

Improving Windows 2000 Performance with Disk Defragmentation

With more and more companies adopting the Windows 2000 operating system for their enterprise, defragmentation technology is playing an increasingly vital role in maintaining systems at peak performance.

BACK in the early days of Windows NT, the initial consensus was that fragmentation did not exist with the new operating system. Some later stated that if fragmentation actually did exist, then the operating system did not suffer much from it. After some experience with NT in action, however, many system managers and other IT professionals disagreed, adopting third-party defragmentation utilities to keep their files consolidated and to prevent performance degradation. Finally, with the release of Windows 2000, Microsoft settled the debate by including a manual defragmenter inside its flagship enterprise OS.

This article will examine the subject of fragmentation in general, the relative value of the Windows 2000 built-in defragmenter, and how to boost performance across a Windows-based network through regular defragmentation.

FRAGMENTATION BASICS

Fragmentation is a condition whereby the various sections of files are scattered around the disk in non-contiguous sectors. It occurs primarily because of multiple file deletions and write operations, but it also becomes evident when software applications are loaded. File fragmentation significantly reduces disk efficiency by forcing the drive's read/write head to travel longer distances to collect and retrieve data. It affects FAT, NTFS and system files, and is the hidden reason behind gradual degradation of performance over time, extended reboots, delayed backups and some system crashes. It is remedied by a procedure known as defragmentation. In

this process, fragmented files are rewritten contiguously on a hard disk. By doing so, gains of up to 200 percent have been recorded in recent studies (see the sidebar "Research Papers and References on Fragmentation").

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How does a defragmenter work? The defragmentation program checks each file to determine which files need to be defragmented and which files the system should move to another location to provide more contiguous free space. To safely move files while the computer is operating, most defragmenters use special Application Program Interfaces (APIs) that are built in to Windows systems. These APIs make it possible to contiguously copy and place the file, change the pointers to it, delete the original fragmented file and de-allocate its space, always in that sequence.

THE WINDOWS 2000 MANUAL DEFRAGMENTER: GOOD ENOUGH FOR THE ENTERPRISE?

The manual defragmenter that comes with Windows 2000 is simply known as "Disk Defragmenter." It is not unlike the defrag tools built in to Windows 9x (Windows NT never had a built-in defrag utility). Disk Defragmenter supports FAT 16, FAT 32, NTFS, and encrypted files. It also includes an analysis program that allows the user to view the extent of fragmentation on a particular partition, and displays a "before" and "after" shot once defragmentation has occurred.

To access this utility on Windows 2000 Server, perform the following steps:

1. At the Start menu click on Programs, Administrative Tools and Computer Management.
2. Open the Disk Management snap-in (it may take a few moments to load).
3. Click on Disk Defragmenter.
4. A window containing two live buttons — Analyze and Defragment — will appear. Hit Analyze and wait for the Analysis Complete dialog box to appear. This enables you to view a report on your machine's state of fragmentation. You can also view a visual representation of fragmentation that is color-coded according to fragmented files (red), contiguous files (blue), system files (green), and free space (white). If an abundance of red appears on the screen or the white spaces are spread all over the disk, your system needs to be defragmented.
5. Click Defragment and wait for the utility to rearrange your files.

For some individual users, Disk Defragmenter may do an acceptable job of maintaining disk performance levels. However, when used within the enterprise, its many limitations are fully exposed. As a manual defragmenter, it can only run one partition at a time. Therefore, when defragmenting several partitions, the user must run the program several times until each partition is defragmented.

Additionally, Disk Defragmenter contains no scheduling features. To enter the Disk Management snap-in, users must either be logged on as an administrator or as a user in the Administrator's Group. In most organizations, such privileges will be restricted. That means an administrator must go from machine to machine, defragmenting every partition individually. Thus, Disk Defragmenter is largely useless in all but stand-alone settings.

But even for the individual user, there are definite drawbacks. Disk Defragmenter contains no priority settings and cannot be set at low priority when running I/O-intensive applications. Accordingly, it exerts a significant drag on system resources and should only be run during off-peak hours.

The manual Disk Defragmenter's biggest disadvantage, however, is that the special APIs that permit safe online defragmentation do not allow consolidation of system files such as the Paging File, the Hibernation File and the Master File Table (MFT). (**Note:** On

Windows NT 4.0, even file directories cannot be defragmented online. In Windows 2000, however, the APIs have been enhanced to allow the directories to be moved safely online during defragmentation).

How important is MFT fragmentation to performance? Since it is used by NTFS to locate every file on a volume, fragmentation of the MFT impacts the ability of Windows NT to retrieve all files, whether fragmented or not. On badly fragmented files, however,

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there is another factor: An MFT record can only hold a limited number of pointers to file fragments. When a file gets too fragmented, you have to have additional MFT records. For every such file accessed, add to each I/O the overhead of reading several file records from the MFT.

Consequently, with the Windows 2000 Disk Defragmenter there is no way to eliminate MFT fragmentation. Over time, despite regular defragmentation runs, free space becomes more and more restricted and performance steadily diminishes. Eventually, Disk Defragmenter will not run at all, but will hang before a run is completed.

In addition to the MFT, there are other types of system files also subject to the adverse performance impact of fragmentation. The Paging File, for example, is a location on the disk that is used to store over-committed system memory. It acts as a virtual memory file that the OS uses to swap data in and out of RAM as necessary. When the Paging File becomes fragmented, it impacts performance by increasing the time it takes to open and close files, or scroll through pages on screen. As the OS always holds an active Paging File open, it is impossible for the manual Disk Defragmenter to access it.

Similarly, the Hibernation File in Windows 2000 is subject to splintering, which cannot be remedied using the built-in utility.

Several solutions exist for system file fragmentation. One method is to bypass the built-in APIs and defragment the MFT online. However, this method is not recommended, as it has a tendency to result in blue screens and data loss. The best alternative is offline defragmentation during rebooting using a third-party network-capable defragmenter that can remotely handle all machines.

DEFRAGMENTING A WINDOWS 2000 NETWORK

Many defragmenters available on the market will run on a network. On Windows 2000, it is always best to use Windows 2000 Certified products where possible due to the stringency of the certification process. Those currently certified for both Windows 2000 Server and Workstation are Diskeeper from Executive Software (www.execsoft.com) and PerfectDisk from Raxco (www.raxco.com). I have based the rest of this article on using Diskeeper because I am most familiar with this program. However, most defrag programs have similar GUIs and function in a similar fashion.

You can use Microsoft Systems Management Server (SMS) to install the utility on every Windows 9x, NT, 2000, and ME machine. Once loaded, you can look at the state of fragmentation by accessing the utility (it shows up under Programs in the Start menu) and clicking on the Analyze button. Server files in particular are subject to amazingly high amounts of fragmentation due to constant reading, writing and deleting, so you may want to first check the state of your servers. You may want to also analyze a few workstations, especially those where you have received user complaints.

Once you have studied the extent of fragmentation across the network, you may need to take some preparatory steps before beginning a defragmentation run. If many disks are full or almost full, it is best to engage in some "spring cleaning" to free up disk space. Otherwise, it is harder for a defrag utility to function due to there being a lack of free space to work with. If this is the case, either transfer data to another disk or delete files to create more room. Even though many current defragmenters have built-in mechanisms to combat a lack of disk space, it is still smart to

RESEARCH PAPERS AND REFERENCES ON FRAGMENTATION

Here is a collection of key references and facts about fragmentation and Windows 2000:

1. Microsoft Knowledgebase article Q231176 (<http://support.microsoft.com/support/kb/articles/Q231/1/76.ASP>) "Although any user can gain access to the Disk Defragmenter console, the ability to analyze or defragment a volume requires administrator privileges."
2. Microsoft Knowledgebase article Q221176 (<http://support.microsoft.com/support/kb/articles/Q227/4/63.ASP>) "The version included with Windows 2000 provides limited functionality in maintaining disk performance by defragmenting volumes that use the FAT, FAT32, or NTFS file system. It has the following limitations: can defragment only local volumes; can defragment only one volume at a time; cannot defragment one volume while scanning another, cannot be scripted; cannot be scheduled; can run only one Microsoft Management Console (MMC) snap-in at a time."
3. National Software Testing Labs comparison testing: Diskeeper vs. the Windows 2000 Disk Defragmenter (www.nstl.com/Content/content.htm). This report finds the third-party utility three to five times faster and far more thorough than the built-in tool.
4. NSTL Report: System Performance and File Fragmentation in Windows NT (www.nstl.com/Content/content.htm). This white paper details such things as how fragmentation affects NTFS and FAT files; the extent of performance degradation that occurs; how NTFS works; how fragmentation impacts system files, Software Raid, Volume Sets, servers and workstations; how disk caching mitigates but does not eliminate these problems; what optimization is, how it differs from standard defragmentation techniques and why it is not a solution for the enterprise.
5. Microsoft TechNet article: Maintaining Windows 2000 Peak Performance Through Defragmentation (www.microsoft.com/technet/treeview/default.asp?url=/TechNet/prodtechnol/windows2000serv/maintain/optimize/w2kexec.asp). This article outlines the relative strengths and weaknesses of the Windows 2000 Disk Defragmenter from the Microsoft perspective. "Disk Defragmenter cannot defragment the MFT once it becomes fragmented. But, because the MFT is constantly being used to access all other files on the disk, it also gradually becomes fragmented, resulting in longer disk access times and diminished performance."
6. White Paper by International Data Corp (IDC): Disk Defragmentation for Windows NT/2000: Hidden Gold for the Enterprise (www.tradespeak.com/docdetails.asp?docid=2390). IDC researchers studied the performance implications of fragmentation, its associated costs and investigated defragmentation as a solution to unnecessary or premature hardware upgrades. It also covers the hidden costs of attempting to use Microsoft Disk Defragmenter in the enterprise as opposed to a third-party tool. "Defragmenters are rising sharply in popularity as people realize they can often deliver comparable performance gains to traditional hardware upgrades at a fraction of the cost," says Paul Mason, IDC system management software analyst. "This might be related to the apparent diminishing returns from recent CPU releases."
7. Defragmentation Performance Testing by NSTL (www.execsoft.com/whats-new/Win2K-Final-nov99.PDF and www.execsoft.com/whats-new/NSTL-final-june99.pdf). These tests show gains of between 20 and 200 percent when comparing fragmented to defragmented systems running Windows NT and Windows 2000.

remove unnecessary data as this makes it much easier to maintain the system at peak performance.

Next, set up a defrag schedule using "Set It and Forget It" scheduling which can run automatically in the background, either after hours or according to a preset schedule. Over a network, you can set it up to run on all disk volumes or on one or more at a time.

Access the "Set It and Forget It" feature via "Network Scheduler" on the toolbar. Specify the times or days when the utility should or should not run. Note that overall defragmentation schedules should be set first for the entire network or for groups of drives before taking care of exceptions that apply to specific computers, workgroups and domains.

The most recent version of Diskeeper (Diskeeper 6.0 Second Edition) includes a new "Smart Scheduling" feature, enabling you to dynamically configure the defrag schedule based on the condition of disks. The program feature notes fragmentation levels and adjusts run-time frequency within a range of every hour to once per week. This saves administrators from having to figure out the right schedule based on a series of variables such as disk size, level of activity, and the size and types of files used. As a rule of thumb for those without "Smart Scheduling," if an analysis shows that fewer than 50 files per run were moved, defragmentation is working optimally. If more than 50 files are moved or the number is increasing, schedule defragmentation more regularly. Remember that busy servers will need to be scheduled far more frequently than workstations.

Priority settings can also be adjusted. "Highest" gets the job done fast but at the expense of system overhead. "Lowest" exerts no observable influence on system resources. Runs during emergencies or off-peak hours should be set high, while those during business hours should choose the lowest priority.

DEFRAGMENTING SYSTEM FILES

While regular defragmentation takes care of many fragmentation problems, it does not deal with system file fragmentation. This is due to an important Windows safety feature that is built in to most defragmenters — files must be closed before an application can move them. This guards the files against corruption, blue screens, and system crashes or data loss. Once the operating system starts up, system files are always open and pieces of them are cached.

System files, therefore, are addressed safely during boot-time defragmentation. Boot-time fragmentation used to be time-consuming, a source of contention among system administrators who were sometimes forced to come in over weekends or delay system file fragmentation until the next scheduled maintenance period. However, those using the latest version have the advantage of a very rapid boot time defragmentation tool that takes very little time to complete. Boot-time mode is accessed via the "Action" button at the top of GUI. Put a check next to MFT and Paging File before setting the program to run during the next reboot.

NT USERS AND DIRECTORY FRAGMENTATION

A final note for those running Windows NT: It is important to also check the "Directories" box when running defragmentation in boot time mode. Although the Windows 2000 APIs were updated to allow safe online defragmentation of directories, this does not apply to NT. As directories are typically strewn throughout the disk when applications are loaded on Windows-based systems, this increases the time it takes to locate files, breaks up free space availability, and presents a barrier to effective defragmentation. Boot-time directory consolidation groups directories into a single location and makes larger portions of the disk available for defragmenting.

PEAK PERFORMANCE

Fragmentation, then, is a serious drain on performance on any Windows-based system. It affects both regular files and system files, and all must be addressed in order to improve speed and responsiveness. That is why you should use only reliable networkable defragmenters. Thoroughly defragmenting all user files on every machine across the network, and then consolidating system files in boot time mode can rapidly return sluggish systems to peak performance. 

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Seven Tips for Defragmentation Software Evaluators

By Jim Williams, Product Manager, Raxco Software, Inc.

The challenge of evaluating disk defragmentation software is what to look for and how to measure the results. Here are a few tips to help you through the evaluation process:

1. If you are looking at several products, you need to have a sector-by-sector imaging tool to clone the disk being defragmented. This lets you test in identical environments.
2. Know how bad the problem is. Most defragmentation products provide disk statistics. Run these before you defragment the disk.
3. Defragmentation software is only as good as your worst disk. Try it out on a disk that is very fragmented and/or very full.
4. After the software runs make sure all your data files are defragmented. Check those statistics again!
5. Make sure the free space is consolidated. Fragmented free space accelerates future re-fragmentation.
6. Is the time required to completely defragment the drive acceptable?
7. Does the scheduling component offer sufficient customization options like multiple schedule support, view and cancel existing schedules, variable priority settings, and administering from servers or workstations?

If you take your time and evaluate all the factors involved in this complex process you can improve the I/O performance on all your machines by 40 to 60 percent, proactively address a system management problem, improve end-user productivity, and give yourself some peace of mind.

Raxco Software is the developer of PerfectDisk 2000, the leading disk defragger and optimizer for Windows 95/98/Me/NT/2000/XP. Raxco Software can be reached at www.raxco.com/ or 800-546-9728.