Identifying Common Reliability/Stability Problems Caused by File Fragmentation

Introduction

An Overview of the Problem

Reliability and Stability Issues Traceable to Fragmentation

    A. FRAGMENTATION AND BOOT TIME ISSUES
    B. SLOW BACK UP TIMES AND ABORTED BACKUP
    C. FILE CORRUPTION AND DATA LOSS
    D. CRASHES AND SYSTEM HANGS
    E. ERRORS IN PROGRAMS
    F. RAM USE AND CACHE PROBLEMS
    G. HARD DRIVE FAILURES

Contiguous Files = Greater Uptime

Executive® Software

Introduction

Over the years, numerous manufacturers, third party analysts and labs have reported on the effects of file fragmentation on system speed and performance. Defragmentation has also gained recognition for its critical role in addressing issues of system reliability and improved uptime, particularly since Microsoft's decision to include a defrag utility in the Windows 2000 and XP operating systems (did not exist in the NT OS).

In this white paper, we explain some of the most common reliability and downtime phenomena associated with fragmentation, and the technical reasons behind them. This includes a discussion of each of the most common occurrences that have been documented by our labs and customers, as well as others, in recent years.

At the end of this report, there is a short bibliography providing links to each reference paper or Knowledge Base article quoted.

An Overview of the Problem

Having all program and data files stored in contiguous form on the hard drive is a key factor in keeping a system stable and performing at peak efficiency. Though unavoidable, the moment a file is broken into pieces and scattered across a drive, it opens the door to a host of stability/reliability issues. Having just a few key files fragmented can lead to crashes, conflicts and errors.

If fragmentation is not addressed routinely, or if there is a failure to understand its role in helping to cause these problems, IT staff experience a greater workload during attempts to troubleshoot and identify the source of the problems. This frequently leads to such common and often unnecessary actions as reinstalling software, re-imaging of hard drives, expensive replacement of hardware, as well as overwork at the Help Desk. By being forced to work reactively on these problems, IT budgets rise and user productivity is adversely affected due to unacceptable levels of downtime.

Reliability and Stability Issues Traceable to Fragmentation

The most common problems caused by file fragmentation are:

a)   Slow boot times and computers that won't boot up
b)   Slow back up times and aborted backup
c)   File corruption and data loss
d)   Crashes and system hangs/freezes
e)   Errors in programs
f)   RAM use and cache problems
g)   Hard drive failures

A. FRAGMENTATION AND BOOT TIME ISSUES

Fragmentation is a major factor in slow boot times. Many cases are on record of machines taking twenty or thirty minutes to reboot that previously took only a minute or two. This situation can deteriorate to the point where a machine will take hours or not boot up at all. Once thought to affect only Windows 9X and NT, this is also seen on fragmented Windows 2000 and Windows XP systems.

According to Microsoft's Knowledge Base Q228734, "This issue can occur when the NTFS bootsector code contained in logical sector zero of an NTFS volume is unable to locate and load NTLDR into memory due to the Master File Table (MFT) being highly fragmented."

Why does this occur? The NTFS bootsector code locates and loads NTLDR into memory. This involves reading the volume's MFT to obtain the root directory. When the MFT is highly fragmented, pieces of the MFT and other metadata that must be read in order to locate the NTLDR may fall outside the areas of the disk that can be read by the BIOS INT 13 routine. Thus the system fails to boot up.

Further Microsoft Knowledge Base (KB) articles outline additional manifestations of similar problems created by fragmentation. Microsoft KB article Q155892 covers the fact that the allocation for NTLDR's $DATA attribute has become so fragmented that the whole $DATA attribute is no longer in the base FRS (file record segment). Microsoft KB article Q176968 explains another manifestation – that when you attempt to boot with an NTFS system partition, the computer may hang after the power-on self-test (POST) and you may receive an error message stating that a kernel file is missing. This can occur if the NTFS disk structure data contained in the MFT is fragmented (as described above), actually preventing boot up.

Previously it was thought that this reliability problem had been eradicated in Windows 2000 and XP. An updated bootsector code and NTLDR was made available for Windows 2000 with the intention of removing its susceptibility to this situation. Similarly, Windows XP includes "prefetching" of boot files and automatically defragments the boot sector to accelerate start up. However, neither has completely eliminated the problem of systems failing to reboot periodically, requiring the necessity to keep these files routinely defragmented.

B. SLOW BACK UP TIMES AND ABORTED BACKUP

The window of opportunity to conduct system backups is shrinking. While IT departments used to have twelve or more hours available for backup and maintenance tasks, or even all weekend, with more businesses operating 24 / 7, they are now expected to perform such actions in a significantly shorter time period. At the same time, the amount of data to be backed up is growing exponentially.

This combination of circumstances leads to two problems. System administrators report that lengthy backups mean they don't have time for other routine maintenance actions. Alternatively, some backups have to be aborted as they take up too much time and threaten to encroach on the working day. This increases the risk of data loss.

Fragmentation multiplies the amount of time needed to get a backup done. If all files exist in a contiguous state, backup occurs relatively swiftly. Instead, if the files are fragmented, the head has to locate and gather together numerous fragments before they can be consolidated into one piece for back up. It is common for IT departments to report their back up times shrinking, often by several hours per night, after instituting routine defragmentation of all servers and workstations. By consolidating files back into single contiguous pieces before backing them up, a much shorter backup window is required.

"To maintain optimal system performance, companies need to schedule disk defragmentation on a regular basis for all their servers and workstation," said Steve Widen, analyst at International Data Corp (IDC). "Otherwise files can take 10 to 15 times longer to access, boot time can be tripled and nightly backups can take hours longer."

C. FILE CORRUPTION AND DATA LOSS

File corruption and data loss are both immediately traceable to fragmentation. In recent tests on Windows 2000 and Windows XP, a specially designed utility was utilized to fragment an NTFS volume. Even though the test drive was only 40 percent full, the files themselves were fragmented resulting in the automatic creation of additional MFT records. When attempting to move one contiguous 72 MB file onto that disk, the result was the corruption of everything on the disk.

Why would this occur? The presence of excessive file fragments on a disk makes it more difficult for the operating system to function efficiently. When a file is added, large-scale data corruption can result.

This message, for example, is not uncommon:

> Windows NT could not start because the following file is missing or corrupt:
> <Winnt_root>\System32\Ntoskrnl.exe. Please re-install a copy of the above file.

This form of corruption/data loss led to the inability to boot up. Why? According to Microsoft KB article Q224526 some key files needed for booting the operating system were situated beyond cylinder 1023 on the volume. But, given the CHS (cylinder/head/sector) setup on the machine, the boot sequence could only see the first 7.68 GB of the volume during the initial boot phase. The needed system file was situated beyond where the INT 13 BIOS interface could find it.

Deleting the first file and replacing it meant that it fell within the first 7.68 GB. Regular defragmentation would then keep system files from becoming too spread around the volume, preventing this situation from recurring.

D. CRASHES AND SYSTEM HANGS

There are many documented cases of errors and crashes on Windows caused by fragmentation. These types of errors include but are not limited to system hangs, time outs, failure to load, failure to save data and blue screens.

For instance, a crash takes place when attempting to run CHKDSK on a highly fragmented drive. According to Microsoft KB article Q160451, "When you attempt to run Chkdsk/f on a drive that is heavily fragmented or that contains bad clusters, Windows NT version 4.0 may halt with a kernel mode trap screen STOP 0x00000024 in Ntfs.sys."

Another Microsoft KB article (Q165456) highlights the reason for a system freezing. "The NTFS file system driver is attempting to perform I/O to a fragmented file and does not correctly clear a required field, causing either a STOP 0xA or a deadlock condition, which causes the process to stop responding."

This means that fragmentation can slow down I/O to the point where programs and processes cease to function entirely. With files scattered throughout the disk in many pieces, they are unavailable to the system when needed and a crash takes place.

E. ERRORS IN PROGRAMS

Errors also occur when applications and/or associated databases are substantially fragmented. As in the previous section, this is related to the sheer size of such applications and the time it takes to physically gather up all of the pieces in order to load properly. In some cases, fragmentation slows down the loading of applications, sometimes significantly. In other cases, the application will time out or freeze.

On Microsoft Word 2000, for example, an error message may appear stating: "There are too many edits in this document. This operation will be incomplete. Save your work." (Microsoft KB article Q224029). This is caused by insufficient disk space on the hard disk containing the Windows Temp folder as well as fragmented or cross-linked files.

Additionally, Windows 2000 can sometimes hang during start up. This is related to the System hive file becoming too large due to fragmentation. According to Microsoft KB article Q265509, "The System hive file is usually the biggest file that is loaded and is likely to be fragmented because it is modified often. If the System hive file is too fragmented, it is not loaded from an NTFS volume, and the computer hangs."

After start up, Windows 2000 can also hang due to the server service being unable to keep up with the demand for network work items that are queued by the network layer of the I/O stream. Due to fragmentation, the server service cannot process the requested network I/O items to the hard disk quickly without running out of resources.

CD Writers and other media devices also experience problems caused by fragmentation. Why? Such devices require data to be supplied sequentially in a steady stream. If the associated files are fragmented, this data stream is interrupted as the system struggles to gather together various file fragments. This interferes with the quality of video playback and leads to CD writes aborting. Regular defragmentation heightens the reliability of such devices.

Per Microsoft KB article Q306524, CD recording may fail intermittently. The document lays out several ways to resolve this issue; however, the primary step is to defragment the hard disk containing the data destined for the CD.

F. RAM USE AND CACHE PROBLEMS

Files often become so fragmented that they take a long time to be read into cache. As well as delays, this can lead to system hangs. Similarly, a fragmented paging file creates system stability challenges. "Out of virtual memory" error messages are prevalent, for example, on Primary Domain Controllers and data loss results.

According to Microsoft KB article Q215859, "The pagefile.sys file is either not large enough or is severely fragmented. This may also cause users to experience problems when they attempt to change their password or gain access to the network."

As covered earlier, such memory issues are rooted in the fact that excessive overhead is required to compile files that are scattered around a disk in many pieces. By keeping files consolidated, these memory problems are prevented.

G. HARD DRIVE FAILURES

Fragmentation hastens the onset of hard drive failure by increasing the amount of disk head movement. Consequently, regular defragmentation extends drive longevity. The reason for this is simple. When a defragmentation program is run it attempts to move files but can uncover bad areas on disk and proactively directs the user to run CHKDSK. Without the running of a defragmentation utility, these bad sectors may not receive the needed attention they deserve. Over time, the amount of bad sectors snowballs, leading to the corruption of the entire drive.

Further, a study by IDC highlighted the fact that regular defragmentation enhances performance and lengthens the lifespan of a machine. "It can be considered that defragmentation software can extend the life of a typical workstation," said Widen. "IDC estimates that enterprises can add up to two additional years of life to the normal three-year usable life of workstations."

Much of IDC's premise is based on the fact that a contiguous file takes the head one I/O to read or write. If a file is fragmented into one hundred pieces, the head has to move one hundred times to access it. If this is occurring every time a file is read or written to disk, the head and associated moving parts are effectively performing 100 times more work than one that is fragment free. Result: more wear and tear on the disk and an earlier failure.

100 pieces per file may be a conservative estimate, however. A study by American Business Research conducted on 100 companies revealed that 56 percent of NT/Windows 2000 workstations had files fragmented into between 1050 and 8162 pieces. One in four reported finding files with as many as 10,000 to 51,222 fragments. For servers, an even greater degree of fragmentation exists. Half of the respondents discovered 2000 to 10,000 fragments and another 33 percent had files fragmented into 10,333 to 95,000 pieces.

Contiguous Files = Greater Uptime

Conclusive evidence exists on the issue of file fragmentation being a primary factor in the most common system stability/reliability problems that companies contend with daily. To greatly lessen these problems, regularly defragmenting every server and workstation should be considered high-level, proactive system maintenance.

To do this, easily and cost-effectively, automation is key. When site-wide defragmentation is fully automated, it represents one of the simplest, yet most effective, system maintenance activities to protect and improve the stability and uptime of an entire network. It's just not possible to manually keep up with the defragmentation demands of more than a handful of machines.

By using automated defragmentation on a network to minimize Help Desk calls, troubleshooting and other reactive system maintenance demands, there are benefits to a System Administrator that go beyond system stability. There is the additional gain of saving significant time and manpower, allowing IT staff to do more important things, delivering a hard dollar savings to a company.

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