

The Key Differentiators Between PerfectDisk and the Windows 7 Disk Defragmenter

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Introduction

This paper provides an overview of the differences between PerfectDisk® and the Windows® 7 defragmenter based on key areas of functionality and defragmentation methods. The process of comparing two utilities that perform a similar function (i.e. disk defragmentation) is not necessarily a case of comparing “apples to apples,” as the two utilities’ philosophies and strategies, and most importantly results, differ substantially.

To assert that “all defragmenters are the same” is a gross oversimplification of the issues surrounding disk defragmentation.

To assert that “all defragmenters are the same” is a gross oversimplification of the issues surrounding disk defragmentation. Sure, data files need to be defragmented; but equally important is the treatment of the remaining free space. System files and metadata files that can’t be moved online are also significant since their location will affect data file defragmentation. Disk optimizing file placement strategies can also make a difference in overall performance.

Lastly, there are issues surrounding the management and use of enterprise defragmentation. What is the best way to proactively defragment hundreds or thousands of machines so fragmentation doesn’t become a productivity drain or a technical issue?

The goal of this paper is to discuss these key areas of functionality and compare the named products and their approaches to the problem. Users can reference this paper for guidance in their own product evaluations.

Centralized Management and Control

Enterprise management of PerfectDisk is provided by a robust enterprise console. The PerfectDisk Enterprise Console can be used to install, deploy, configure, patch, schedule, manage, and report. Other capabilities include:

- A digital dashboard that provides a visual overview of fragmentation issues in your enterprise
- The ability to create custom computer groups for easy management
- The ability to import groups from Active Directory®
- Automatic synchronization with changes made through Active Directory
- 11 user-configurable reports including warnings and alerts with email notifications
- Remote control via an automatically generated hotlink to remote PerfectDisk Clients
- Integrated management tools such as Remote Desktop and Remote Event Viewer controls
- Network wide access to drive statistics for reports that track trends and system configurations

- Manage PerfectDisk clients across multiple domains
- Make configuration changes for any combination of groups or individual clients using easy to follow wizards
- Set defragmentation schedules and settings, including automatic defragmentation, to any combination of groups or individual computers with easy to follow wizards
- Pre-configure clients prior to deployment
- All the features listed in this document, can be centrally managed on any combination of clients.
- Once configured, provides automated management and reporting.
- Scripting via Windows Script and WMI for additional management/administration flexibility.

PerfectDisk can also be deployed and configured using Active Directory Group Policy Administrative Templates. As a new computer is added to an OU, PerfectDisk can be automatically installed and configured. Using GPO, you can also control which users have access to specific PerfectDisk features and even assign/enforce licensing on a group by group basis.

The warnings and alerts system provided by the PerfectDisk Enterprise Console allows IT staff to address problems before they become serious issues.

The warnings and alerts system provided by the PerfectDisk Enterprise Console allows IT staff to become aware of issues and to deal with them without interrupting user productivity. Problems can be addressed before they become serious issues that impact user productivity and create additional workloads for everyone from users to Help Desk and Senior IT staff members.

Why is this important?

The Windows 7 defragmenter provides no mechanism for enterprise management and control. This forces IT staff to manually configure the Windows 7 defragmenter on a machine by machine basis. No reporting is provided, so your IT staff will be completely unaware of either the quality of the job being done, or whether tasks are even executing as planned.

Using the Windows 7 defrag also introduces internal cost overhead for IT man hours. Making even simple configuration changes to any single or group of systems requires work on an individual machine basis. In the event IT staff opts for the use of scripting, man hours will be required to maintain and configure scripts. A configuration change to a single server or desktop requires the pushing of a newly modified script with the possibility of human error. This also means changes made are not immediately available in real time and are reliant on triggers like user logons.

For example, if an IT staffer is tasked to change the defragmentation on a user's computer from Wednesdays to

Tuesdays, the staff member has to physically travel to the user's desk and interrupt the user to make the necessary change. If the user is not a local administrator, the IT staffer will have to wait until the user can afford down time so the user can be logged off.

In the event the user turns his or her machine off, the task will never run. With PerfectDisk, the task can be set to execute at the next system power on, automatically reschedule itself, or to run automatically when either the system is idle, or when the user is away. (Screen Saver)

The Windows 7 defragmenter offers no integration with Active Directory in any form. Since no reporting is provided with the Windows built-in solution, users are likely to report issues to the helpdesk on a reactive basis.

PerfectDisk does not require that end users have Administrative rights in order to run.

Administrative Rights

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Why is this important?

The Windows 7 defragmenter requires Administrative rights in order to run. In most corporate environments, end users are not given Administrative rights. This essentially renders the Windows 7 Disk Defragmenter useless to users in many environments.

Automating Defragmentation-Flexible Unattended Operation

Through AutoPilot Scheduling™, PerfectDisk provides maximum flexibility and control so defragmentation occurs on your terms. Users can combine the use of dynamically defined and automatically run tasks such as:

- One Time defragmentation
- Revolving every X days
- Revolving on specific days, weeks
- Automatically, by Idle resources (CPU and Disk I/O)
- Automatically, by user activity (Screensaver).

Tasks can also be offset X number of days or weeks and multiple tasks can be created for specific disks using specific strategies.

In addition, PerfectDisk uses task prioritization to allow multiple strategies to be applied on a disk by disk basis. Of equal importance, PerfectDisk allows the specification of Maximum Run Durations so that a task can be set to run within your predetermined maintenance windows.

- *Screen Saver Mode*

Many companies enforce as a matter of security policy that if a user steps away from their computer for a period of time, the locked Windows Screen Saver is activated.

PerfectDisk's screen saver mode can ensure that the system is defragmented when the Windows Screen screensaver is on - stopping when the user resumes keyboard/mouse activity.

- *StealthPatrol™*

PerfectDisk's StealthPatrol can defragment the system when the computer is idle and includes the ability to avoid running when specific applications are running.

Both Screen Saver and StealthPatrol intelligently defragment only when it is necessary – automatically detecting when the drive was last defragmented and only running again if a certain number of days have passed.

When enabled, automatic defragmentation allows PerfectDisk to maintain or improve system performance and user productivity throughout the day as needed.

When enabled, automatic defragmentation using StealthPatrol or Screen Saver allows PerfectDisk to maintain or improve system performance and user productivity throughout the day as needed, rather than on a less than optimal and rigid schedule. In this way, PerfectDisk takes advantage of even user lunch breaks to improve system performance and user productivity.

- *Defined Date/Time*

PerfectDisk can also defragment according to a defined schedule - daily (one or more days per week) and weekly (including bi-weekly and monthly). PerfectDisk provides the ability to control access to CPU and disk resources to minimize the impact of defragmentation or to ensure that sufficient resources are available to defragment. In addition, the ability to configure a maximum duration for a defined schedule ensures that PerfectDisk completes running during a maintenance window.

The Windows 7 defragmenter does not have robust and flexible background processing options. It can be run manually (assuming Administrator rights - not typically granted to end users) or via limited scheduling and doesn't allow you the flexibility to control access to CPU or disk resources. The Windows 7 defragmenter is "scheduled" using Windows Task Scheduler and the command line interface to the built-in defragmenter. There isn't an easy way to centrally manage Windows Task Scheduler tasks. The Windows 7 defragmenter has no ability to defragment only when the Windows screen saver is active. While the Windows 7 built-in defragmenter comes automatically scheduled to run every Wednesday at 1:00am, this may not ensure that defragmentation actually occurs or occurs in a timely fashion.

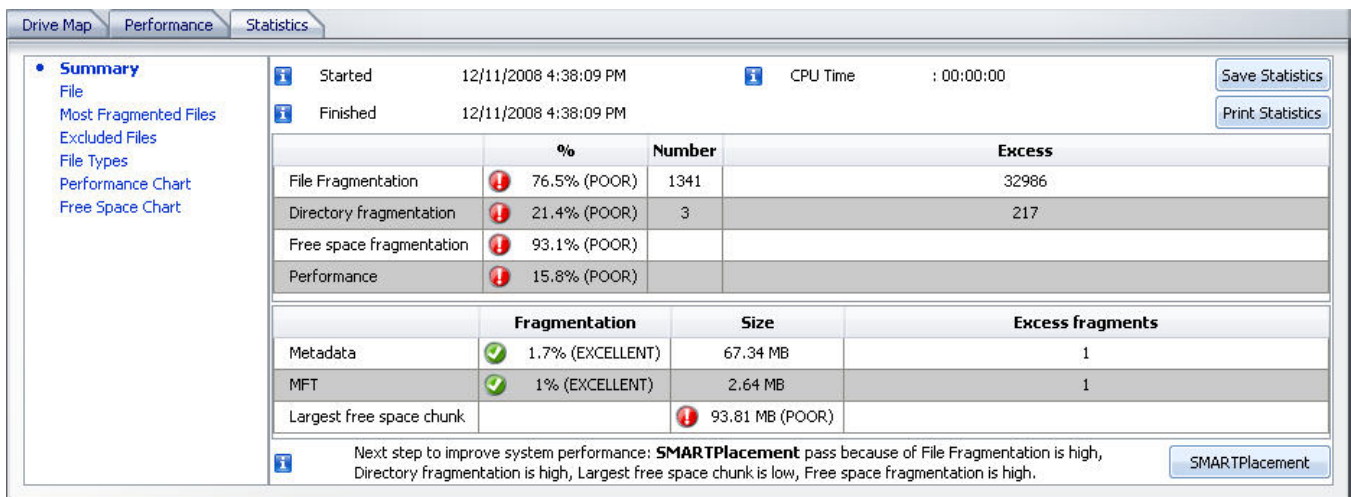
Why is this important?

With restrictive background defragmentation options and no central management of the Windows 7 defragmenter, implementing an optimal un-attended defragmentation solution using the Windows 7 defragmenter is not only difficult, it is also a time-consuming and IT resource wasting process.

The Windows 7 defragmenter is not well suited to automatic defragmentation. It has limited ability to monitor available system resources and is not easily capable of intelligently running during times of opportunity. This limits its effectiveness as a means to improve or maintain performance levels, but also means servers, workstations and users will only see performance benefits immediately following maintenance windows as opposed to throughout the work day when needed.

Detailed Fragmentation Information

PerfectDisk at the client level provides detailed information on how fragmented the drive is, which files are heavily fragmented, etc. The PerfectDisk Enterprise Console uses this information to proactively alert helpdesk/IT staff to any fragmentation related issues in your environment.



The screenshot displays the 'Statistics' tab in the PerfectDisk Enterprise Console. It shows a summary of fragmentation metrics for a drive, including file fragmentation, directory fragmentation, free space fragmentation, and performance. The metrics are presented in two tables. The first table shows overall fragmentation levels, and the second table shows fragmentation levels for specific file system components. A 'SMARTPlacement' button is visible at the bottom right of the statistics area.

	%	Number	Excess
File Fragmentation	76.5% (POOR)	1341	32986
Directory fragmentation	21.4% (POOR)	3	217
Free space fragmentation	93.1% (POOR)		
Performance	15.8% (POOR)		

	Fragmentation	Size	Excess fragments
Metadata	1.7% (EXCELLENT)	67.34 MB	1
MFT	1% (EXCELLENT)	2.64 MB	1
Largest free space chunk		93.81 MB (POOR)	

Next step to improve system performance: **SMARTPlacement** pass because of File Fragmentation is high, Directory fragmentation is high, Largest free space chunk is low, Free space fragmentation is high.

The Windows 7 defragmenter doesn't provide detailed fragmentation information in a form that is readily accessible to administrators. Detailed fragmentation information is only available via the command line interface and it isn't reported back to a central location.

Why is this important?

Without detailed fragmentation information, available locally as well as centrally, IT staff are not able to quickly and easily tell if defragmentation is occurring as expected, or if configured defragmentation methods are effectively addressing fragmentation issues in their network. With the Windows 7 defragmenter, users are likely to report performance issues to the helpdesk on a reactive basis instead of fragmentation issues being automatically detected and appropriate staff notified for a proactive resolution.

Single Pass Defragmentation

PerfectDisk employs a single-pass defragmentation engine designed to immediately address the issue of file and free space fragmentation to provide the best possible drive performance. This means PerfectDisk will defragment 99-100% of all data files and consolidate free space in one run regardless of the severity of fragmentation or the amount of free space.

Why is this important?

The Windows 7 defragmenter is the same product for workstation and server and it is a multi-pass defragmenter. The multi-pass aspects of the Windows 7 defragmenter are evident when disks are severely fragmented or have limited free space. Gartner Research published a report making this observation about multi-pass defragmenters:

"The Windows built-in defragmentation tool is a multi-pass defragmenter that must be run over and over to defragment the disk, especially when defragmenting very large disks with heavy fragmentation and limited free space. As such, multi-pass defragmenters characteristically fragment the remaining free space on the disk, which accelerates fragmentation later. It is recommended that a third-party single-pass server defragmentation tool be implemented instead."

Total Free Space Consolidation

With PerfectDisk's advanced Space Restoration Technology™, in the same single pass that PerfectDisk defragments files it also consolidates the available free space on the drive into the largest possible pieces, which improves drive write performance. As the Gartner report states, fragmented free space accelerates new file fragmentation. PerfectDisk provides statistics on free space fragmentation so you can actually see PerfectDisk addressing this vital drive performance issue.

As the Gartner report states, fragmented free space accelerates new file fragmentation.

While the Windows 7 defragmenter's command line interface has an option to force free space consolidation, this option is NOT specified for the default schedule. In order to force free space

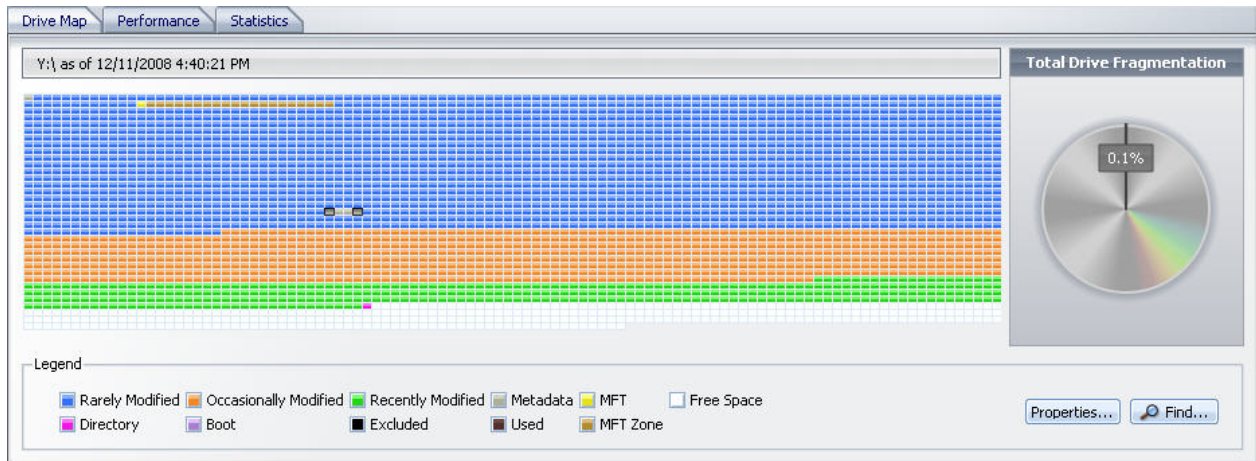
consolidation, the Windows 7 defrag schedule has to be modified to include this parameter.

Why is this important?

Since the default behavior of the Windows 7 defragmenter is to NOT force free space consolidation any moderate amount of file write activity will result in new files being created in a fragmented state – slowing down disk write speed and causing an immediate fragmentation issue for these new files. With no central management ability, it is a time consuming and resource intensive process to configure the Windows 7 defragmenter to force free space consolidation in its scheduled defragmentation pass.

SMARTPlacement™ Optimization Strategy

PerfectDisk uses a patented file placement strategy based on file modification activity. SMARTPlacement is part of PerfectDisk's single-pass defrag process. This strategy groups files with similar modification patterns together.



- “Rarely modified” files (files that haven’t changed in X days) are grouped together, the next time PerfectDisk runs, it is very likely nothing in this file group has changed. The files are already contiguous and where they are supposed to be, so on subsequent defrag passes PerfectDisk does not needlessly shuffle files wasting time and resources.
- “Recently modified” files (created or changed in X days) are adjacent to the contiguous free space. If one of these files grows the fragment will be allocated in one piece from the contiguous free space. This file can be made contiguous with minimal shuffling of clusters. As a result, fewer defrag passes are actually needed and subsequent defrag passes take less time, CPU, and memory.

PerfectDisk's patented SMARTPlacement file placement technology is the only proven and patented method to provide the absolute best in drive performance.

PerfectDisk's patented SMARTPlacement file placement technology is the only proven and patented method to provide the absolute best in drive performance. SMARTPlacement is available in all PerfectDisk versions. With PerfectDisk, you don't have to pay a premium price to get the best possible drive performance.

Why is this important?

The Windows 7 defragmenter has no file placement strategy whatsoever. Files are defragmented and placed randomly with no regard to type and/or usage pattern. No attempt is made to improve the speed of subsequent defragmentation passes in order to reduce resource impact, and no attempt is made to consolidate free space for the best possible write performance. As a result, the Windows 7 defragmenter will never provide the same level of performance and resource optimization as PerfectDisk.

All defragmenters require some free space to defragment. PerfectDisk needs only a minimum of 1% available.

Free Space Requirement

All defragmenters require some free space to defragment. PerfectDisk needs only a minimum of 1% available. This makes significantly more disk space available for users.

Why is this important?

Unless a volume has at least 15% free space, the Windows 7 defragmenter is likely to fail to run, fail to complete, or take a very long time to complete. For every 100GB of disk space 15GB of free space needs to be available to defrag with the Windows tool.

Volume Shadow Copy Service (VSS) Capability Mode

On Windows systems, defragmentation activity can result in snapshots/shadow copies being purged ([Microsoft® KB article 312067](#)). If the drive is formatted with a 16k cluster size (or multiple of 16k), then VSS can detect defrag activity and minimize the purging of snapshots/shadow copies. On VSS enabled drives where the cluster size is < 16k, to minimize snapshot/shadow copies being purged you need to minimize the amount of file movement when defragmenting. By default, PerfectDisk addresses this issue with VSS compatibility mode with a configurable threshold.

Why is this important?

The Windows 7 defragmenter has no VSS compatible mode which means that if it is run on a VSS-enabled drive, snapshots/shadow copies may be completely purged.

PerfectDisk provides the ability to exclude files/folders from defragmentation.

File/Folder Exclusion

PerfectDisk provides the ability to exclude files/folders from defragmentation. This may be important if whole drive encryption (WDE) software is installed as there may be certain files that should not be defragmented. In addition, PerfectDisk supports the following top encryption vendors:

- PC Guardian
- PGP Whole Disk Encryption
- BestCrypt
- PointSec
- SafeBoot / McAfee Total Endpoint Protection
- SafeNet Protect Drive
- Safeguard Easy
- DESLock+
- WinMagic

And because PerfectDisk allows File and Folder Exclusion, it can be made to support any encryption solution or any other application that would necessitate excluding files from defragmentation.

Why is this important?

The Windows 7 defragmenter does not provide the ability to exclude files/folders, and as a result, can be directly responsible for the entire loss of an encrypted disk.

Directory Consolidation

PerfectDisk provides directory consolidation to further improve drive performance.

Why is this important?

Directory consolidation directly improves the speed at which any disk scanning or analysis takes place. This includes everything from user performed file searches to Anti-Virus scans. The Windows 7 defragmenter does not perform any directory consolidation.

Space Management

As was indicated in the sections above, free space consolidation has as much impact on overall disk performance as file defragmentation. PerfectDisk provides several tools to identify and recover additional free space. These include:

- **Recycler** - reclaims free space by removing temporary files and emptying the Recycle Bin

Free space consolidation has as much impact on overall disk performance as file defragmentation.

- **Duplicates Finder** - identifies duplicate text, video, picture, music or other files and provides a mechanism for their deletion
- **Space Explorer** - graphically displays which folders are using the most disk space and provides “drill down” capability to identify candidates for deletion
- **Space Reports** - identifies files by their creation, modification, or access date over a specific time period or date range; also identifies files by size or file type.

Why this is important?

To get the most from your disk drive and to attain peak performance it is essential to keep obsolete or junk files from cluttering the disk. Deleting these files frees up disk space which can be consolidated and reused, prolonging system life and performance. Sorting through hundreds of folders is a painstaking and labor-intensive task that system administrators just don't have time to perform.

The Windows 7 defragmenter offers no facility for identifying files that may be candidates for deletion.

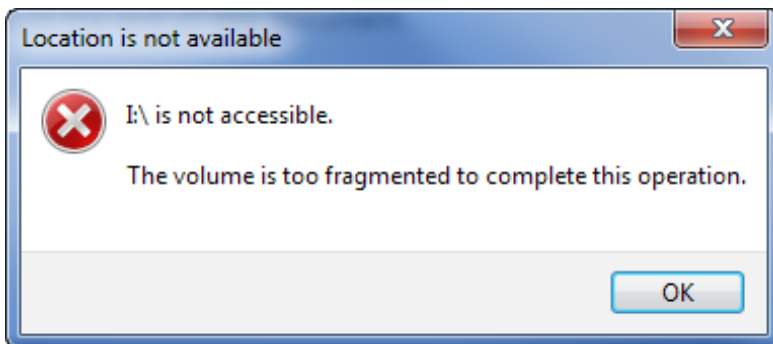
NTFS Metadata

PerfectDisk defragments all of the NTFS metadata files.

PerfectDisk defragments all of the NTFS metadata files. These are the files that define the file system to NTFS. You can see a list of these files in PerfectDisk by clicking on the Excluded Files tab in the Statistics windows that appears after a partition analysis. PerfectDisk defragments all of these during the system file (boot time) defrag.

Why is this important?

The Windows 7 defragmenter does not defragment these files and will not even report on the vast majority of them. Yet, Raxco has seen countless situations where as little as 17% NTFS Metadata fragmentation, which includes the MFT and MFT Reserve Zone, to trigger the following error from which the only recoverable option is restoration from backup. As such, the Windows 7 Disk Defragmenter provides no protection from failures directly attributed to Metadata fragmentation.



STATUS_MFT_TOO_FRAGMENTED
(Windows NT Status Code)

ERROR_DISK_TOO_FRAGMENTED
(Win32 Error Code)
302 (0x12E)

The volume is too fragmented to complete this operation.

For more information on this error, see the following MSDN and Microsoft support documentation on Windows Error Codes:

<http://msdn.microsoft.com/en-us/library/ms681382%28VS.85%29.aspx>

<http://msdn.microsoft.com/en-us/library/cc704588%28PROT.10%29.aspx>

<http://support.microsoft.com/kb/113996>

PerfectDisk was the first defragmenter to support large drives of several terabytes that are now common.

Designed for Disks of Several Terabytes

PerfectDisk was the first defragmenter to support large drives of several terabytes that are now common. Available with all editions of PerfectDisk (including Professional and Home), PerfectDisk is designed to defragment these large drives quickly while using minimal resources.

The Windows 7 defragmenter is designed for simple drives. It is not designed to quickly or efficiently defragment large drives, drives containing a large number of files, severely fragmented drives, or drives that are low on free space. All PerfectDisk editions support unlimited drive sizes. This means that even PerfectDisk Professional and PerfectDisk Home will allow you to defragment multi-terabyte drives with millions of files and very low free space.

Why is this important?

Drive sizes are ever increasing and an efficient solution is needed to optimize difficult volumes. To truly demonstrate the differences in capability between PerfectDisk and the Windows 7 defragmenter, a conservative test case of just 100GB of fragmented data was put together to compare the effectiveness of the Windows 7 Disk Defragmenter against PerfectDisk. The results can be reviewed at the end of this document.

Page File/Hibernate File Defragmentation

The PerfectDisk System File defrag will completely defrag the page file and hibernate file as long as there is a minimum of 1% free space available on the partition.

Why is this important?

Page File fragmentation directly impedes system performance since it serves as an extension to the memory subsystem of the operating system. As a result, Page File fragmentation is commonly considered the most detrimental to overall system and application performance.

Hibernation File fragmentation directly impedes Hibernation and Restoration times for mobile and desktop machines that utilize Hibernation. It can also be responsible for hang ups or lock ups that cause restorations to fail, resulting in loss of work.

The Windows 7 Defragmenter is not capable of processing either of these files.

PerfectDisk allows users to specify one or more individual files to defragment, rather than an entire drive.

Selected Files Defrag

PerfectDisk allows users to specify one or more individual files to defragment, rather than an entire drive. This is particularly useful for large files such as database files and multimedia content.

Why is this important?

The Windows 7 defragmenter has no selected file defrag capability. In a production environment, it is important to have the flexibility to choose to process either a single or specific group of files for optimization. Specifically, older or legacy systems may not have suitable resource availability to process an entire disk. This level of flexibility allows users to address the issues on a drive selectively where the scalpel is preferable to the sword.

Consolidate Free Space Defrag

Part of PerfectDisk's Space Restoration Technology, this defrag method creates the largest pieces of contiguous free space available. This is useful prior to creating large files or in performing partition resizing operations. It is also useful prior to compressing a virtual hard drive on a virtual machine, as a larger amount of disk space will be recaptured from the virtual hard drive.

Why is this important?

The Windows 7 defragmenter has no specific capability for the consolidation of free space. Though it does attempt to consolidate free space, its effectiveness is not well demonstrated in benchmarks. Please review the test case at the end of this document for details.

PerfectDisk GUI-less Installation and Deployment

PerfectDisk can be installed or deployed without a GUI present on the target machine. This feature is made available for those installations exercising a "locked down", secured environment. Only the administrator can schedule or initiate defragmentation via the central management console or through Active Directory.

Why is this important?

Securing the use and visibility of any flexible and powerful utility is desirable for most organizations for a host of reasons, including but not limited to, ensuring the ignorance of a user base as to the use of or even the existence of such a utility and its policies. The Windows 7 defragmenter does not offer this capability.

User-Defined Thresholds and Minimum Periods

PerfectDisk has thresholds that skip a defragmentation pass if fragmentation does not exceed a user-specified percentage, thus saving system resources. Thresholds can be applied on a partition-by-partition basis.

Why is this important?

This is a resource saving feature that prevents defragmentation from occurring needlessly, ensuring that resource consumption takes place only when needed. The Windows 7 defragmenter does not support fragmentation thresholds or minimum periods of activity, thus it will run arbitrarily with no regard to the waste of system resources, while creating needless wear on a physical disk.

Summary

PerfectDisk and the Windows 7 defragmenter vary greatly in terms of available functionality, strategies and flexibility. The goal of this paper was to provide software evaluators with a comprehensive menu of functions from which they can select the ones that are applicable to their environment. Small businesses with a few computers have different needs from the large corporate IT department looking to implement a proactive enterprise defragmentation solution on thousands of workstations and servers.

This paper identifies the differences between the basic functionality provided with the operating system and what is available commercially.

This paper identifies the differences between the basic functionality provided with the operating system and what is available commercially. The paper is not a replacement for actual testing on systems that replicate the actual environment where the software will be used. Testing and identification of the right features for your situation will provide the best informed decision.

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Appendix

Test Case Benchmark Results

To truly demonstrate the differences in the technical engine capability between PerfectDisk and the Windows 7 Defragmenter, a conservative test case of just 100GB of fragmented data was put together to compare them.

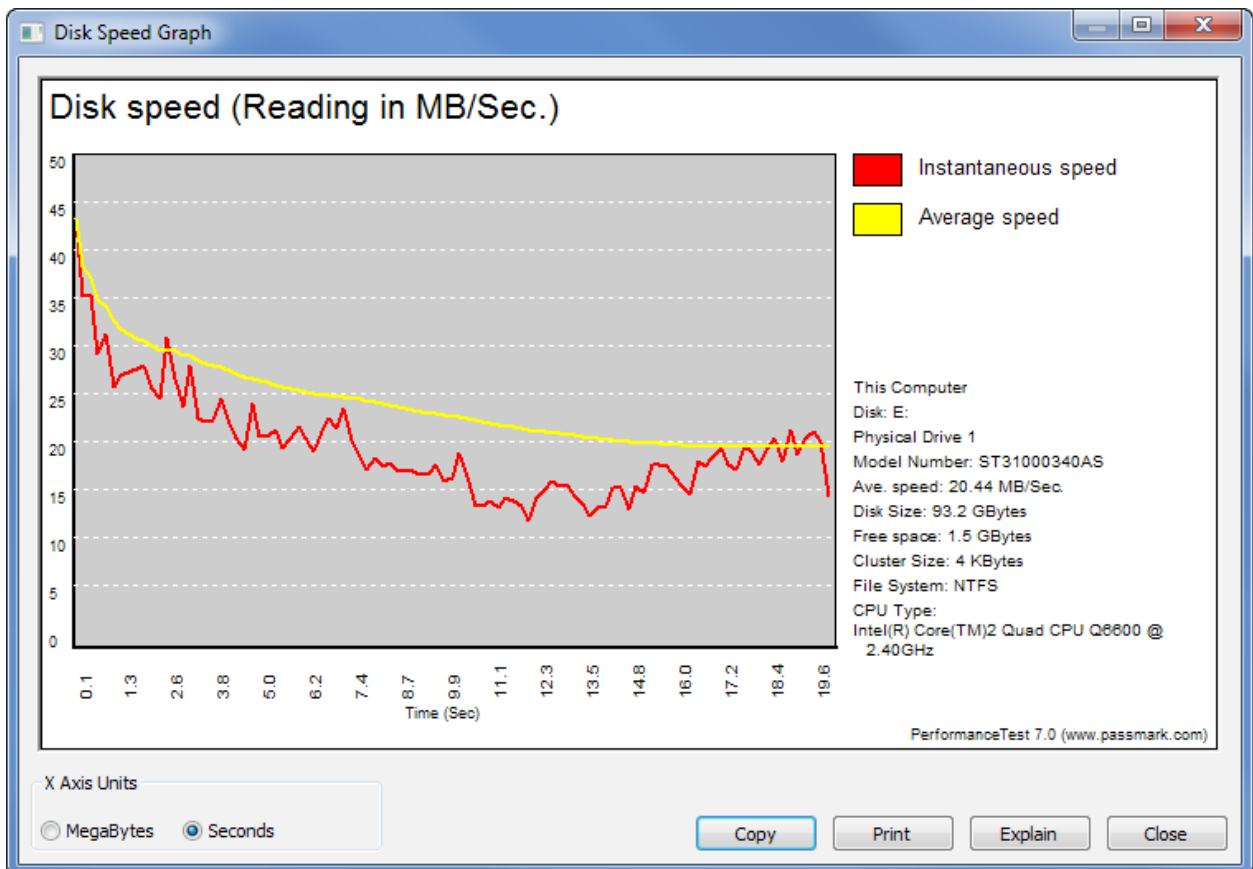
The 100GB drive partition was imaged and restored to the same hardware configuration between tests and benchmarked with PerformanceTest® 7.0 from Passmark® (www.passmark.com) and the results documented.

System Setup

OS: Windows 7 Ultimate (64-bit)
Motherboard: AB9PRO (Intel965+ICH8)
CPU: Intel Core2 Quad Q6600 @ 2.40GHz
RAM: 8.0GB
Tested Disk Manufacture: Seagate®
Tested Disk Model Number: ST31000340AS
Tested Disk Configuration: 3 Disk Stripe (RAID 0)

Base Score Results (No defragmentation performed)

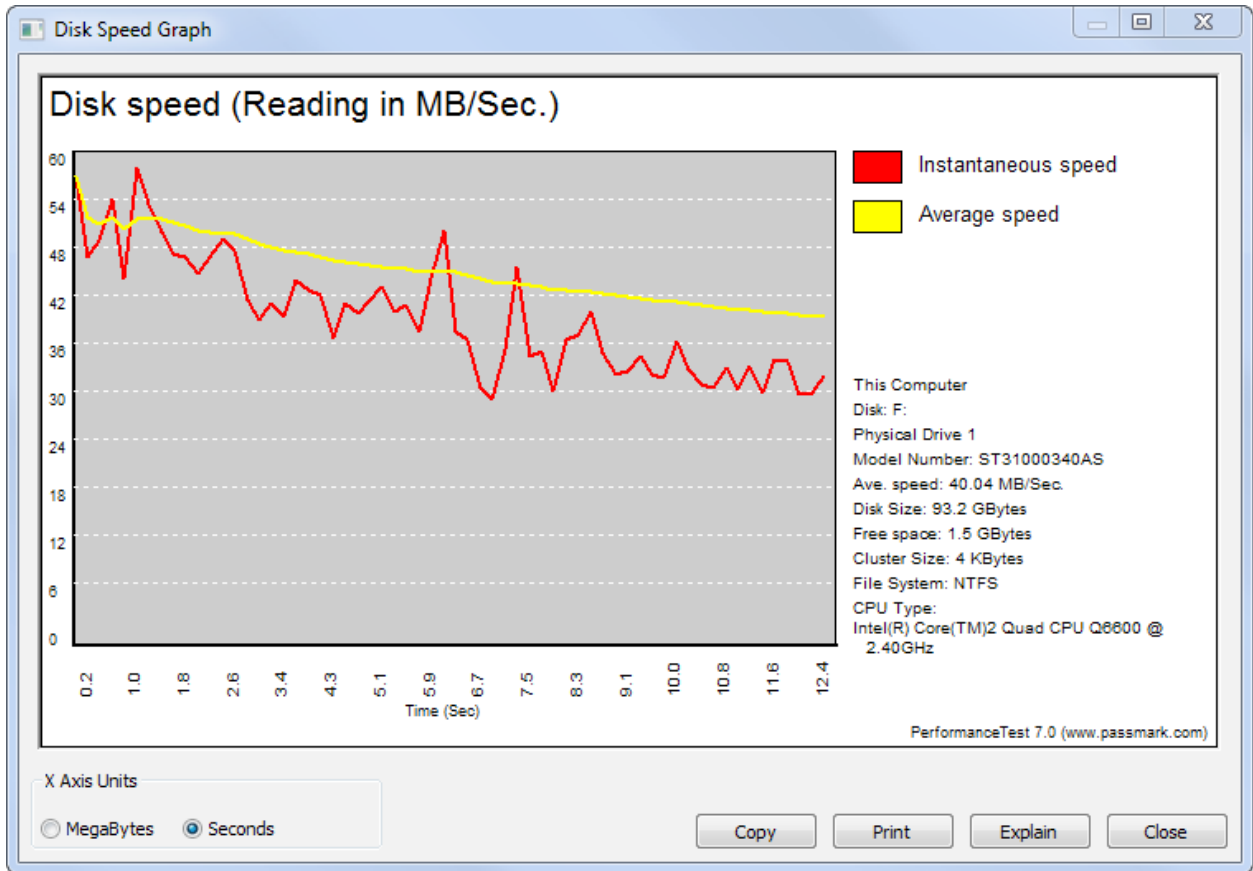
Average Disk – Sequential Read: **20.44 MB/s**
Average Disk – Sequential Write: **31.80 MB/s**

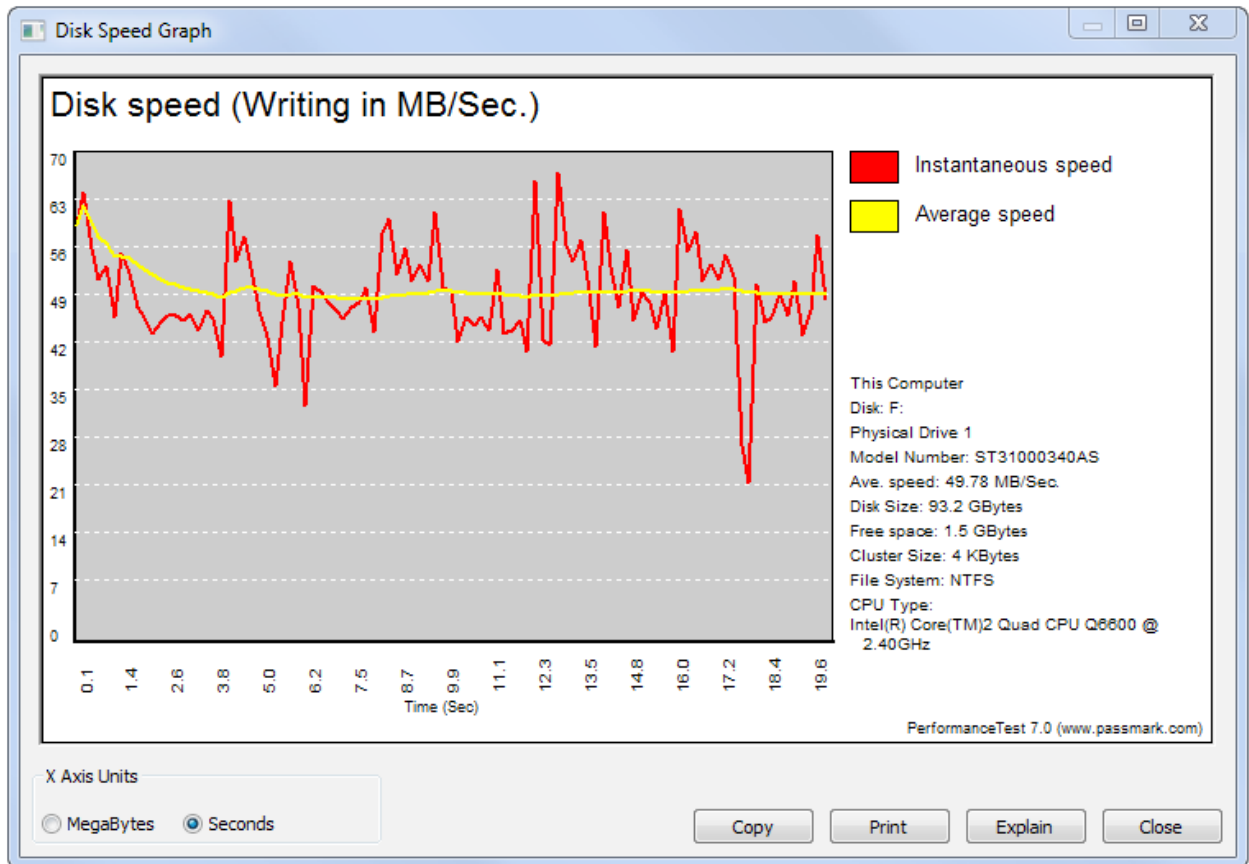




Windows 7 Disk Defragmenter Results

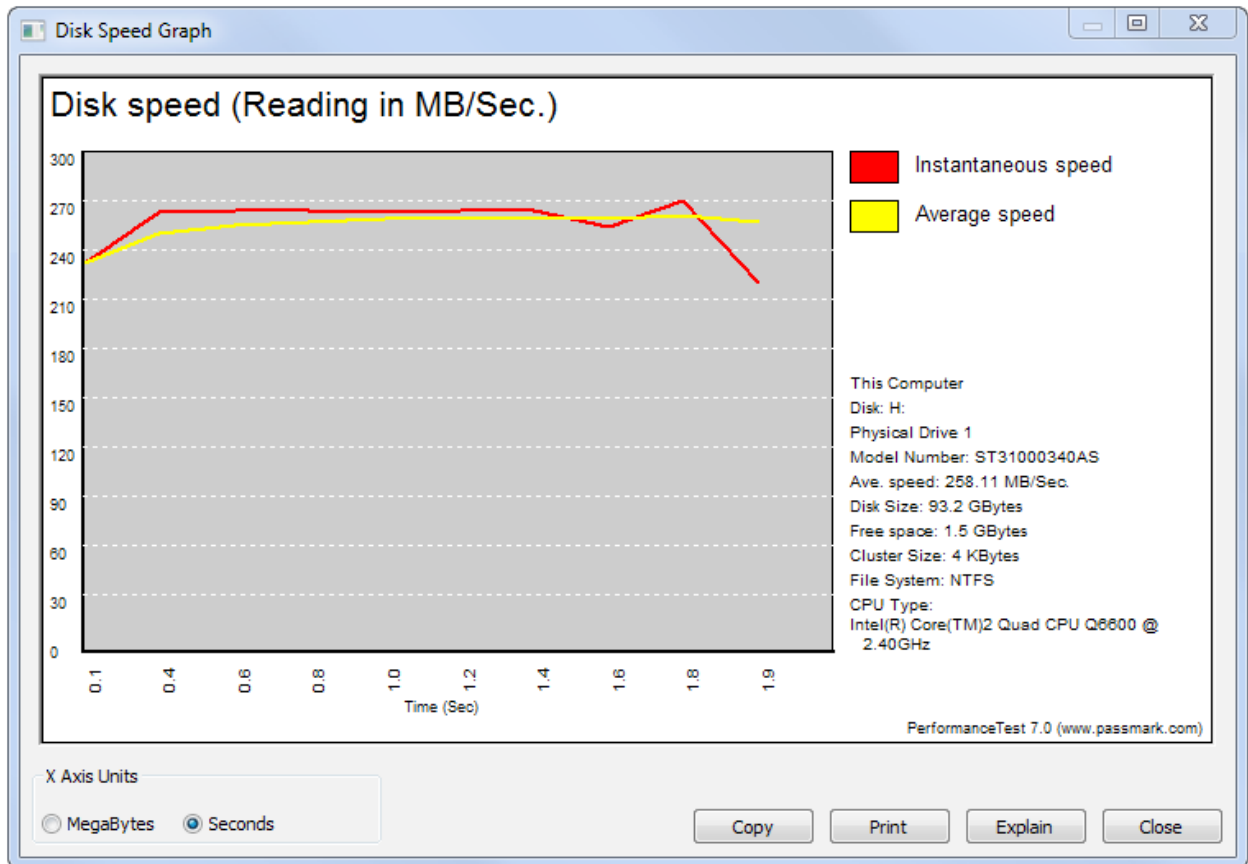
Average Disk – Sequential Read: **40.04 MB/s**
Average Disk – Sequential Write: **49.78 MB/s**

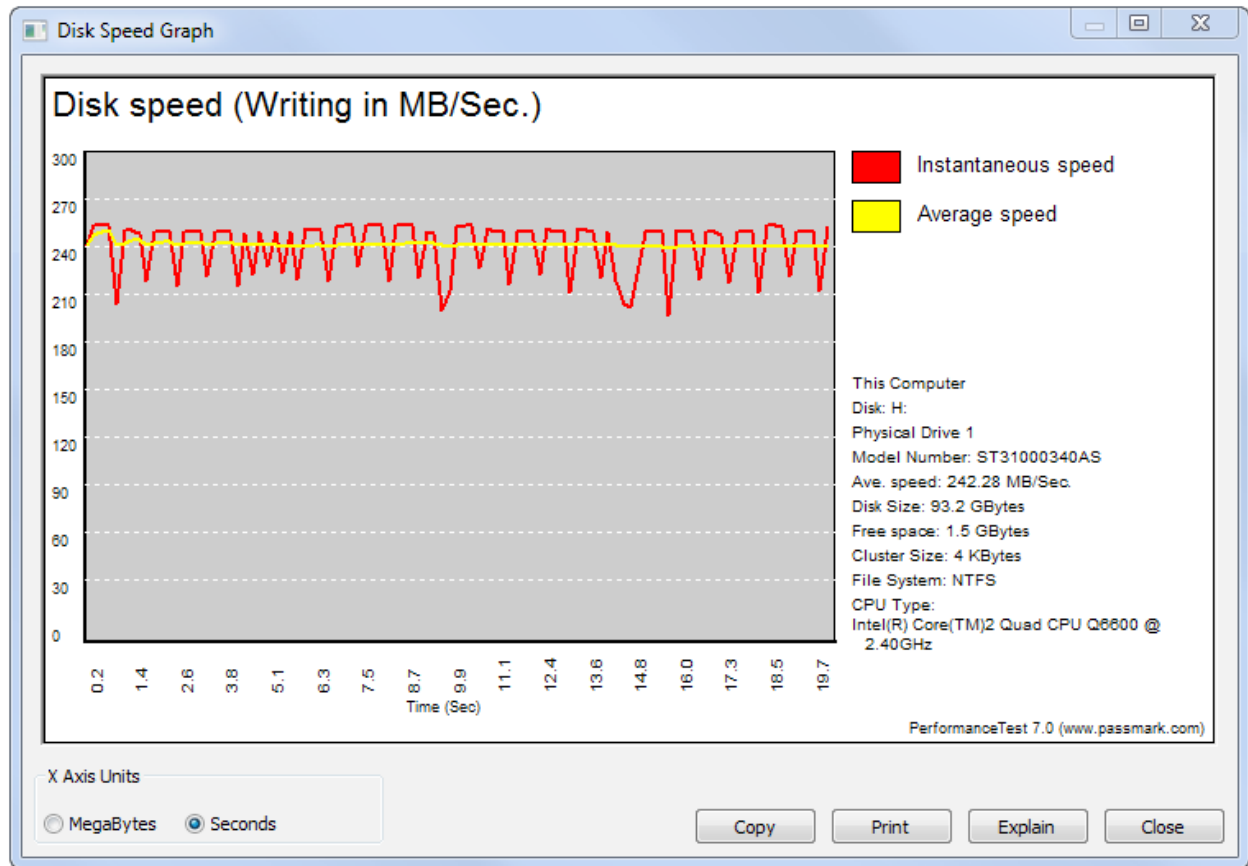




PerfectDisk 10 Results

Average Disk – Sequential Read: **258.11 MB/s**
Average Disk – Sequential Write: **242.28 MB/s**





Observations from Results

- 1) Despite the use of a fast 3 drive stripe (Raid 0), file fragmentation is capable of severely affecting the sequential read and write performance of a disk. While this is not the fastest of drive arrays possible, it does reasonably demonstrate the performance impact of disk fragmentation.
- 2) The Windows 7 Defragmenter does clearly demonstrate an ability to improve over all disk performance.
- 3) The Windows 7 Defragmenter is only so effective because of its multi-pass strategy. Unfortunately, subsequent passes did NOT further improve performance.
- 4) The Windows 7 Defragmenter did not provide the best results because it failed to effectively remove file fragments while simultaneously consolidating free space. The key to solving the fragmentation issues on any drive is the consolidation of free space so that

defragmented files can be written out contiguously. Failure to effectively consolidate free space will always result in subpar performance for reading and writing.

- 5) PerfectDisk was able to restore the disk array to near 100% performance in a single pass. The charts provided are a good visual aid that clearly show how fragmentation causes the read / write heads on a disk to thrash wildly. When fragmentation is effectively eliminated, average speeds will normalize with instantaneous speeds. The graphs clearly show that near maximum read performance was achieved, and that maximum write performance was not only reached, but limited only by the size and speed of the write buffer. This is visibly demonstrated in the square wave like form of the graph.