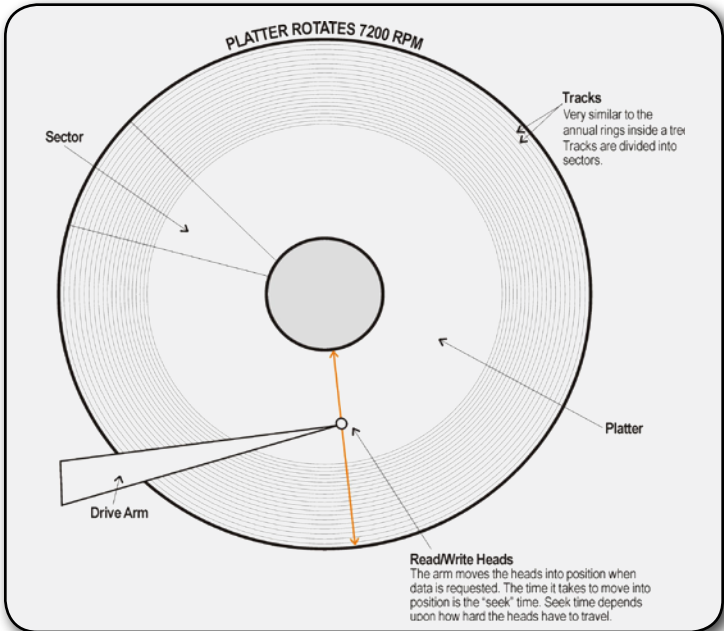




Hard Drive Performance Theory

Please read on to see how fragmentation and other, even more, important factors act to slow your hard drive's performance.



How Your Hard Drive Works

Your hard drive is the only "data handling" peripheral in your computer with moving parts. This makes it the slowest performing peripheral, when compared to the CPU and memory. As a result it is the performance rate limiting device on your computer. Most of the time, the CPU and memory has done its work and is waiting on the hard drive to provide or save data.

In the most simplistic of descriptions, your hard drive consists of spinning platters and read/write heads. The platters contain data bits that consist of magnetic patterns of data. The platters spin at a rate of anywhere between 4,200 and 15,000 RPM, depending upon your drive specifications. This rapid rotation of the platters results in a cushion of air that makes the read/write heads float only a few micrometers above the surface of the platters - just like a hovercraft floats a few inches above the water. When a request for a file is sent from the main CPU the read/write heads move across your drive to locate the file, they then read that file and send the data back to the CPU.

A file may be 512 bytes in size or it may be many Gigabytes in size.

If you do not run any kind of defragging or file ordering process, generally speaking, files exist on your drive in random order. Files may also become fragmented and this is a leading cause of reduced hard drive performance.

A Little About Drive Fragmentation.

Fragmentation of your computer's hard drive is a natural phenomenon that occurs when deleted files leave empty spaces amongst your drive's data. When the operating system needs to write another file back to the hard drive it generally looks for the first available free space and writes the data to that free space. If the data to be written does not fit in that space it will fill the space with data and then move onto the next free space and continue to write the data until the file is completely written – the result is parts of a file scattered in a fragmented (non-contiguous) manner.

When the operating system requests that fragmented file from the hard drive the hard drive read-write heads need to move around the drive to collect all the pieces of that file. The result is vastly reduced performance since the hard drive head has to make many movements to collect all the pieces of the file rather than pick it all up in one smooth motion from consecutive clusters.

The more fragments a file has the longer it takes to load that particular file. The result is that your hard drive performs far slower than it is capable of in the process of loading that file.

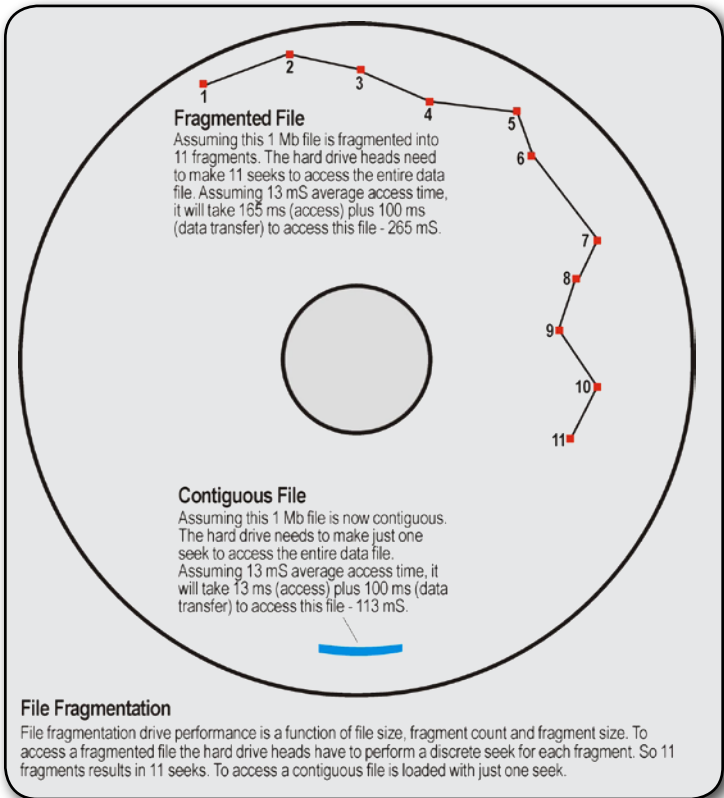
This is, in a nutshell, the phenomenon of file fragmentation.

Fragmentation and Optimization

File fragmentation is only part of the equation in the cause of reduced hard drive performance. UltimateDefrag addresses this and the other, more important, part of the equation in reduced hard drive performance and that is, the placement and ordering of files on your hard drive.

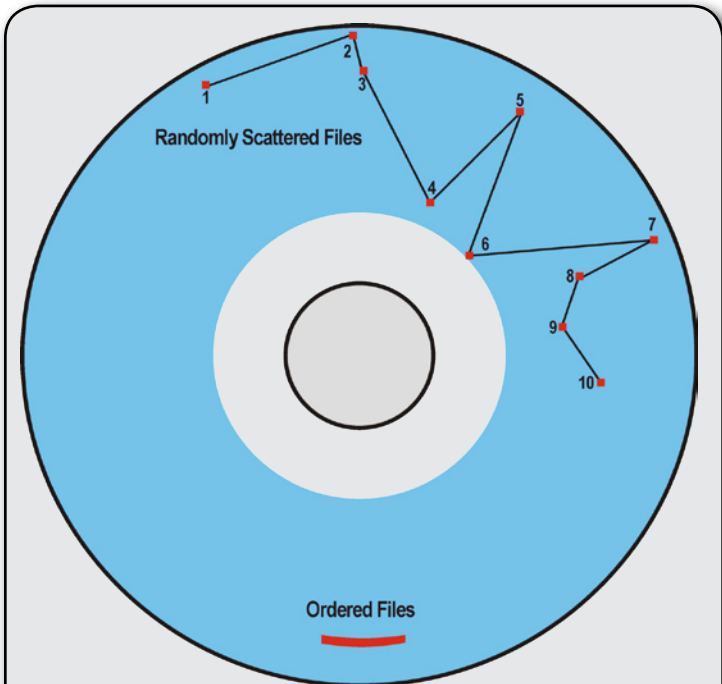
File Placement - A More Important Issue

Most defraggers that are out there have pretty much ignored this much more important aspect of hard drive performance – the placement of files on your hard drive. Loading one file that is fragmented is a discreet issue at the individual file level. However, the way in which the Windows operating system and NTFS file system function results in an almost constant dialog between the computer and the hard drive as hundreds of files are accessed during system boot time and during regular operation of the computer.



What comes into importance here is the work the hard drive read-write heads need to do to read all of these files that are both fragmented and scattered all around the drive. If they are not fragmented they are still scattered all around the drive and loading these files requires extensive movement of the hard drive read-write heads to pick up these files from wherever they may be on the drive – from the outer tracks to the inner tracks. Reading a file from the outer tracks and then having to go all the way to the very inner tracks takes the amount of time that is actually twice as slow as your drive's rated seek speed. If your hard drive has an average access speed of 13 mS then reading a cluster from the outer and then the inner track takes about 26 mS.

See the File Scattering Example diagram.



File Scattering Example

Let's assume that the files above are file for a particular program that you are loading. Let's assume that file 1 is the .EXE file and 2 to 10 are .DLL files that are also loaded when the program is launched. You'll see that it is not too different a scenario from loading a fragmented file. The hard drive still has to make 10 seeks to load the files required when launching that particular program. Since the above drive is almost full there are a lot of "long" seeks required to find the files. A good estimate here is 10 accesses of around 20 mS or around 200 mS just to access and locate the files.

Now look at the bottom of the disk when the files are "ordered" alphabetically. They are considered to be in adjacent sectors. When files are in adjacent sectors or tracks - seek times change to what are known as instantaneous seeks and track-to-track seeks. Track-to-track seeks are typically around 1.5 to 2 mS. So the worst case scenario for the 10 accesses is around 25 mS.

A logical order to file placement can result in vastly improved access and seek times.

Hard Drive Hot Spots

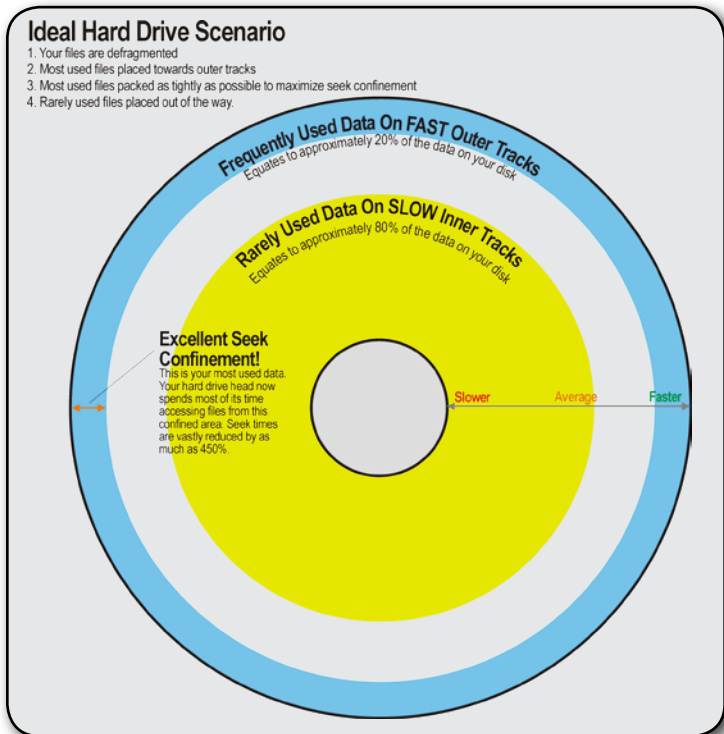
Another important item to note is the location of the data on your hard drive. It is a fact that data transfer from the outer tracks of your hard drive platter is about 180 to 240% that of your inner tracks. This is due to the phenomenon of zoned bit recording and angular velocity. Please consult the Basic Hard Drive Theory section for more information on this.



The Ideal Scenario

Your hard drive is capable of performing around 4 times what manufacturers specify as average performance for your hard drive. This is what UltimateDefrag strives to achieve. In order to have your hard drive perform as fast as it is capable of and even faster than the average rated speed, four elements need to be considered.

1. Your files need to be defragmented in order to minimize drive head movement while reading a file.
2. Your files need to be placed as far as possible towards the outer tracks of your hard drive in order to be accessed from the fastest part of the hard drive.
3. Your files need to be placed or consolidated as closely together as possible to minimize head movement while loading different files – also known as “seek confinement”



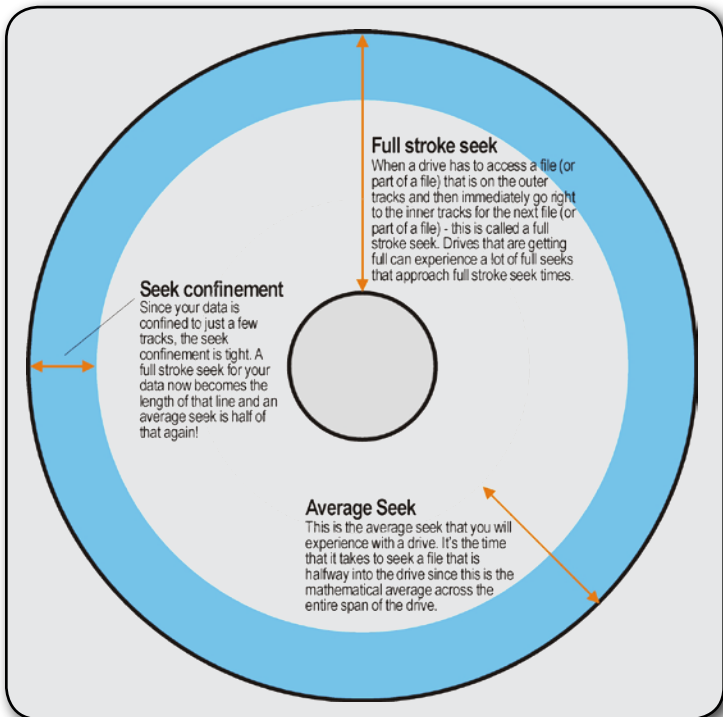
- Files that are rarely used should be placed out of the way so that your most used files are clustered as closely together as possible.

UltimateDefrag achieves all this with the end result being hard drive performance that is around 300 to 400% that of your drive's current manufacturer rated performance.

Since hard drives and the Windows OS already have built in performance enhancing measures - the performance increases you'll see from UltimateDefrag will be anywhere between 30% and 100%.

Basic Hard Drive Theory

We will now focus a little more closely on how your hard drive works from the viewpoint of data access. When you understand this you will understand how UltimateDefrag, which is more than just a defragger, does what it does to vastly improve your drive's performance.





Some Important Terms:

Seek Time: The amount of time a drive head takes to move to the correct position to access data. Usually measured in milliseconds (mS)

Latency: Also know as rotational delay. The amount of time it takes for the desired data to rotate under the disk heads. Usually the amount of time it takes for the drive to perform a half revolution. Usually measured in milliseconds (mS)

Access Time: The amount of time a drive head takes to access data after the request has been made by the operating system. Usually measured in milliseconds (mS). Other minor factors taken out of the equation it is very closely approximate to: Access Time = Seek Time + Latency.

So when data is being requested from the drive the hard drive head moves into position (seek), waits for the data/sector to move into position under the head (latency) and then accesses the data. The time taken for these 2 steps is the access time.

Full Stroke Seek: The amount of time it takes for the drive head to move from the outermost track to the inner most track.

Track-To-Track Seek (Adjacent Track Seek): The amount of time it takes for the drive head to move from one track to the very next track

Data Transfer Rate: The speed at which data can be read from the hard drive. Measured in Megabits per second

Zoned-Bit Recording: A method of optimizing a hard drive (at the factory) by placing more sectors in the outer tracks of a hard drive than on the inner tracks. Standard practice for all modern hard drives.

Sectors: The smallest individually addressable unit of data stored on a hard drive. In a typical formatted NTFS hard drive it is usually 512 bytes.

Tracks: Tightly packed concentric circles (like the annual rings on inside of a tree) where sectors are actually laid out.

Rotational Speed: The speed at which a drive platter rotates in revolutions per minute.

With all these terms now outlined, let's look at the numbers in a typical 160 Gb EIDE hard drive.

Read Seek Time:	8.9 mS
Latency:	4.2 mS
Full Stroke Seek:	21.0 mS
Track-To-Track Seek:	2.0 mS
Transfer Rate:	750 Mbits/s

Hard Drive Performance Explained

Let's look at how these factors work to affect hard drive performance

Data Access

When the CPU submits a request for a file from the hard drive - this is what happens.

1. CPU sends request to the hard drive
2. The read/write head moves into position above the track where the data is. This is the seek and the amount of time taken is the seek time.
3. The read/write head waits until the data that is requested spins underneath the head. It then reads the data. The time taken for the data to move beneath the head is the latency and is usually the time it takes for the platter to rotate a half revolution.
4. Data is accessed and transferred back to the CPU.

The time it took for the initial request, the seek and the latency is approximately equal to the access time.

Having the numbers above available now enable further explanations of data performance to be put into comprehensible perspective.

The average Access Time for this hard drive is $8.9 + 4.2 = 13.1$ mS.
The minimum access time is $2.0 + 4.2 = 6.2$ mS and the maximum access time is $21.0 + 4.2 = 25.2$ mS.

When complete data files or parts of a data file are scattered all around the hard drive you will get a performance that is the average rated access time – in this case 13.1 mS – some accesses are as little as 6.2 mS but some are as great as (or approaching) 25.2 mS. So there is a 406% performance difference between fastest and slowest access time.

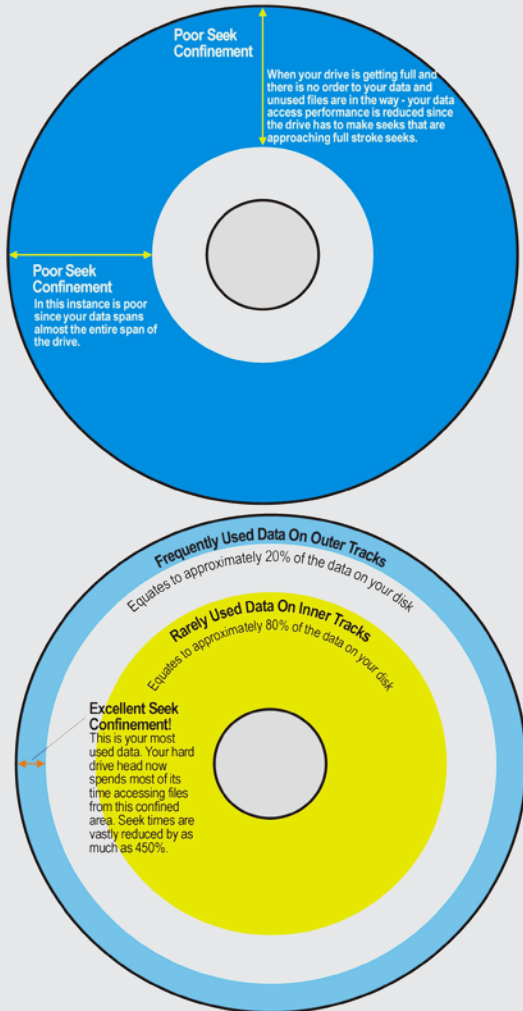
Often, hard drive and operating system intelligence result in a lot of instantaneous track-to-track seeks i.e. without the latency due to file layout patterns and relative location of data. On top of this, the "seek confinement" of the data also promotes vastly increased probabilities of instantaneous, zero-latency, seeks due to the "compaction" of the data. This increases the probability that the data requested will already be under the drive read/write heads. This actually increases the theoretical 406% figure in the above paragraph to a greater number however it is not accurately quantifiable but can be as high as 1000%.

In a typical fragmented and non-optimized hard drive you will only achieve the average rated performance as average access time with some accesses faster and some slower.



Seek Confinement

When your data is spanned randomly across the drive you experience seek times that approach full stroke seek times. When your data is consolidated on the outer tracks (blue band) you increase the seek confinement and seek and access times are dramatically reduced to a fraction of that when your data is scattered.



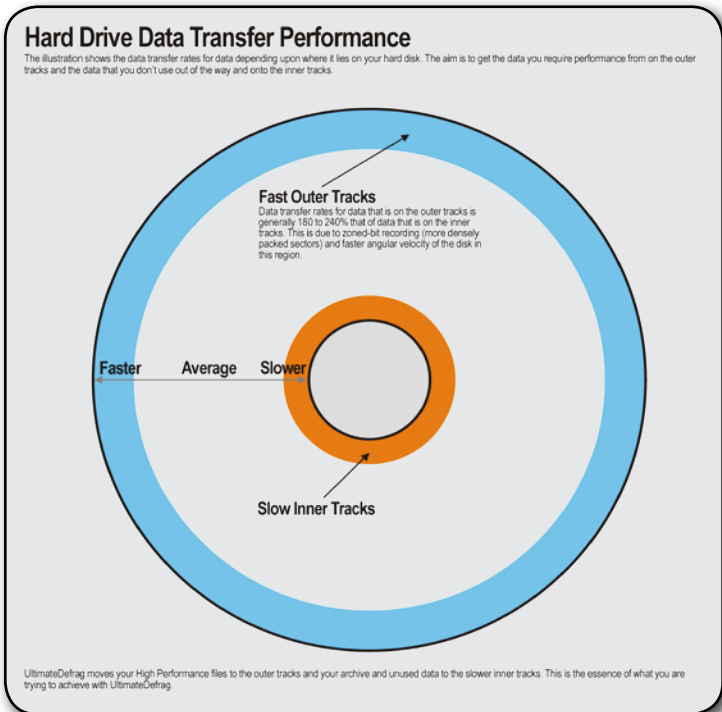
Pareto's Rule

80% of the time you only use 20% of your data. So let's put this data on the outer tracks and compact it. And let's put the other 80% of the data on the inside tracks.

Data Transfer

Part of the hard drive performance equation is Data Transfer Rates. Due to a combination of Zoned-Bit Recording (more densely packed sectors) and angular velocity i.e. the outer tracks of the hard drive have a greater angular velocity – data transfer at the outer tracks of the drive is typically 180 to 240 % that of the inner tracks. So when a drive is boasting a maximum of 750 Mbits/second as the maximum – the minimum is about 350 and the average about 550 Megabits per second.

Again – if you're operating a full, fragmented and non-optimized hard drive, performance is more around the average of 550 Megabits per second.



Hard Drive Fatigue

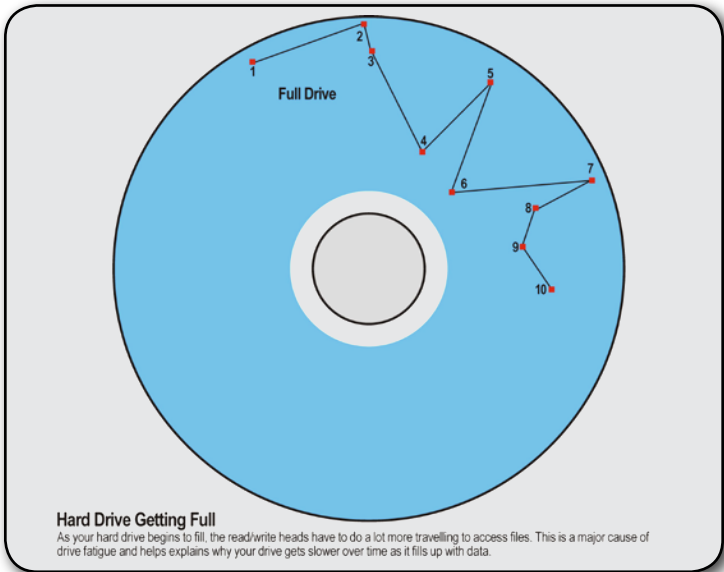
When it comes to hard drives, entropy is alive and well.

If you've had your computer for a while you will notice that, when compared to when it was brand new, it feels a whole lot slower. Also, as your hard drive gets fuller you'll notice the same phenomenon.



This is due to several factors with the main one being that with the hard drive filling up and files being fragmented and scattered all over the drive in no particular order, your drive is performing more like the “average” quoted performance as opposed to when the drive was new and mostly empty and performing better than quoted.

Depending upon where your mostly accessed files are located, it could be performing much less than quoted averages.



UltimateDefrag Does It's Magic

Please refer to the ideal scenario at the beginning of this help file. There are four main factors that contribute to reduced hard drive performance and subsequently four main factors that can be addressed to improve your hard drive performance. These incremental improvements all compound each other so the result is greater than the sum of parts. The improvement is not just an improvement to average performance, instead it's improved by up to 300 to 400% of your drive's quoted average performance!

Most defraggers only deal with “fragmented” files – they quote performance improvements by up to 100%. But all they are referring to is the performance of accessing those fragmented files. Which you may only rarely access anyway! They might add only milliseconds of performance improvement. No consideration is taken into placement of files and other items that need to be considered to improve the performance of your drive.

As a result – a “defragger” only brings your hard drive and fragmented files back up to average quoted performance.

This is where UltimateDefrag does its magic! UltimateDefrag brings your hard drive up to performance that exceeds average drive manufacturer quoted performance by around 300 to 400%. Since there are already performance enhancing systems in hard drive logic and Windows O/S, you will experience performance increases anywhere between 30 and 100%.

Pareto’s Rule – The 80/20 rule

Pareto’s rule pervades our world. 80% of the wealth is distributed amongst 20% of the population. 20% of a company’s customers contribute to 80% of its revenue.

Pareto’s rule also applies to PC file access. 80% of the time you only access 20% of your files. You can extrapolate that to 90% of the time you only access 10% of your files.

UltimateDefrag Applies Pareto’s Rule To Give a Boost To Your Hard Drive’s Performance

If you apply Pareto’s Rule to 100 Gb of data, generally speaking, 80% of the time you only access about 20% of that data, so why not...

1. Place your least accessed data out of the way of the high performing areas of your drive and move it to the slowest part?
2. Get the data that you access the most and place it to where you get the best performance?

These two single most important aspects of file placement are what UltimateDefrag addresses – and it gives you almost no limit of power as to what you can do as far as manipulating what goes where on your hard drive – right down to the individual file level. This is why UltimateDefrag is a revolutionary defragmentation and disk optimization product.

Is UltimateDefrag (and Defragging) Safe?

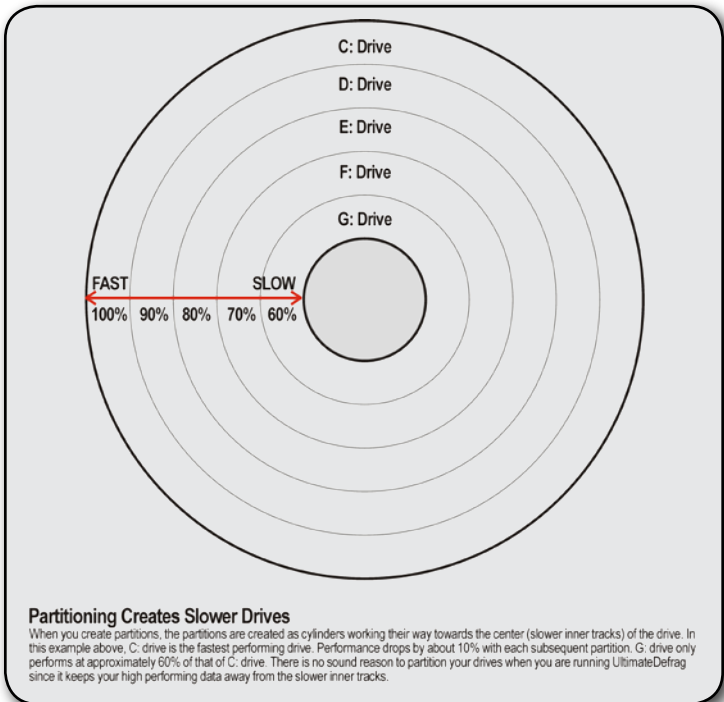
This is one question that a lot of people ask. In the pre-NTFS days there was risk to defragging. If there was a power outage in the midst of a defrag – you could have lost important data. That has all changed now and defragging with NTFS is 100% safe. The actual defragging APIs are APIs created by Microsoft themselves for NTFS and all defraggers use these APIs. In general with these APIs – data is not erased from its original location until it is verified as being correctly written. A product such as UltimateDefrag simply uses those APIs to place files where it wants them to go.



What About Partitioning?

There are many arguments for partitioning. Proponents of partitioning argue that it helps organize your data, keep your hard drive “less” complex etc. They advise to put your operating system on one partition, archive on another, program files on another, data on another and it seems a sound argument.

The main problem with partitioning however is that actually creates drives that are slower and slower as more partitions are created. Partitions are created in cylinders (group of tracks) working their way inwards as more are created. So when you create say 5 partitions of 40 Gb on a 200 Gb drive. The very inner partition – the highest drive letter is actually also created at the inner tracks. So it actually performs twice as slow as the primary partition. Remember our discussion of data transfer above. Each partition is about 10% slower than the previous one. C: drive gives you fastest performance; D would be approximately 10% slower; E: approximately 20% slower; F: 30% slower; and so on. You may be putting the games or product that you want highest performance from on a partition that results in much slower performance of that product.



UltimateDefrag eliminates any requirement for partitioning for the purpose of data organization and totally dispels the requirement for partitioning from a performance point of view.

UltimateDefrag lets you take the hotchpotch of files that are on your system – put the least used and unused files to the inner tracks and keep the most often used files to your outer tracks where you require performance regardless of which files they may be. It's like partitioning on the fly without the "mental" decisions of needing to constantly think about what goes to which drive when you are saving data and installing programs. Simply do it all on the one physical drive. Partitioning overhead is eliminated. Use folders for what they were intended for and then use UltimateDefrag to keep what you need where you need it on your drive. No partitioning required!

Using UltimateDefrag

UltimateDefrag is very simple to use yet very powerful in its defragging and file placement options.

Even though it's more about file placement and relocation (as well as defragging), we will refer to each option as a "Defragging Method". With UltimateDefrag there is a Defragging Method for virtually every computer or hard drive application – from gaming machines to servers, from empty drives to full drives.

UltimateDefrag lets you customize your hard drive layout right down to where individual files are placed on your hard drive relative to the other files.

If you have a specific game or application that you want best performance from – you can move its files to the very outer tracks ("hot spots") of your drive. If you want all your programs to load as fast as possible when you execute them – put all your EXE's and DLL's to the outer tracks. If you want Windows to boot as fast as possible – put all your Windows boot files to the outer tracks. If you want best performance from your digitized photo album browsing – put all these to the outer tracks.

Conversely, if you have Zip files of archived data that you never use – put them to the inner tracks where performance is slowest since you will never need them. All those Windows update files that never get used again – put them to the inner tracks and out of the way. Windows actually only uses about 20% of the files in the Windows folder – the ones that aren't can be placed right out of the way and to the slower performing inner tracks since you never use them. In UltimateDefrag, we call putting these files to the inner tracks "archiving"

You can choose individual files or file types for both high performance and archiving or you can let UltimateDefrag do it automatically based on last usage of those files.