Hidden IT Costs

Avoiding the real cost of file fragmentation on Windows systems

Abstract

Costs continue to play a decisive role in today's economy. Whereas expenditures in the IT Sector were reaching the sky just a few years ago, they have now become one of the favored areas where business controllers and consultants look to save money. All too often, however, it's just the obvious expenses that are taken into consideration, leaving an enormous savings potential left untouched. This study will explore the problem of high costs arising as a result of data fragmentation and how they can be eliminated and avoided with just a minor investment.

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Chapter 1

The real cost of using Windows systems

The magic formula concerning IT expenditures is, without a doubt, TCO –Total Cost of Ownership. This is understood to be the sum of expenditures related to furnishing a workplace with information technology. Over the years, it's been tried, time and time again, to relegate and prioritize these expenditures more precisely. It begins with the purchase of hardware and software. After acquisition, there are the costs of maintenance by IT personnel as well as additional expenditures for software updates and hardware resupply.The final expenditures emerge when the material is put out of operation and needs to be discarded.

It's now obvious that the cost of operating a PC system far exceed those related to simple acquisition and disposal. Alone the cost of calling in an IT specialist to repair a defective PC system can be very high. In addition, viral attacks and other malware are responsible for burdening businesses with enormous costs every year, and these wind up directly into the TCO calculation.

This study will concern itself with detecting additional costs beyond those already mentioned, ones that are normally never found in any calculation. These are the hidden IT costs that are considerably higher than what we would expect.

1.1   Cutting costs on the job is a multiplying factor

It should be pointed out that improving worker efficiency actually has a much greater impact on savings than cutting-back on administration. Thanks to modern software, administration can already be reduced and such cuts affect relatively few workers - namely the IT personnel. Increasing worker productivity, however, is a much greater multiplying factor. Even after a short time, the effect this has on company finances will be obvious and attract increased attention from both the IT department and company management.

1.2   File fragmentation occurs on every PC workstation

There are even further costs arising on every workstation and these are a multiplying factor as well. These costs are not obvious. They are hiden and conceal themselves primarily behind the technical features of a system or software, or are considered to be an inherent part of the system. In the following sections, we will highlight one such cost factor: file fragmentation on local disks, especially hard disks. Many are aware of this phenomenon and know what to do against it, but do they also know the true cost of fragmentation? Here's a little hint before we get started: the price is dramatically higher than you'd think.

The interesting and decisive thing about file fragmentation is that it inevitably turns up on every workstation. It makes no difference what kind of operating system or software is being used. Fragmentation is an intregal part of how a computer saves data and is therefore unavoidable. There is, however, one effective remedy: periodic defragmentation using software developed specifically for this purpose. How easily and effectively this software can be applied will be discussed in detail in a later section.

1.3   The hard disk — storage location for all data

All data that needs to be permanently saved must be deposited on a secondary disk for storage. These are usually hard disks but recently, external USB hard disks, memory cards, and Solid State Drives (SSDs) have been added to the list. Thanks to their capacity and low price, however, hard disks remain the preferred disk for saving data. They are used for loading all operating systems and programs, and all data is saved on them. This can occur on a local workstation computer or on a central file server in a company.

Along with CD-Rom and DVD drives, the hard disk is one of the last mechanical components of a modern computer system. Even when a computer has the fastest processors and memory chips, its overall speed will always depend on the speed of the hard disk.

The capacity of a present day hard disk is 250 times greater than it was 15 years ago (see Figure 1.1). The speed of data processing has also increased enormously, though not to the same extent. The speed of a hard disk is limited by its mechanics and, therefore, by the laws of physics. Deciding factors here are the number of turns per minute, and the average access time needed for reading and writing data.This has barely been reduced over the past 15 years whereas the physical speed has just about doubled (see Figure 1.2).
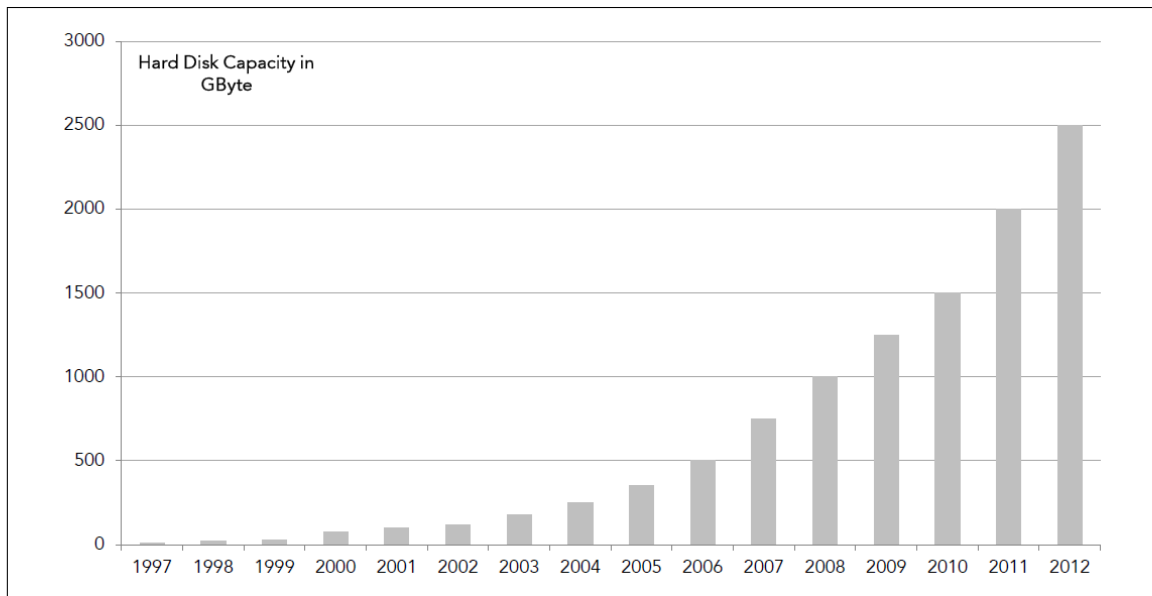
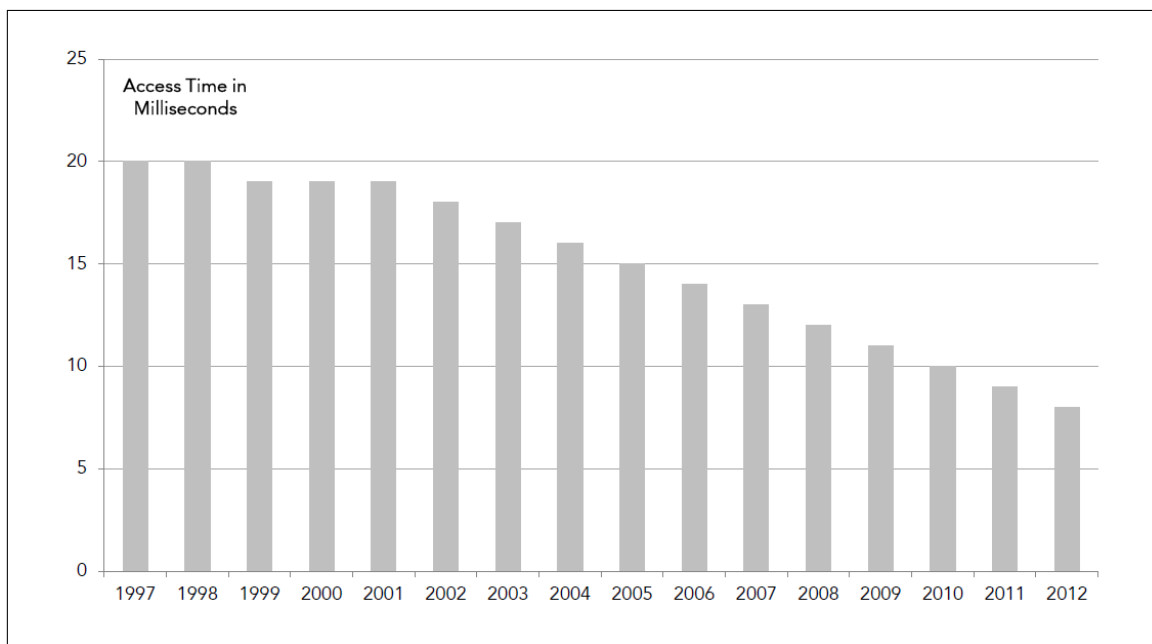**Figure 1.1:** *Development of hard disk capacity in the period 1997 to 2012*

Figure 1.2: *Development of the average hard disk access speeds in the period 1997 to 2012*

Chapter 2

Technical reasons for fragmentation

All data is written on the hard disk in concentric tracks.Each of these tracks has a particular storage capacity which require very large files being split among multiple tracks. In order to read such a split file, one track after the other has to be approached by the read/write head. This next track should normally be located very close to the first one, in order to minimize the time needed for repositioning the head.

This sounds very simple in theory, but in practice it is nearly impossible.The operating system cannot know in advance where certain files in differing size and number should be stored.Every file will saved by itself. The operating system's main objective is to save data on the disk as quickly and securely as possible, so that no data is lost in the event of a system failure. This, however, inevitably interfers with the optimal positioning of files.

When files are changed or even deleted afterwards, their original storage location will be freed by the operating system and used for saving other files. Over time, this results in so-called "fragmented" files. The data of those files is not saved consecutively but scattered across the entire hard disk. The Figures 2.1 and 2.2 illustrate the difference between scattered (fragmented) and consecutive (defragmented) file fragments.

The consequence of all this is obvious: reading and writing a fragmented file on a hard disk takes longer because the read/write head must be repositioned for every single data fragment. This mechanical process has a very negative influence on the PC system's overall performance and results in a considerable loss of speed for the user.

2.1   Fragmentation of free disk space

It's not just file fragmentation that causes a decrease in performance; the fragmentation of free disk space can also lead to significant losses in system velocity. This form of fragmentation is also known as "free space" fragmentation and is brought about by the gaps created after files are deleted.

The operating system will fill these gaps with new files. Once again, the operating system does not optimize the placement of files so under certain conditions, newly created files will be immediately fragmented. This is often the case with larger files. Defragmenting file systems not only requires defragmenting files, but merging them as well so that any existing gaps can be closed. This is, in fact, the only way for correcting free space fragmentation and preventing any new file fragmentation from occurring.If new fragmentation were to occur, it would quickly lead to new decreases in performance and severely weaken the results of defragmentation.

Figure 2.1: *Files are not saved consecutively so their data takes longer to read. New fragmentation can arise very quickly and slow down the system.*
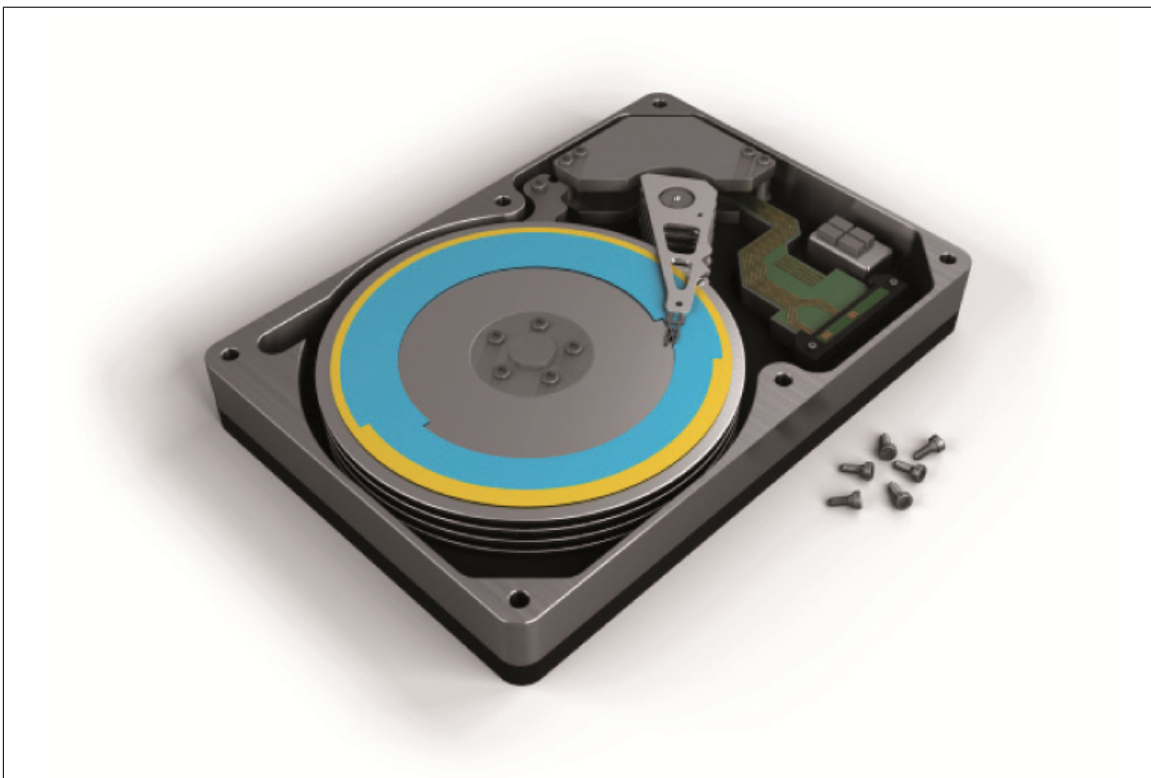

Figure 2.2: *Files are saved consecutively. Access is thereby significantly faster and new fragmentation prevented.*

Chapter 3

Hidden costs as a result of fragmentation

Now that the technical foundations have been explained, we can turn our attention to the costs arising from fragmentation using concrete calculations drawn from examples.

It has already been mentioned that the hard disk constitutes a mechanical component of a computer system. All data will be written and read upon it. This is done with a read/write head that is moved at low elevation and at very high speed above the magnetic disk. Every physical read or write process occurs in two steps:

1. The positioning of the hard disk head above the corresponding place on the magnetic disk

2. The subsequent reading or writing of the data

The time needed for the first step is defined as the average access time of a hard disk. On modern hard disks, this takes an average of 9 milliseconds[4]. The time required for the second step is called the data trasfer rate and involves the actual reading or writing of data as well as its transfer onto the computer. The transfer rate moves between 50 and 100MB per second so we can assume an average speed of about 75 MB per second [5].

3.1   Time lost as a result of increased access times

To simplify things, let's say that it's not the actual reading or writing of data that requires time, but the positioning of the hard disk head that makes all the difference. In this way, calculating lost speed involves only the average access time, the amount needed for directly accessing a sector of the hard disk.

This allows us to conclude that a file deposited on a continuous region of the hard disk will be read within the easy average access time. If this same file were split between two sectors, the amount of time needed for accessing would be doubled because two independent regions would now have to be read. Taking it one step further, a file split into ten segments would correspondingly take ten times longer. This calculation can be arbitrarily extended for however many segments or fragments a file possesses: the higher the number of fragments, the longer the access time needed for reading and writing.

Let's now consider what happens when certain files having an ideal total loading time of one second are deposited on the hard disk consecutively and in one large block.

These can be program files from the Microsoft Office family (Word, Excel, Outlook and Access) or normal data files as well, such as letters, documents, table calculations or databases.

If 100 of these files are loaded on one day, the user would have to wait 100 seconds for loading process to end. Let's now say that instead of existing in one block, these files are deposited on two blocks of the hard disk, which means twice the amount of time needed for loading.

The user is now forced to wait 200 seconds for these files, a time span 100 seconds longer than before. This increased waiting time has to be multiplied when considering servers because, as is the case with workstations, a bottleneck develops as a result of the files that have to be read and written daily. What follows can therefore be applied to servers.

3.2   Lost working hours increase costs

These nearly 1.5 minutes a day don't sound very dramatic at first, but when we imagine a company with 500 employees working on PC systems, we arrive at a total of 50,000 seconds a day lost as a result of fragmentation. This adds up to a total of 13.8 hours a day. Or put another way, almost two workers will be needed to make up for this amount of time lost.

In 201, according to the United States Department of Labor, Bureau of Labor Statistics, the average cost of labor in industry was 30.11 USD an hour[3].

Based on these hourly costs, our sample company loses 416 USD a day. Taking an average of 220 working days a year, the annual costs amount to 91,500 USD or 183 USD per workstation. It should be emphasized that these costs will definitely not turn up in any TCO calculation, so the ones we've indicated can truly be described as hidden. For our purposes, we can put them down as personnel costs.

3.3   Reducing costs with O&O Defrag

Such expenses can, however, be avoided – by defragmenting a computer automatically on a regular basis using a professional solution. O&O Defrag does that for you and also gives you the option of background defragmentation without affecting employees while they work. It also features an integrated function for consolidating free disk space that lets you eliminate free space fragmentation.

Let's take another look at the company we used in the earlier example: an O&O Defrag license for 500 computers, including network control, costs 5,200 USD. To this figure, we're going to calculate two eight-hour working days needed for an administrator to test and install O&O Defrag on all the computers. Allowing for the previously mentioned, average hourly cost of labor, this results in additional costs of 482 USD This makes a total of 5,682 USD, and for 500 workstations this works out to a cost of 11.34 USD per workstation.

3.4   O&O Defrag pays off within just a few weeks

If you compare this amount to the cost of 183 USD per workstation caused by fragmentation, the acquisition of O&O Defrag pays for itself after only 14 days (in view of the above named 220 working days per year). The bottom line is that the company saves 170 USD per year and workstation! And these are just the benefits of eliminating normal fragmentation. Defragmentation also gives you the advantage of needing less time for making backups and restoring data. It also reduces the strain on hard disk mechanics and this directly increases the life expectancy of all computers. Had we included all of these factors

into the calculation, the purchasing of O&O Defrag would have paid itself off even sooner. A more detailed description of these further advantages can be found in the chapter 5.

Chapter 4

Why Windows can't help

4.1   The operating system cannot prevent fragmentation

The Windows file system alone is not capable of counteracting fragmentation. The operating system's main concern is with the reading and writing of files, not with their optimal placement for increasing access time. In order to do this, a supplementary defragmentation software is required, and it must be used on a regular basis so that the inevitable fragmentation that arises is eliminated.

Ever since Windows 2000, Microsoft has been delivering its products with an integrated defragmentation software. In many ways, however, this integrated program is simply not enough for meeting the daily demands placed upon a well-functioning computer system. The following will present some of the most frequent problems arising from the day to day experience with the Windows Defragmenter.

You can find a detailed comparison of O&O Defrag with the current Windows Defragmenter in the whitepaper "O&O Defrag and the Windows 7 Defragmenter:A comparison"[2].

4.2   No automatic defragmentation is possible

The Windows Defragmenter can only be run manually. The user must personally see to it that defragmentation takes place regularly. When this is not done, successive defragmentation runs will take considerably longer because increasing numbers of files have to be processed. In addition, the loss of performance between two defragmentation runs will be much higher, reducing the overall effectiveness of defragmentation itself. Fragmentation can occur every time files are changed and is therefore responsible for an immediate slowing down of the system. As stated earlier, the only way to avoid this is by defragmenting regularly.

The O&O Defrag scheduling feature provides an option of running automatic defragmentation with just one push of the button. A user can decide whether to setup a schedule for running defragmentation or enable automatic defragmentation. Once set, automatic defragmentation will monitor a system's fragmentation level in the background and run a defragmentation whenever a specified fragmentation level is exceeded. In this way, a computer's highest level of performance can be guaranteed.

4.3   The Defragmenter is hard on system resources

One major disadvantage of the Windows Defragmenter is the burden it places on system resources. In fact, it's almost impossible to use a computer while the Defragmenter is running. As a result, the increased speed you might gain is canceled out by the time lost waiting for defragmentation to be completed. Depending on how long the Windows Defragmenter takes, using it could even work out more to your disadvantage.

That's why O&O Defrag uses a one-of-a kind technology to constantly monitor a computer's load and then adjust O&O Defrag's consumption of resources accordingly. This allows a user to continue working without being disturbed by the defragmentation process. A system administrator's life is also made easier with O&O Defrag. There's no longer a need to set aside a special time for defragmenting because it can be run at any moment: without interfering in the employee's ability to work.

4.4   The user needs administrator permissions

The Windows Defragmenter requires administrator permissions in order for it to be run, i.e., the the user must possess these permissions. This gives the user complete control over his or her computer, which, in view of the security risks involved, is most often not possible within a company.

O&O Defrag offers administrators various options for avoiding such security risks. Users can be blocked from running the program so that only administrators have the authority to configure settings. The administrator may, however, give users direct access to O&O Defrag when, for example, they're travelling with their notebooks on the road.

4.5   Remote management not possible

The lack of an option for remote management is one major disadvantage of the Defragmenter for company administrators. If they relied on the Windows Defragmenter, administrators would need to to run from computer to computer in order to make sure all machines were being defragmentated regularly. Working this way would, however, prove to be very time-consuming and expensive.

O&O Defrag, on the other hand, features a centralized network management that allows all its activities and settings to be run. Everything from automatic installation, configuration, and upgrading of software and settings can be done remotely.

Setting up sites makes it possible to breakdown computers into groups so that, for example, workstations and servers can be treated separately. As such, two different schedules for defragmentation can be setup and automatically assigned. From that point on, no further intervention will be necessary.

O&O Defrag can also be fully integrated into already existing software management systems without any problem. Its complete conformity to the Windows standards laid down by Microsoft make it possible to create configurations or even script files for automatic execution. Management overhead can be reduced to an absolute minimum, saving both time and money.

4.6   Windows defragmentation is just not enough

All in all, Windows defragmentation software should be seen as merely a rudimentary tool. Good enough perhaps for the occasional PC user but it makes no sense for daily use by

businesses or even by demanding PC users. This is because the costs generated by manual defragmentation remain too high when compared to the defragmentation software that's commercially available. Only these provide the features needed for really saving money.

Chapter 5

Further advantages of defragmentation

In the previous chapters, we've discussed in detail the problems caused by file fragmentation and the ensuing time lost when reading and writing data. We'd now like to turn our attention to additional problems resulting from fragmentation, ones that periodic defragmentation could correct.

5.1 Less wear on hard disk mechanics

We frequently hear the following argument from our clients: defragmenting files on a regular basis puts considerably more strain on hard disk mechanics than not running one. This statement is then followed by a conclusion that a computer's life expectancy will be reduced as a result. This is,in fact, totally wrong because fragmented files actually put much more strain on the mechanism than files that are defragmented.

5.1.1 An example

Let's say we have a file that needs to be loaded every time the system boots. We start the computer one time every working day. To simplify things, let's assume that the year has 220 working days. If this file is spread over the hard disk into 50 fragments, whenever the file needs to be read, the read/write head will have to be moved into a new position exactly 50 times. Over the course of a year, this adds up to 11,000 movements of the read/write head for just this one file.

When we now defragment this file, we'd need a total of 50 movements for reading and one movement for writing the defragmented file, which makes a grand total of 51 movements. To this one movement we can now add the read processes that will be conducted over the course of a year. Given that the file can now be read in one process, the head only has to be moved one time to reach the file's position on the hard disk. This results in exactly 220 movements over the course of one year.

We now have a total of 271 movements, including the one we needed for the defragmentation. This difference has let us save 10.729 movements when compared to the fragmented file – or expressed differently: the hard disk head had to move approximately 40 times more for the fragmented file than it did for the defragmented one.

We can now see clearly that the real strain on the hard disk is caused by fragmented data. A hard disk performing under such strain will suffer higher abrasion, and possibly have its mechanism break down earlier than it would under a regularly defragmented system. This is also a considerable cost factor. The keywords here are hard disk replacement and the amount of time needed for installion and implementation.
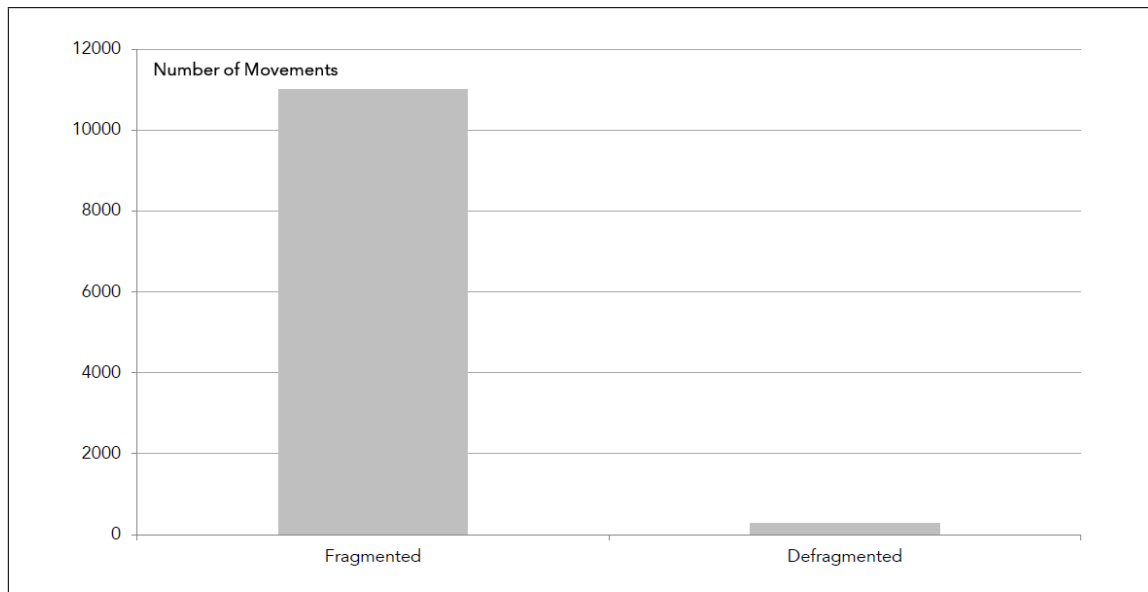
Figure 5.1: *The number of movements made by hard disk head are reduced significantly by periodic defragmentation. This helps preserve hard disk mechanics.*

5.2   Restoring data is made easier

Data restoration poses an additional problem for fragmented systems. While this is certainly not something needed every day, a problem with data restoration can have fatal consequences.

If a hard disk breaks down as a result of a hardware or software technical problem, its table of contents could be destroyed (for NTFS file systems, this is the Master File Table). This table of contents is the key to all data. If it's lost, it can usually be restored using special data recovery software such as O&O DiskRecovery [1]. Software like this will scan the entire hard disk for files and restore them. If these files are located consecutively on the hard disk –meaning, defragmented – restoring them is very easy. Combining fragmented files, on the other hand, is extremely difficult, partially even impossible, unless there is additional information about the file system available.

5.3   Less time needed for backups

Backing up data is one of the most important assignments for management. It's normally done once a day so that if a crash ever happens, the most current database will be available. Data backup like this is usually run on servers at night. There are a number of reasons for doing this. For one, a user would otherwise not be able to work undisturbed because the hard disks on servers are under a heavy load while backups are being run. Another reason involves the need for maintaining a consistent status so that data is not altered in any way during the backup. At best, no other application should be running that might change data as a result of its own activity. This is why administrators require a special time period for making backups.

Present day data traffic being what it is, guaranteeing a complete and consistent backup of large data volumes has become one of an administrator's most difficult assignments. Users are saving, editing, and also deleting ever increasing amounts of data on servers. These constant changes are responsible for a high level of file fragmentation, which again

leads to a noticeable decrease in the speed required for reading and writing data. A backup requires all data to be read.

Every administrator is thankful when the time needed for making backups is shortened. Many are already using software developed for this purpose, ones that limit the amount of data any user may save. Such a limit is supposed to control the volume of the backup.

Many administrators probably don't even consider defragmenting data as a way of making backups much faster. Think of the valuable time they'd gain without interruptions in the daily workflow or interventions in the system!

5.4   Acceleration of other applications

Aside from backups, other applications also run much faster as a result of frequent defragmentation. Among them, applications that affect very large numbers of files such as antivirus-programs and processes for searching and indexing. Loading applications consisting of many individual files can also be done faster on a defragmented computer.

Chapter 6

Potential savings by network defragmentation with O&O Defrag

Manual defragmentation is impractical and costly for both users and administrators because such a defragmentation has to be controlled locally. Special user permissions are also required to run defragmentation locally and this is usually not permitted by a company's security policy. Running the Windows Defragmenter can't produce the desired results because as soon as it's started, the demand it places on system resources makes working with the computer much more difficult.

What makes matters worse is the fact that the computer has to be on when defragmentation is set to run. Otherwise, it will take place at the the next system start and the time when work can begin will be delayed considerably.

O&O Defrag provides a convenient and cost-saving option for management across a company network. The TCO can be lowered regardless of the number of computers involved.

Pressed for time, IT personnel might neglect maintaining the system properly and this can lead to diminished system performance as well as reduced efficiency and productivity. This in turn leads to complaints by users to the IT personnel who then have to take time and resolve the issues that are raised. A vicious circle.

Our network management provides flexible, sophisticated features for installation, control and scheduling of O&O Defrag. Optimized performance lets companies sink the TCO because system administrators are controlling the product across a network from one central console.

The TCO (Total Cost of Ownership) can be drastically reduced by network defragmentation.

The following example compares the administrative costs of manual defragmentation to one controlled across a network. Let's assume that it takes an IT employee at least one working hour to manually defragment one workstation or server. This includes all administrative assignments such as scheduling, going to and from the computer, and processing. The manual defragmentation should only be run once a month and we'll make a conservative estimate of 30.11 USD an hour for IT and other personnel costs[3]. Based on this example, the following calculation can be made:

By introducing network-capable defragmentation software. IT personnel costs could be cut significantly. Processes could be controlled at all times and fully automated to achieve optimal system maintenance with a minimum of administrative involvement. Beyond that,

Company size	Total cost of manual defragmentation
100 workstations	3,011 USD per month
500 workstations	15,555 USD per month
1,000 workstations	30,110 USD per month

downtime could be avoided because workstations are no longer blocked the way they are when defragmented and managed manually.

Administrative costs for network defragmentation are almost negligible for companies of any size.

O&O Defrag only needs to be configured and have its jobs defined once. Thanks to background defragmentation, the workstation's user can keep on working because product management is taking place in the background.

If we estimate it taking something like five hours per month to manage defragmentation across a network, we come up with the following figures:

- Acquisition of a PC system: 1,500 USD per system

- Cost of hardware over a three year service life: 500 USD per system per year

- Savings for extension of service life for one year: 500 USD per system per year

Regardless the size of any business, the IT costs and TCO will be much lower. From a TCO point of view, the numbers speak for themselves: network defragmentation is a must for all companies.

6.1   Extend the life expectancy of PC systems

Most businesses have recognized file fragmentation as a problem. Very few of them, however, are truly aware of the consequences reduced system performance has on IT costs and the costs for refurbishing hardware. These are expenses that are ultimately reflected in the net operating profit of their companies.

Fragmentation under Windows can lead to severe limitations of system performance. This may result in premature or unnecessary purchases of new hardware for increased performance.

Minimal system performance caused by file fragmentation can lead to avoidable investment in new hardware. Regardless of the fragmentation level, simple optimization strategies can help use available resources with much greater efficiency. Sad to say, this doesn't correct the real causes of the problem and they'll be sure to resurface on any new hardware. When confronted with a severe loss in system performance, many businesses purchase new hardware prematurely or for no good reason. By using a defragmentation program such as O&O Defrag, however, these businesses would achieve increased performance comparable to that gained by any new hardware.

The overall expense of refurbishing hardware and new hardware acquisition are tied in with the cost for time spent by IT personnel and the ensuing downtime of systems that

> *The extension of an optimized system's life expectancy is an important factor in the total cost of hardware.*

Size of company	Total cost following automatic defragmentation
100 workstations	$5 * 30.11 = 150.55$ USD per month
500 workstations	$5 * 30.11 = 150.55$ USD per month
1,000 workstations	$5 * 30.11 = 150.55$ USD per month

need to be adjusted. All of this must also be brought into the equation when calculating corporate expenses.

Let's assume the price of purchasing a new system to be 1,500 USD. For our example, an older system would also cost 1.500 USD. The average service life of the system will be assumed to be 3 years. To simplify matters, we'll ignore any possible value the old system might have. Thanks to frequent defragmentation, we can assume an extended service life of 1 year because the existing hardware resources are now functioning more efficiently.

We'll also ignore the IT personnel costs for disassembling hardware, system conversion, and setting up the new system. Based solely on the delayed acquisition of new hardware, a company would save 500 USD per workstation annually. These savings would repeat themselves with every hardware cycle and added to them are the designated IT costs for converting hardware. Even when using different parameters, the extent of potential savings is plainly visible.

As a final remark, it should be emphasized that an investment in O&O Defrag carries over when older hardware is replaced.

Chapter 7

Conclusion

Demands on the IT department increase faster than ever before. Just a few years ago, a normal workstation consisted of just one desktop PC and maybe a notebook. The current workstation now often has smartphones and tablets as part of the setup so there's not only a larger number of systems needing to be managed, the diversity of technology has increased as well. In spite of terminal equipment from Apple and Android operating systems with Google being on the rise, Windows will certainly remain the dominating operating system for desktop PCs and servers in the coming years. This makes it a sure bet that the need for cutting down on maintenance and repair costs in this sector will continue to be a top prioriy.

As the concept implies, hidden costs are difficult to uncover. In the previous sections, we have provided examples of the amount of money that gets wasted unnoticed on account of fragmented computers—day after day, year after year. A professional defragmentation solution such as O&O Defrag provides an economical option for sinking costs quickly and in a way that gets noticed. While Microsoft does offer its own solution in Windows, we have explained why this option is not viable for businesses. Same goes, by the way, for the Windows data backup tool. No company should want to depend on these alone.

Good business requires that software rollout and management be done as easily as possible in company networks. O&O has its own network management that allows companies to do just that with O&O Defrag and other products.

Aside from making computers run faster and more efficiently, defragmentation performed regularly brings with it a number of other positive effects. These include a longer service life of hardware, less time needed for making backups,and increased chances for restoring data on defective systems.

Chapter 8

Contact

8.1   About O&O Software GmbH

Berlin-based O&O Software GmbH has been developing and selling standard software for Windows since 1997. Its customers include private customers, companies and public authorities. The products are sold successfully in over 140 countries, both direct and through a network of partners. The product portfolio comprises applications for performance optimization, data recovery, secure data deletion and Administration, all under Windows. O&O products have won numerous awards and comparison tests, being named in the process as technological leader in its field. Further information and free trial versions of all products are available on the O&O website.

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8.2   About the author

Olaf Kehrer is Managing Director of O&O Software GmbH and is responsible for product development. His focus is centered on developing new concepts for the system tools sector as well as in expanding and adapting existing product lines. Olaf Kehrer was one of the founders of O&O Software GmbH in 1997 and has played a primary role in developing O&O products. Even today, he remains at the very center of their further development and remains dedicated to the goal of creating the best possible products for O&O customers. He has also published white papers on the subject of "Data Data Everywhere". These papers analyzed the handling of obsolete and discarded hard disks and their undeleted data. Olaf Kehrer studied at the Technical University Berlin and has a diploma in Computer Science.

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