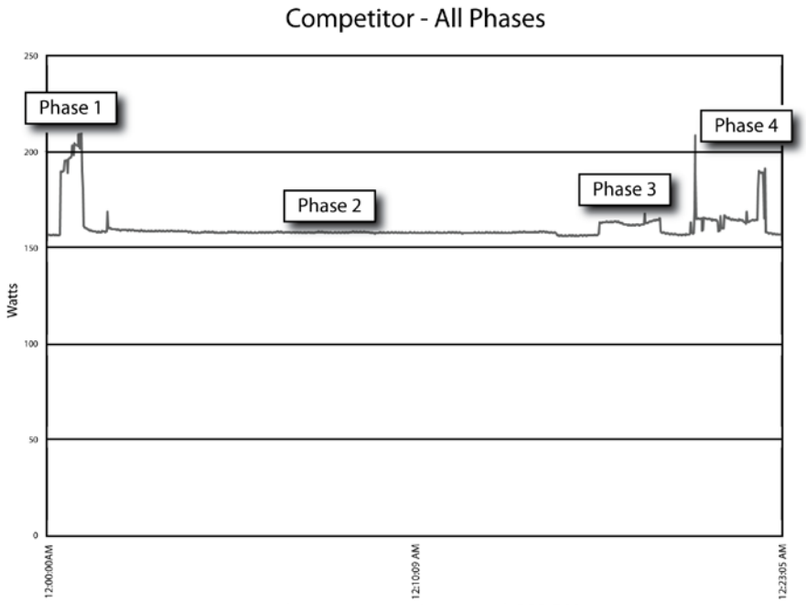


Figure 8 Resolving Free Space Fragmentation

The following graphs compare the energy readings from both solutions for all test phases.



Total Average Watts Consumed: 38,391
Average Watts per second: 170.62



Total Average Watts Consumed: 209,561
Average Watts per second: 160.09

Summary

The above tests show conclusively that the majority of the energy savings that can be attained through the prevention of fragmentation is not in the act of preventing fragments or in the avoidance of defragmentation, but in the performance gained when reading back files after the fact. Once this is understood, it becomes evident that in order to attain the best performance and energy savings, the prevention solution must factor in the placement of data and avoid the excessive creation of free space fragmentation. Otherwise the solution will simply trade one problem for another and require that additional system resources and energy costs be spent to fully restore performance. The simple act of preventing fragmentation is not enough to justify doing so if the solution sacrifices fast sequential reads for slow random reads.

It should be kept in mind that free space fragmentation is the most prevalent cause for the creation of fragmentation, failing to avoid it when preventing files from fragmenting simply delays the inevitable. If you simply prevent file fragmentation at the expense of creating free space fragmentation, a volume will inevitably be forced to fragment files regardless of any prevention method. Any solution that fails to understand this in its implementation will at best delay the need to defragment, and at worst, eventually promote the need to do so. There is an additional consideration to be made; thin provisioned systems that use high water marking are negatively impacted by any form of fragmentation prevention that creates excessive amounts of free space fragmentation. This is because such solutions artificially push files down the volume to higher LCN ranges by creating large free space gaps between files. The use of such a solution will promote the rapid provisioning of a thin provisioned volume and should be avoided. OptiWrite is designed with these considerations in mind by allowing its behavior to be customized as needed. Not all data, hardware and workloads are created equal, and so to provide the best performance and energy savings, a fragmentation prevention solution must provide sufficient flexibility and customization to meet the task at hand.

Minimum Requirements & Compatibility

OptiWrite runs on any Workstation or Server PC running Windows XP SP3, Server 2003 SP2 or higher. This includes all 32-bit and 64-bit versions of Windows Vista, Windows 7 and Server 2008 / R2.

The following File Systems and storage technologies are supported:

NTFS
NTFS attached SAN storage
Thick & Thin provisioned virtual disk (Microsoft Hyper-V & VMware vSphere)
Thick & Thin provisioned SAN storage
Copy on Write & WALF enabled storage
CBT (Change Block Tracking) enabled storage (VMware vSphere)
VSS enabled storage
Software RAID
Hardware RAID
Mirrored volumes
All partition types
Mounted Volumes without assigned letters

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About Raxco Software

Raxco Software has been helping large enterprises, small businesses, and consumers with their computer resource management needs for over 30 years. Its PerfectDisk is Windows® Certified by Microsoft®, and optimized for Windows 7. The PerfectDisk line has a long award-winning history, most notably its perfect 5-star review from CNET Download, winner of the *Windows IT Pro* Readers' Choice Awards for Defragmentation Utility and Storage Management Tool, and Redmond Magazine's Best of the Best Award, and having won PC Magazine's Editors Choice award multiple times. In addition to its PerfectDisk line, Raxco also produces PC optimization software for Windows operating systems and HP's OpenVMS operating system. Raxco Software can be found on the Web at www.raxco.com.