GIS'90 Symposium

Vancouver, British Columbia
March 1990

PC System Configurations and Operations for GIS and Image Analysis

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Abstract

There can be difficulties associated with the installation, operation, and maintenance of a GIS and/or image analysis system on an IBM/MS-DOS PC-based workstation. The increasing requirement for large data storage has conflicted with the high memory requirements of the GIS and image analysis software programs. The economic and practical necessities of operating complementary applications such as statistical packages, spreadsheets, data bases and word processing have also posed operating constraints. Optimal computer performance solutions to be implemented include device driver management, overcoming the DOS 640 Kb conventional memory limitation, managing shadow and extended memory, optimizing disk buffers and caching utilities, writing batch files, and using TSR programs. Though these solutions are software-based, an intimate understanding of the capabilities and limitations of the computer hardware platform is required. Increasing difficulties are being reported on available memory, with respect to the relation between increasingly larger logical hard disk partition size and the corresponding increase in memory required by DOS buffers. The suitability of the 80386 over the 80286 for production applications is reviewed, since it offers several advantages of larger memory addressing, faster clock speeds, multitasking, downward compatibility and a larger software base. Recommendations are given for hard disk management, file management assisted by utilities, minimizing file fragmentation, and the necessity for routine backups.

The mention of any trade names does not imply endorsement by the authors or their institutions nor does it constitute criticism of similar products not mentioned.

Introduction

The installation and operation of a GIS and/or image analysis system on a personal computer (PC) may result in difficulties associated with available memory and processing speed. Achieving an optimal configuration is becoming increasingly difficult, as these software packages increase in size while constrained within the Disk Operating System (DOS) limitation of 640 kilobytes (Kb) conventional memory. Several GIS systems are now requiring upwards of 580 Kb and in some cases, extended memory to function reliably. This results in only 60 Kb of conventional memory being available for the DOS, device drivers, disk buffers, and terminate and stay resident (TSR) programs.

Depending on partition size, large disk drives (i.e., 130 megabytes (Mb) and larger) will also influence the size and number of individual disk buffers needed and thus the amount of conventional memory required (TYDAC 1989).

Economic and practical necessity demands that a computer system be adequately flexible to support more than one computer application. Complementary applications such as statistical packages, spreadsheets, data base management systems and word processors, have specific memory and configuration requirements which may conflict with the GIS system.

Networking to communicate and exchange information with another computer system is also becoming increasingly important. Connection via direct line, ethernet, or modem with mainframes, minicomputers (e.g., Digital VAX) and other PCs each have unique requirements for device drivers, interface cards, and operating memory.

How can a multiple platform operation be achieved on a PC, given the limitations posed by the operating system? This paper will describe optimal computer performance solutions with respect to managing computer memory, device drivers, memory resident programs, and disk buffers and caching utilities. Complementary to achieving an optimal configuration, however, is maintaining its performance. Procedures and recommendations will be described on how to minimize file fragmentation, implement file management procedures, and perform regular backups.

Why a 386?

With the availability of inexpensive fast 20 megahertz (MHz) 80286 AT computers, the question may arise as to why select a 80386 over a 80286 computer for GIS and/or remote sensing applications? There are several technical factors and cost considerations that govern why an 80386, rather than an 80286, would be preferable for PC-based GIS installations.

The 80386 is a true 32-bit processor compared to the 16-bit processor of the 80286 (Petzold 1986), and is upwardly compatible with its ancestors, 8086, 8088, 80186, 80188 and 80286. This means that virtually all software written for these ancestor microprocessors will run on the 80386 (Petzold 1986), although the converse is not true. The 80386 design process, unlike the 80286, had input from major developers and had OS/2 and DOS in mind (Machrone 1989).

At power-up, the 80386 and 80286 microprocessors function in what Intel calls real mode (Petzold 1986, Duncan 1989). In real mode, the 80386 and the 80286 central processing units (CPUs) generate 20-bit memory addresses. The maximum amount of memory that can be addressed in real mode is therefore 2^{20} bytes or 1 Megabyte (Mb) (Petzold 1986). Real mode enables the 80386 and 80286 to retain their upward compatibility.

The 80386 and 80286 also function in what Intel calls protected mode (Petzold 1986, Duncan 1989). In protected mode, the 80386 and 80286 are no longer upwardly compatible with their ancestors. In protected mode, the 80386 processor has access to 2^{32} bytes or 4 gigabytes[1] (Gb) of addressable memory because the 80386 chip has 32 address lines. Similarly, the 80286 has 24 address lines and thus has access to 2^{24} bytes or 16 Mb of addressable memory. The 80386, consequently, has considerably more addressable memory[2] than the 80286. Protected mode can also access virtual memory. Virtual memory allows the use of data stored on a hard disk as though it were stored in memory. The 80386 can access 64 terabytes[3] (Tb) of virtual memory address space compared to the 1 gigabyte (Gb) of virtual memory addresses that the 80286 can access. To switch between real and protected modes is far simpler on the 80386 than on the 80286 (Machrone 1989).

One major advantage of the 80386 over the 80286 is the available memory management capability (Nimersheim 1989). The 80386 microprocessor supports virtual 8086 sessions, which means the 80386 can imitate a one megabyte addressing environment which appears to be an 8086 computer to existing programs (Petzold 1986). More significantly, several 8086 environments can be maintained concurrently and are only dependent on available memory (Nimersheim 1989).

The recent availability of the 16 Mhz and 20 Mhz 80386/SX-based computers have complicated the selection between them and 80386 or 80286-based computers. Internally the 80386/SX and the 80386 microprocessors are identical (Drude 1989). The 80386/SX is therefore software-compatible with the 80386 (Dickson 1989). There are however, a few differences between these two microprocessors. The 80386 microprocessor contains 32 data lines and 32 address lines. Similar to the 80286, the 80386/SX microprocessor contains 16 data lines and 24 address lines (Drude 1989). The maximum addressable memory the 80386/SX can access is 16 Mb. The 80386, because of its 32-bit data bus, is inherently faster than the 80386/SX and the 80286 (Drude 1989). The advantage of the 80386/SX over the 80386 is cost. The 80386/SX is cost comparable to the 80286 and is therefore less expensive than the 80386.

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[1] 1gigabyte = 10^9 bytes

[2] $2^{32}/2^{24} = 2^8 = 256$ times as much addressable memory

[3] 1terabyte = 10^{12} bytes

DOS operates only in real mode on 80386 and 80286 microprocessor-based computers since it was strictly designed for the 8086/8088 microprocessor. This explains why DOS is unable to employ technological advances such as 32-bit registers, maximum segment size of 4 Gb and support for up to 64 Tb of virtual memory (Davis and Rosch 1989). The inability of DOS to run in protected mode also results in a 80386 and 80286 with similar clock speeds to achieve roughly the same performance. There is, however, DOS-based software already written to take advantage of the features of the 80386 (i.e., Windows386, DESQview386, etc.) and more is continually being developed. These software packages provide access to more than 1 Mb of memory and multitasking capabilities to DOS (Rosch 1989).

Optimal Performance
Among the major components of achieving optimal performance from a PC-based GIS or image analysis system include managing device drivers, TSR programs, memory, buffers, disk caches and batch files. The purpose of this section is to describe what they are and how they can be managed and configured for GIS or image analysis operations.

Device Drivers
When DOS was developed, the designers published specifications so hardware manufacturers could develop their own software modules, called device drivers, that would access the operating system (Somerson 1988). Device drivers are program modules which provide a communications interface between DOS and various peripheral devices. In this way, DOS wouldn't need to be upgraded each time new hardware devices were developed.

DOS generally installs device drivers from the file CONFIG.SYS at power-up. Device drivers are loaded into conventional memory directly above the operating system's file-control blocks and disk buffers. Device drivers become permanently resident in memory and act as extensions of the operating system (Rizzo 1989). Conventional memory available for the GIS and/or image analysis system is therefore reduced by each device driver added. Not all device drivers are needed concurrently . For optimal performance device drivers that are not needed should be removed from the CONFIG.SYS file. If a tape drive is a peripheral and is only used for backups, for example, then the tape drive device driver should only be installed when backups are to be performed.

Guidelines for Managing Device Drivers
There are two methods of managing device drivers from the CONFIG.SYS file. The most common method is to have multiple CONFIG.SYS files with different names or extensions with unique combinations of device drivers for particular applications. The required configuration is then copied over the CONFIG.SYS file and, by re-booting, the new control file takes effect. This method is cumbersome, especially if there are many CONFIG.SYS files. A more efficient method is to use a boot interrupt like CONFIG.CTL[4] which facilitates the user selection of device drivers to be installed by CONFIG.SYS at boot-up. This kind of boot interrupt is especially useful for trouble-shooting and determining an optimal configuration when new peripherals or software programs have been installed. It also eliminates the requirement for multiple CONFIG.SYS files. The use of a boot interrupt is particularly beneficial in multiple platform operations and in PCs that support both GIS and image analysis systems.

TSR Programs
To appease demands for multitasking, the first developers of DOS 1.1 introduced a terminate-and-stay-resident function call. A few background printing utilities that utilized this function call were included with DOS 1.1. These utilities were useful but not interactive. The perceived benefits of the TSR function call resulted in availability of several RAM-resident utilities such as Sidekick. TSR utilities are typically installed into conventional memory after DOS during the execution of the AUTOEXEC.BAT file, and remain in memory while application programs are being executed (Raskin et al 1986). Interactive TSRs install keyboard interrupt handlers that look for special key combinations called a 'hot key'. When the appropriate key combination has been entered, the current process image is saved and control is passed to the TSR program. When the TSR is finished,the process image is restored and the original program continues from the point of interruption.

TSRs can be very useful but there are inherent problems associated with their use. DOS was not designed to be a multitasking system. RAM-resident programs therefore exist in an environment that was never meant to support them. If two RAM-resident programs use the same hot key sequence (the most common problem), collisions will occur when the two programs attempt to write into the same place in memory. Memory limitations can cause difficulty as well. If several TSRs have been installed, GIS and/or remote sensing programs which are memory intensive will have difficulty operating to their full capabilities.

Guidelines for Employing TSRs
For optimal computer performance, it is highly recommended to install as few TSRs as possible. TSRs that can be removed from memory without re-booting should be preferred to those that cannot. Most TSR programs cannot remove themselves from memory and the computer has to be re-booted to remove them. Use TSRs that have definable hot keys. Until multitasking in the DOS environment becomes an easily implemented reality, use only the TSRs that are essential for the specific program or application that requires them. One approach is to install TSRs by executing batch files rather than placing them all in the AUTOEXEC.BAT file.

Buffers And Disk Caching
A buffer is a portion of RAM, set aside by DOS, that contains data recently read from or written to a disk (Somerson

[4]A special device driver that allows you to modify config.sys configuration dynamically. It is public domain software (Mefford 1989).

1988). The number of buffers specified can affect the speed at which an application program reads and writes from a disk. Each additional buffer, however, demands an additional 512 bytes of RAM. This reduces the amount of RAM available to the application. Every PC configuration has a unique optimal amount of buffers. Choosing more or less than the optimal number of buffers can degrade performance (Mendelson 1989).

There is a relation between the amount of RAM for each DOS buffer and the logical partition size on the hard disk. The larger the partition, the larger the amount of RAM for each buffer (TYDAC 1989). This has become an important concern with the increasing use of larger physical disk drives of 130-300+ Mb, in PC-based GIS and image analysis systems, unless the partition size is limited to the nominal DOS 3.3 limit of 32 Mb. Large disk partitions although convenient, are therefore not necessarily optimal from a computer performance perspective.

Buffers are a primitive attempt by DOS at disk caching. A disk cache can reduce hard disk access time by a factor of 10 and floppy disk access time by a factor of 50 (Mendelson 1989). Disk caches, like buffers, reduce access time by producing data from RAM rather than from a hard drive.

Managing Buffers for GIS and Image Analysis Systems
DOS 4.01 permits DOS buffers to operate in expanded memory. Memory managers such as QEMM will provide utilities such as BUFFERS.COM and LOADHI.COM that allow the moving of DOS buffers into available memory in the 384 Kb shadow RAM. Alternatively, the amount of buffers can be reduced to a very small number and a disk cache could be installed into extended or expanded memory. This will free more of the 640 Kb conventional memory for application programs.

Batch Files
A batch file is an ASCII format file with the .BAT extension that contains a list of DOS commands and application programs to be executed. When instructed, DOS executes each line in the file as if it was typed from the keyboard. Batch files can be invoked by typing the batch file's name. The most familiar batch file is AUTOEXEC.BAT which is executed whenever the system is re-booted. Batch files are basically rudimentary computer programs (Somerson 1988) that can perform loops, conditional statements and allow manipulation of variables.

Guidelines for Employing Batch Files
For optimal computer performance, batch files should be written for long, error-prone repetitive tasks. Batch files could be utilized, for example, to start a GIS or an image analysis program. This would allow the computer operator to use the GIS and/or image analysis program and install environment variables through the execution of a single command. In this way the end user's interaction with the operating system is minimal and thus less error prone.

What Is Computer Memory?
There are two kinds of memory, Random Access Memory (RAM) and Read Only Memory (ROM). The purpose of this section is to describe the differences between them and managing memory for GIS or image analysis operations.

ROM
ROM is usually contained in one or more chips and contains essential, permanently stored, software routines that help the system function. Included among these software routines are copyright information, tests, tables and error messages. ROM is non-volatile (permanent) memory, whereas RAM is volatile (temporary) memory whose contents vanish every time the computer is re-booted.

RAM
Computer RAM is usually comprised of three areas; conventional, expanded and/or extended memory. Conventional memory is the 1 Mb of memory that can be accessed by all IBM personal computers (Figure 1). IBM originally divided this available megabyte into 16 blocks each 64 Kb long. Of these 16 blocks, 6 blocks or 384 Kb were reserved for ROM, displays and Basic Input/Output Systems (BIOS) extension programs. This left 10 blocks or 640 Kb for DOS and its applications. The amount of 640 Kb memory that DOS requires increases with every new release. MS-DOS 4.01, for example, requires 40 Kb more RAM than MS-DOS 3.3 (Magid 1989).

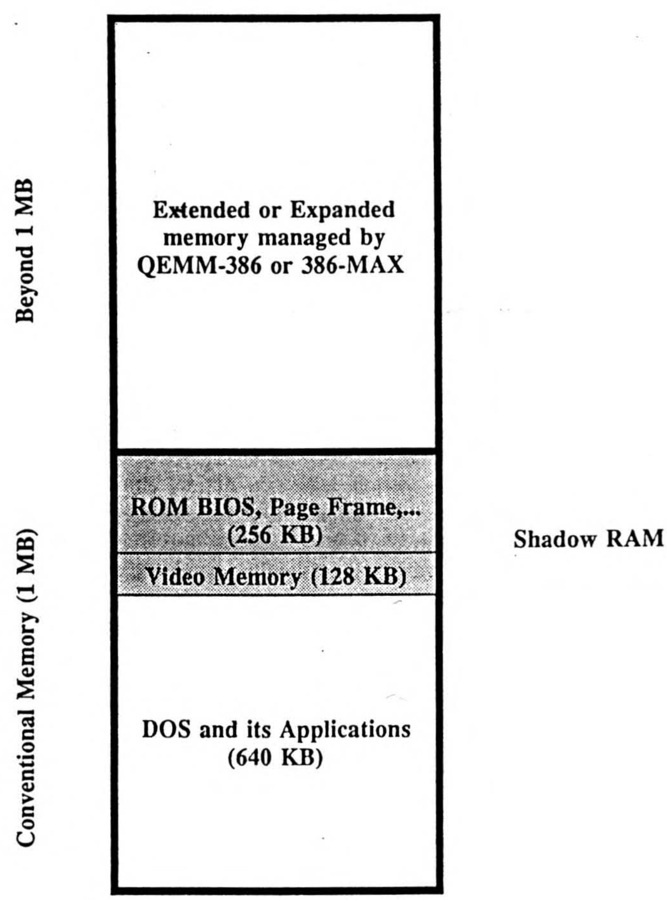

Figure 1. Typical Memory Allocation on a DOS-Based Personal Computer

Extended memory is the memory above 1 Mb and can only be accessed by 80286 and 80386 personal computers when running in protected mode. Current versions of DOS and most application programs cannot use extended memory because of significant differences between real and protected mode. A few vendors have written applications that take advantage of extended memory such as virtual drives, disk caches and memory managers. Virtual drives are sometimes called RAM drives and are usually installed through the VDISK.SYS or RAMDRIVE.SYS device drivers. Memory managers allow user definable conversion of extended memory to expanded memory.

Expanded memory refers to bank-switched memory, whose specification was developed by a consortium made up of Lotus Development Corporation, Intel Corporation and Microsoft Corporation. They named this specification LIM (LOTUS/INTEL/MICROSOFT) and the latest version is LIM V4.0 (Somerson 1988). Expanded memory can be mapped as pages into conventional memory. Data is mapped to extended memory through a 64 Kb segment near the top of the PCs addressable megabyte. This 64 Kb is used as a narrow doorway into expanded memory and is called a page frame. The page frame contains four smaller 16 Kb sections called windows. When an application that supports expanded memory needs more RAM, it could swap some information into expanded memory, and retrieve it later, by shuttling it back and forth through one of these windows. There is an increasing availability of programs and utilities that will operate either faster or more reliably if expanded memory is available. Examples of programs and utilities that will utilize expanded memory include LOTUS 1-2-3, PC Tools Deluxe and DOS buffers version 4.01.

Shadow RAM

If a computer has a shadowing option enabled, re-booting the PC causes pertinent ROM to be copied into the memory below 1 Mb or low RAM. The PC can then access a copy of these routines much faster than from the original contained on the ROM chip. 80386 and 80286 microprocessor-based computers can also use special software called memory managers that map ROM into the 384 Kb of RAM between 640 Kb and 1 Mb. In this way, shadowing is facilitated through software rather than hardware. Memory managers can also map extended memory into all the free areas of the 384 Kb range above the base 640 Kb. Making this memory available to DOS-based real mode programs. In effect, this memory becomes available for loading device drivers and TSR programs outside of the 640 Kb conventional memory.

Managing Memory for GIS and Image Analysis Systems

Most of the PC-based GIS systems have now reached a level of sophistication and capabilities that requires a large portion of the 640 Kb conventional memory to operate reliably. From a survey of 5 GIS and image analysis systems, the conventional memory requirements ranged from 540-580 Kb. The largest user of extended memory required upwards of 2.5 Mb of extended memory as a virtual drive for video display buffers. One system required 1 Mb of extended memory and one system suggests use of a memory manager to access available memory in shadow RAM. Another system is contemplating use of extended memory. The trend is in utilizing memory beyond 640 Kb, and the use of a memory manager such as QEMM-386 or 386-MAX is recommended for an optimal configuration. Memory management provides an additional benefit of freeing more of the conventional 640 Kb by moving device drivers, buffers, TSRs and disk caches into shadow RAM or expanded memory. This is particularly beneficial to those users who purchase systems with large hard drives.

Multitasking

Multitasking is when a system provides an applications environment which appears to the user to be performing more than one task at the same time (Krantz et al 1988). Multitasking allows several applications to share the single CPU present in personal computers.

DOS was designed to be a single-tasking environment, where the system can process only one segment of work at a time and only one application at a time. There are enhancements available to the DOS environment (e.g., DESQview386, Windows386, etc.) that support a multiple application environment. These enhancements use the 80386 virtual mode to turn the PC into several virtual machines, each of which can simultaneously run a standard DOS program. Being in a DOS environment, however, these enhancements come up against many of the limitations of the real mode environment of the virtual machines. It is very difficult to support useful multiple applications while fitting the enhanced environment, DOS, and the multiple applications all in 640 Kb. Some enhanced environments like DESQview386 map each virtual machine, which may use physical memory in the extended addressing range, into the DOS 640 Kb addressing range while the virtual machine is executing (Rosch 1989). In this way the 640 Kb barrier is broken. Unfortunately, virtual machines executing in a real mode environment do not protect one application from another and do not protect the operating system from the applications. These enhanced environments are a hybrid of DOS and protected mode operating systems.

The problems associated with DOS and the enhanced environments disappear when the personal computer is operated in a protected mode operating system like OS/2 or UNIX. These protected mode operating systems provide large virtual address spaces for each application. They utilize the protection mechanisms available in the protected mode of the 80286 and 80386 chips to provide protection between the applications and between the operating system and applications. Most importantly these operating systems allow multiple applications to execute concurrently. These systems were designed to be multiuser, multitasking environments. It is these protected mode systems that will give GIS and image analysis systems the computing power of a mainframe on the desktop. Protected mode systems, however, are not a panacea but merely the next step in the PC operating system evolutionary ladder.

Of five GIS and image analysis systems surveyed, one already has an OS/2 version available, and two others are actively planning releases. Three of these systems also have UNIX versions and another is pursuing a UNIX version in conjunction with another GIS software company. The trend is therefore obvious, DOS operating limitations have encouraged development in protected mode environments.

Hard Disk Management

The performance of a PC-based GIS or image analysis system can be greatly improved by efficient management of the hard disk. The purpose of this section is to describe management techniques that will deal with the problems of file fragmentation, file allocation table integrity, file management disk parking and backup.

File Fragmentation

When a file is stored on a hard disk, DOS splits the file up into cluster size blocks and starts looking for vacant parts of the hard disk to store these blocks. On a newly formatted hard disk all these blocks are contiguous. A disk that has seen massive file creation, deletion and editing activity, especially if the disk is nearly full, will result in DOS taking longer to find empty spaces. Typically, the file may end up being stored in dozens of fragmented clusters scattered all over the surface of the hard disk. This is known as file fragmentation. File fragmentation will cause a slow down in performance because the disk read/write heads must skip around the disk looking for clusters of data to assemble a complete file. If a hard disk is well organized and not fragmented, lost data recovery would also be possible since files are stored in consecutive clusters. There are generally two methods of unfragmenting of the hard disk. The first method is very drastic, cumbersome and time consuming. The hard disk must be completely backed up, reformatted and then the data must be restored. The second simple and recommended method involves the execution of disk optimizer software (e.g., available in PcTools, Disk Optimizer, etc.) on a regular basis.

FAT

DOS relies on a chart called the File Allocation Table (FAT) to store those clusters on the disk which are temporarily unused. The FAT also keeps track of where all the blocks that make up each file are located. The FAT is so important that most disks contain two identical copies, and updates both each time it adds, deletes or modifies a file. DOS directories also contain the address of each file's starting cluster. When DOS accesses a file, it uses the starting location in the directory and then uses the FAT to find each subsequent part of the file on disk. The original designers of DOS gave the FAT a maximum of 16-bit addresses, which meant that the largest possible table could have (216) 64 Kb worth of entries. Since each entry in the FAT chart was a sector 512 bytes long, the maximum size of any single DOS disk was 64 Kb 512 bytes = 32 Mb. The FDISK command of DOS version 3.3 allowed the user to partition one large physical hard drive into several smaller logical drives, each 32 Mb or less and each with its own drive letter. DOS provides the utility program CHKDSK.EXE to verify that the FAT is intact and that file clusters have not been lost . If CHKDSK is run in its 'fix' mode (i.e, execute CHKDSK/F at the DOS prompt), it will repair the FAT if it finds a problem. It is highly recommended to run CHKDSK habitually to verify FAT integrity, particularly for large capacity or frequently used hard drives.

File Management

Hard disks are capable of storing hundreds or thousands of files. If all these files were stored in a single directory, the user would find a slowdown in performance by DOS as well as suffering needless complications in locating a particular file. To overcome these barriers, the designers of DOS borrowed the concept of hierarchical directories (Figure 2) from UNIX and other main frame operating systems (DeVoney 1986). To understand these hierarchical or subdirectories the hard disk could be compared to a filing cabinet, which usually has several drawers or partitions. Inside each drawer are file folders or subdirectories. Each folder in the file cabinet contains material that applies to a particular subject. In similar manner, each subdirectory should contain related files. An accounting spreadsheet should not, for example, be contained in a subdirectory containing the GIS

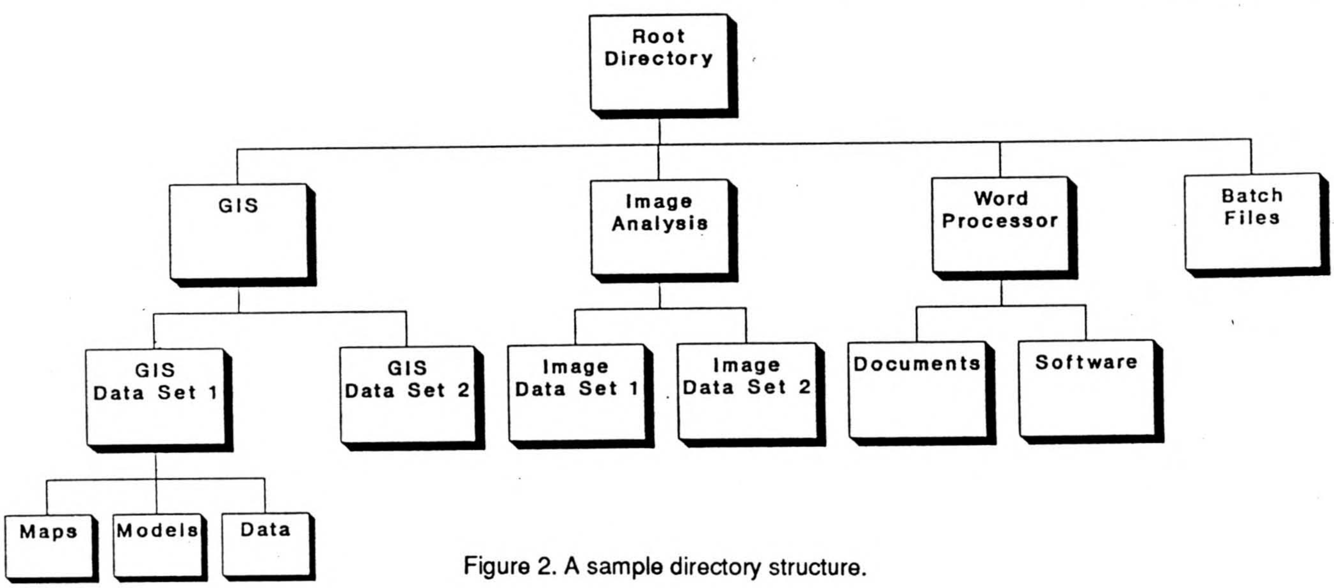

Figure 2. A sample directory structure.

or image analysis system programs. Organization of files will reduce the time the user and DOS will take to access a file or program. The organization of files will also increase security. For optimal performance, disk organization is essential, but more importantly, once a disk is organized keep it organized. This entails backing up files that are no longer needed and then removing them from the hard disk. Don't keep multiple copies of the same file on the hard disk.

In addition, the hard disk should be organized into subdirectories of files that are similar in nature. Naming conventions for files should also be adopted and standardized throughout the hard drive. This will enable the user to remember what a particular file contains in the future. It is also highly recommended that data files not be placed in the same directory as software files (Figure 2).

What Is Disk Parking?

When the low level format is done on the hard disk it is recommended to create a dedicated landing zone. The landing zone is the place the read/write heads will position themselves over when the disk is inactive or parked. DOS will mark the landing zone clusters as bad and will not write data to them. This will mean that if the machine is bumped and the read/write heads touch the hard disk platters, data will not be destroyed. If the hard disk is *not* self parking, it is highly recommended to park the heads before the machine is moved or powered down. There are disk park TSRs available that will automatically park the disk whenever it is inactive for any time. It is recommended to leave the PC powered up all the time. Power surges generated by unnecessary on/off switching causes mechanical stress to the hard drive (Alford 1988). It is, however, necessary to dim or turn off the display monitor to avoid the possibility of phosphor burn-in which results in the screen image becoming permanently etched on the monitor (Alford 1988).

Backup

Expect hard drive failure! Typical hard drive life expectancy, measured as mean time between failures (MTBF), is 30 000-100 000 hours. This is equivalent to 3.4-11.4 years, but more importantly this is a mean rating since half of all hard drives will fail before the MTBF rated hour of operation. Alford (1988) stated "Remember, with hard drives it's not a question of *if* you'll lose your data but *when*." There are some disk errors that no utility program can correct. There is only one way to prepare for a hard disk disaster and that is to regularly backup the hard drive. An example of a good backup strategy is a generational approach which requires three separate, complete backups. The medium that contains these backups is then recycled by making the current backup on the oldest copy of the three. In this way, if the most recent copy of the backed up material fails, there are two supplementary copies that will facilitate the recovery of the lost data.

Summary

Achieving an optimal computer configuration has become increasingly difficult within the increasing memory requirements of GIS and image analysis systems, and the operating requirements of peripheral hardware and software. Technical information on hardware architecture and software requirements provide the basis for achieving an optimal configuration which will vary from machine to machine.

With the fast 80286 microprocessors now on the market, there has been some question about the suitability of 80286 or 80386-based microprocessors for GIS or image analysis systems. A rationale was given for 80386 computers based on an increased addressable memory, the ease of protected mode accessibility, memory management capability and downward compatibility.

Achieving an optimal configuration depends on the variety of uses the computer is being employed for. Third party software such as word processing, data base management, communications and statistical analysis for stand alone functions, or in concert with a GIS or image analysis system poses more constraints for optimal performance than a single application. This complex problem can be successfully resolved on a single PC platform by properly managing device drivers, TSRs, computer memory, buffers, disk caches, and employing batch files. Of particular value for managing device drivers is a public domain boot interrupt called CONFIG.CTL.

Guidelines to using TSR programs include selective use, placement into shadow RAM and placement into specific batch files to start the application that requires them. Seldom will one require all TSRs to be installed at start-up. The key is to maximize available memory for memory intensive applications.

In 80386 computers with a megabyte of memory or more, expanded memory managers such as QEMM-386 and 386-MAX allow user-defined conversion of extended to expanded memory. The programs and utilities that can operate in higher memory can then be placed accordingly.

Optimal utilization of batch files would include programs that initialize environment variables, parameters and install device drivers as they are needed rather than when the computer is booted. The memory otherwise required for these programs is then freely available to the operating environment and its applications.

Within certain limitations, multitasking within DOS for DOS applications can be achieved with programs such as DESQview and Microsoft Windows. The large memory requirements of GIS and image analysis systems has not effectively permitted multitasking of DOS applications and GIS and image analysis systems in a DOS environment. The increasing development and availability of GIS or image analysis systems within protected mode operating systems like OS/2 or UNIX, will allow true multitasking to be realized on the desk top.

Critical to maintaining optimal performance are the effects of day-to-day operations and employing good hard disk and file management practises. File fragmentation is a frequent problem and contributes to both increased access times and wearing of the hard disk.

Backup, backup, backup! How often have you heard this? There is no replacement to having recent backups if a failure occurs.

Optimal configuration of a PC for GIS and image analysis operations can only be achieved by application of established file, system and memory management techniques. To apply these techniques, there must be more than a cursory understanding of the hardware platform, software applications and operating system environment limitations.

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March 1990

ISSN 0835-0752

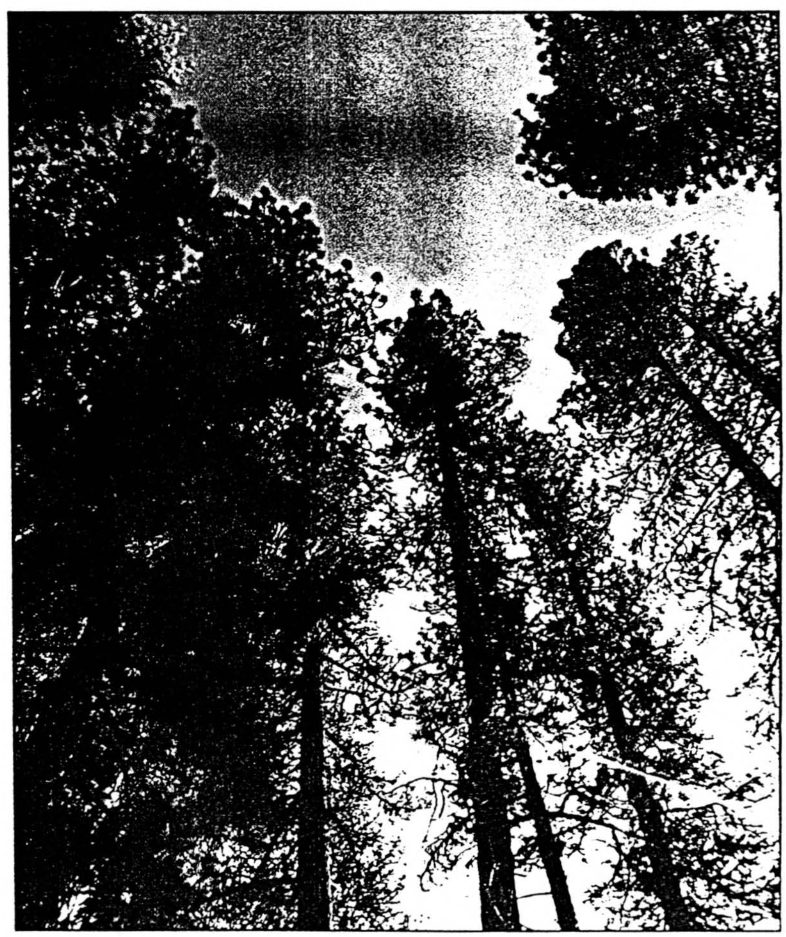
SYMPOSIUM PROCEEDINGS

GIS '90

Vancouver Canada

MARCH 13 - 16 1990

"MAKING IT WORK"



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