Taking Advantage of the SAS® System on the Windows® Platform

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ABSTRACT

As the Microsoft Windows platform continues to evolve and mature, business applications can more effectively realize large-scale benefits in this relatively cost-effective environment. This paper presents a discussion of the state of the Windows platform (including Windows 2000 and Terminal Services) and how the SAS System takes advantage and integrates with the operating system. New features of the Version 8 SAS System are also covered.

INTRODUCTION

In the history of SAS software on the Windows platform, SAS Institute has provided various methods of taking advantage of features and other applications available on personal computers. In addition to reflecting the native look and feel of the Windows platform, interoperability has been a hallmark of the SAS System for Windows. This interoperability has taken the form of support for e-mail, Lotus Notes, Windows Explorer integration, and other methods of interacting with client application software.

As the Windows platform has evolved as a capable server platform, this focus has shifted towards server exploitations of high-end hardware capabilities and large-scale processing abilities in Windows NT. These exploitations center around the most effective use of the SAS System on large NT Server systems in applications such as data warehousing and decision support. In one sense, taking advantage of the SAS System on the Windows platform is easy because SAS Institute has included much of the basic support in the software itself, ready for use. In another sense, though, the task is more complex than before, because server-based features can be technically more difficult to understand as they relate to the operation of a specific use of SAS software.

This paper will cover the current state of Windows operating system software and high-end server hardware likely to be applied to large-scale computational tasks. Some of this background will help the reader understand the quickly changing landscape of basic capabilities on personal computers.

PLATFORM ISSUES

It is useful to survey the state of operating systems and hardware from time to time, and much has occurred in the last year: Windows 2000, Windows 98 Second Edition, and improved PC hardware is now available. In addition, future processor improvements and the advent of 64-bit personal computers are expected later in 2000.

Welcome to Windows 2000

During 1999, much of the interest in the Microsoft Windows platform revolved around the expected release of the Windows 2000 operating system. After a very long development cycle, Microsoft announced in December 1999 that the product line would be available in February 2000, and the wide range of new capabilities of Windows 2000 deserves study by administrators and organizations considering its deployment.

Windows 2000 joins the Windows NT4 and Windows 98 platforms as a modern, business-targeted platform that scales from individual workstations (called Windows 2000 Professional) through servers (in Windows 2000 Server and Advanced Server) and very large configurations (with Windows 2000 DataCenter Server).

As Table 1 indicates, the server versions of Windows 2000 include a range of features and limits. Terminal Server (TS) and Enterprise Memory Architecture (EMA) are available on some of the higher server levels, and are discussed later in this paper. Failover clustering support (formerly known as "Wolfpack") is also built into some Server versions.

Table 1. Comparison of Windows 2000 capabilities

	Pro	Server	Advanced Server	Data Center Server
# CPU limit	2	4	8	32
RAM limit	4GB	4GB	8 GB (EMA)	64 GB (EMA)
Cluster?	None	None	2 node	4 node
Single User?	Yes	T.S.	T.S.	T.S.

In addition to feature differences, the highest-capability version, DataCenter Server (expected to ship by June 2000) is planned to become available only through computer vendors as part of a certified package. DataCenter Server should ship at the same time as Service Pack 1 of Windows 2000.

Windows 2000 Server versions now incorporate Terminal Services, which was a separate version of Windows NT in the past. Terminal Services allows multiple users to share a single Windows Server, using their own GUI and normal applications that have been installed on the server. In the style of X-Windows on UNIX, administration is centralized and client systems don't need to be as capable since they're only used as "dumb terminals" when Terminal Services is in use.

Deployment of Windows 2000 in large organizations can be a very complicated affair, and Microsoft makes available a 1206 page Windows 2000 Deployment Planning Guide to assist in this undertaking. Much of this complexity has to do with the directory service integrated into Windows 2000 servers. Called the Active Directory, it will become the basis for many forms of organizational data used by future software products. Since the optimal operation of these products depends on an accurate underlying organization, many enterprises will need to devote much study to developing an organizational structure that can grow with their anticipated future needs.

On the smaller system side, Windows 98 Second Edition has become available and is now the basic standard for lightweight PC application requirements. Although the Windows 98 family continues to evolve, Windows NT and Windows 2000 remain the optimal Windows platform on which to run mission-critical and data-intensive processing typically performed with the SAS System. Reliability and inter-application security remain key reasons why Windows 98 is best suited to lightweight application requirements.

Windows Millennium is expected to ship later in 2000 and will become the most current member of the family that includes Windows 95 and 98 and is generally used in consumer applications. Originally expected to include major GUI changes, Millennium is now expected to be more of a Windows 98 replacement, including many modernizations included in Windows 2000. An additional expected aspect of Windows Millennium was the merging of codebase between the consumer line (Windows 98) and business line (Windows 2000). As of this writing, this merging still awaits a future version of a Windows product.

Windows 2000 Benefits

In addition to the new features already discussed, it may be found to be an ideal platform for other reasons as well:

- Microsoft has worked hard to improve reliability, and Steve Ballmer of Microsoft has indicated that $162M was spent to improve the quality of the system. This translates into fewer crashes or other service interruptions.

- The addition of Plug and Play support means that laptop computer users can finally step up to a very reliable operating system. Moreover, Windows 2000's improved power management support could lead to longer battery life for traveling users.

- Administrators could find it easier to manage through features like Intellimirror, roaming user support, and group policies. Also, the convergence of management applications to the Microsoft Management Console makes various types of administration and management easier to locate and know how to use.

- Administrators will benefit from the Active Directory, which can act as a central information repository for data about computers, users, and resources in the enterprise. In addition, the central location will make it easier for applications to access this information.

- Microsoft has claimed that many users will notice a performance boost when running applications on Windows 2000, as compared with Windows NT, Windows 98, and Windows 95.

- Windows 2000 includes Internet Explorer 5, which is a faster and more reliable browser than previous versions of Internet Explorer.

Current State of the Art: 32-bit Personal Computer Processors

1999 saw continued consistent improvements in processor speed, with current speed limits at 800MHz as of this writing, nearly twice as fast as a year ago. Other improvements in RAM technology and bus speed have produced commensurate throughput improvements. In addition, the capacity of disk drives continues to grow steadily as does their basic performance.

While Windows NT 4 was available for various hardware platforms including the Intel x86 family (such as the Pentium processor), Compaq Alpha and MIPS processors, Windows 2000 only supports the Intel compatible processor family. Intel-compatible processors such as the AMD Athlon are also coming into wider use and offer a cost effective yet high-performance alternative to genuine Intel processors.

For the Intel-based IA-32 family of processors, in March 1999 the Pentium III Xeon processor became available for server systems. This processor continues to provide the highest throughput levels in a PC-class server. Xeon processors include a memory addressing mode that allows use of more than 4GB of memory, which is the typical limit for 32-bit computers. This mode, which actually uses 36-bits of addressability instead of the otherwise standard 32-bits raises total memory availability from 4GB

(2^{32}) to 64GB (2^{36}). Version 8 of the SAS System takes advantage of this capability though its support for ESMA (Extended Server Memory Architecture). This architecture allows an application to utilize more memory than the Windows NT operating system is capable of accessing via an Intel-supplied driver program. Windows 2000 Advanced Server and DataCenter Server platforms also take advantage of this capability natively using EMA (Enterprise Memory Architecture), which is similar to ESMA but much more integrated into normal operating system operation.

Version 8 of the SAS System also takes advantage of other features of the Pentium III processor line which are called Streaming SIMD instructions. These new processor capabilities facilitate faster completion of some types of operations such as data retrieval and data throughput as well as improved floating point calculation performance.

The SAS System utilizes new instructions that ask the processor to prefetch data before it is actually needed for calculations. In this way, the processing of data can continue to proceed nearly as quickly as the processor can run instead of having to stop frequently to ask for and then receive data from slower main memory areas. Another way in which Version 8 of the SAS System exploits the Pentium III processor line is through wider data movement. Utilizing new, wider registers present in the Pentium III processor, the SAS System can move larger individual pieces through the processor to speed overall throughput. In these ways, throughput is maximized more effectively than on other types of processors.

For high-end Intel-based servers, the arrival of a standard 8-way platform in 1999 brought very high-performance operation into the Windows NT world. These systems support up to 8 CPUs and currently up to 16GB of RAM per system. Internally, a dual PCI bus architecture ensures maximal throughput to disks and other peripherals.

The future of Intel's IA-32 family looks to remain continuously improving in terms of processor speed and new capabilities, starting with the next processor expected

code named Foster. As new features become available that lend themselves to useful performance improvements, SAS Institute will continue to evaluate them for inclusion into future versions of SAS software.

On the non-Intel front, AMD released the Athlon processor in mid-1999, which has increased customer options on the high-end PC front. Through Athlon, AMD has kept upward pressure on the Intel-compatible processor line, the end results of which are lower customer cost and accelerated performance increases. In some cases, the Athlon may outperform the current best Intel Pentium III processor, depending on product release schedules. SAS Institute includes the AMD Athlon in its mix of processors in which SAS software is tested

On the horizon: 64-bit Personal Computer Processors

Beyond the 32-bit world, news of the Intel-based 64-bit processor family (IA-64) has been available for some time. The processor formerly known as Merced has been renamed the Itanium™ in 1999. This processor is expected to ship sometime in the latter half of 2000.

SAS Institute views the 64-bit IA-64 family of Intel processors (of which Itanium is the first implementation) as very significant because of the vastly increased scalability it will allow for truly high-end applications. The Institute plans to support the Itanium processor with SAS software ready when the processor becomes available. ESMA and EMA provide some scalability improvement on 32-bit platforms, but the most generally useful way to improve scalability is with 64-bit processing directly.

The key benefit of SAS applications running on Itanium is scalability. With 64-bit addressing, memory can be addressed up to 2^{64} (or 18,446,744,073,709,551,616) bytes, opening the door to more sophisticated algorithms that can benefit from the vast memory space.

In addition to scalability, the Itanium includes hardware compatibility with IA-32 software

and new throughput enhancements. These enhancements include:

- the ability to execute multiple instruction sequences concurrently, which is called Instruction Level Parallelism, effectively multiplying throughput by the parallelism factor

- a much larger set of processor registers allowing higher degrees of algorithm optimization

- instruction predication to facilitate a more consistently busy processor. Using predication, multiple code sequences can execute in "what-if" scenarios whose outcome only later become known

- improved floating point performance to speed typical mathematical operations, of which SAS applications are typically comprised

- speculative data loading to request data early and execute programs as if the data were retrieved in a timely fashion. Again, another form of "what-if" processing that allows the processor to remain busy and ready for multiple eventualities.

SAS Institute continues to work on its 64-bit readiness as well as studying features of the Itanium processor to facilitate timely availability of the SAS System for the Itanium. As part of this effort, SAS Institute has worked with simulator systems that run on conventional 32-bit PCs and simulate the run-time Itanium environment.

In spite of the significant benefits of the IA-64 family, many users of SAS software will likely continue to remain dependent on 32-bit computing platforms for a variety of reasons:

- some applications won't need the vastly improved memory scalability to perform their basic tasks

- Itanium systems will likely not be as cost-effective as 32-bit PC hardware for smaller applications

- performance of 64-bit Itanium systems might not be significantly different from then-current 32-bit processors for applications in which scalability isn't a concern. Future 64-bit processors may change this significantly, however, closer to 2002.

- 32-bit systems will continue to evolve and remain attractive due to performance and feature improvements. 32-bit PC processor performance is expected to reach 1 GHz (gigahertz) by the end of this year. Intel has publicly indicated a future 32-bit plan for improvements through at least 2002.

- Although SAS Institute products will become 64-bit capable in a timely manner, other software packages may remain 32-bit. The premium price of a 64-bit PC may not be easily justified, even if that PC can run 32-bit applications well.

- Later generations of the IA-64 family (code named McKinley, Madison, and Deerfield, listed here in the expected delivery order) should demonstrate large improvements over Itanium. It is likely that initial Itanium performance many not be significantly different from Foster, the next generation of IA-32 processors.

In short, customer choice options will grow with the advent of 64-bit PC systems. Both 32-bit and 64-bit systems will continue to evolve and lead to a wider range of choices for SAS software users.

PLATFORM FEATURES

Beyond taking advantage of basic operating system and processor capabilities, the personal computer platform has evolved towards a complete system on which to run mission-critical applications. SAS System support for these capabilities is covered in this section.

Interoperability

The SAS System takes advantage of interoperability with other applications available on the Windows platform.

Communication to applications such as Lotus Notes Mail, Microsoft Exchange, and other SMTP-based systems is supported through MAPI and SMTP. This SMTP support is enhanced in Version 8.1 of the SAS System, which supports SMTP mail directly (as compared with earlier versions that depended on MAPI mail clients to perform this function). SAS System output can be formatted in HTML to allow sharing and collaboration with many applications.

Beyond HTML, Version 8.1 has a new portable engine, named XML, that generates XML tagged output from a SAS data set.

Security

The SAS System takes full advantage of security services provided by the operating system. This includes the improved security services present in Windows 2000 such as Kerberos support.

File Systems

NTFS remains the filesystem of choice for complex applications. NTFS 5, newly available on Windows 2000 adds basic functionality to the overall NTFS picture, of which maximum reliability is the key benefit.

NTFS support for journalled recovery, dynamic resizing, fault tolerance, off-line (Intellimirror) support, hierarchical storage management, and built-in compression or encryption make it a high-performance and safe location for critical data storage. NTFS also remains the only Windows filesystem capable of storing individual files that exceed 2GB in size. Although FAT32 supports overall partitions larger than this size, it limits individual file size to a 2GB limit. As a result, SAS System applications that require access to files larger than this limit should use NTFS.

A frequently forgotten aspect of filesystem performance is fragmentation. As larger and larger disk drives are used, the potential for high degrees of fragmentation rises dramatically. In addition, with single drives past 36GB in size, some systems will operate with a smaller number of "spindles" or individual disks in use. The heavy use of

very large volumes can exacerbate the effects of high fragmentation. A high-quality defragmentation package (and schedule for its use) is a must for mission-critical applications.

WINDOWS COMPATIBILITY

Since the SAS System first became available on the Windows platform, SAS Institute has strived to keep the product maximally compatible to allow SAS users to reap the full benefit of Microsoft's investment in the Windows environment. As the latest version available, Version 8 of the SAS System demonstrates this through having received the "Designed for Microsoft Windows NT and Windows 98" logo.

This testing was completed on the latest versions of Windows available when Version 8 of the SAS System became available. The logo indicates that the SAS System meets basic requirements for user experience, installation and uninstall, stability, and other application standards.

Another product that has received the same logo certification is Enterprise Guide Version 1.0. This product is an alternate front-end for SAS users who want a more menu-driven interface to the power of the SAS System. Like the SAS System itself, logo certification of this product indicates it is among the state of the art applications for the Windows platform. Please refer to the paper, "Enterprise Guide, An Intelligent Client interface that provides access to all of the power of the SAS System", also in these Proceedings.

Like other applications that use a unique file format, the SAS System also makes available a lightweight viewer which can be freely distributed to facilitate access to SAS data formats. The SAS System Viewer continues to improve, and for Version 8.1 adds full column customizability so that the viewed data can be organized in the manner desired by the

user. This customizability allows the user to drag and drop columns or use a column chooser dialog to organize columns of data as needed.
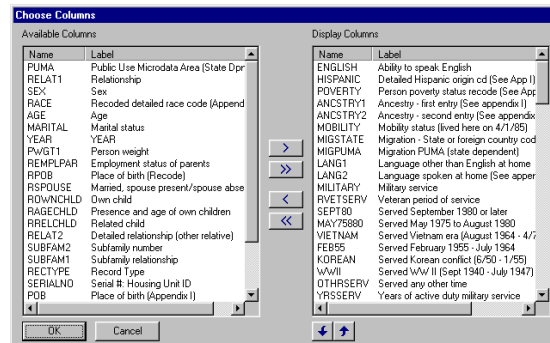

Figure 1. Column chooser from the Version 8.1 SAS System Viewer.

In addition to reordering, the new Viewer also supports the hiding of columns and column "freezing".
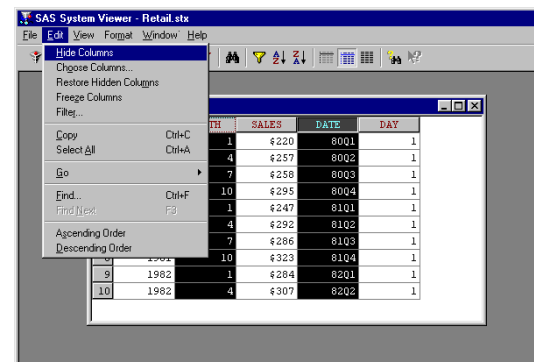

Figure 2. Viewer columns can be hidden or frozen.

Freezing allows the user to specify a range of columns that don't scroll with the rest of the data so that specific columns can be used as label values.

Operation as a Windows NT Service

Version 8.1 of the SAS System adds the capability of running a SAS session as a service, which can be started in unattended mode, and which can be remotely administered using the Windows NT Service Control Manager. The SAS Service Configuration Utility allows ease of installation for administrators via a GUI-based interface, command line interface via

a data file. This utilitycan be used to specify various service parameters and also to perform various maintenance activities on the running service.
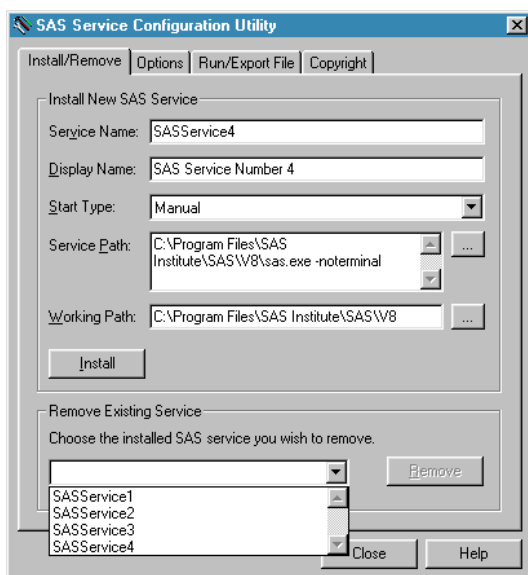

Figure 3. Version 8.1 SAS Service Configuration Utility for installation and removal of SAS services.

Options related to service operation are highly configurable through the GUI interface and all of this information can be saved to a data file that can be re-used to configure a collection of servers to run similar services.
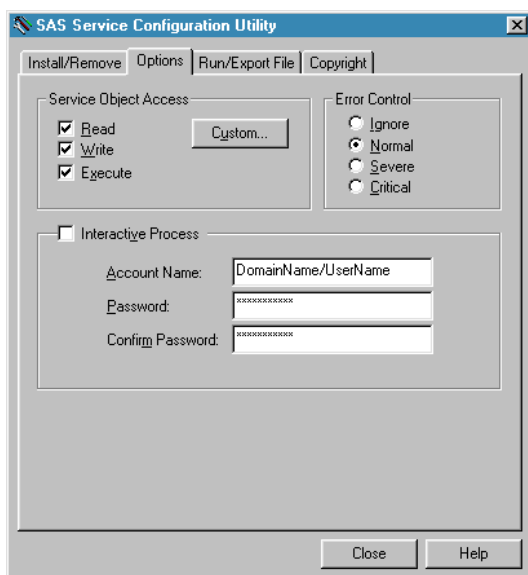

Figure 4. Account and interactivity settings for service configuration.

User Experience

Windows 98 and Windows 2000 add support for multiple monitors on a single computer. For knowledge workers, this can lead to increased productivity, since even large monitors eventually fill up with application windows. In a multi-monitor configuration, the user can drag windows from one screen to the other as user tasks evolve. The SAS System functions well in a multi-monitor environment with other applications.

Windows 2000 also adds a general feature called "auto-complete", which benefits users of the SAS System on that platform. When using standard dialogs for operations such as opening files, the dialog will present easily selectable completion choices which can save a lot of typing for some operations.
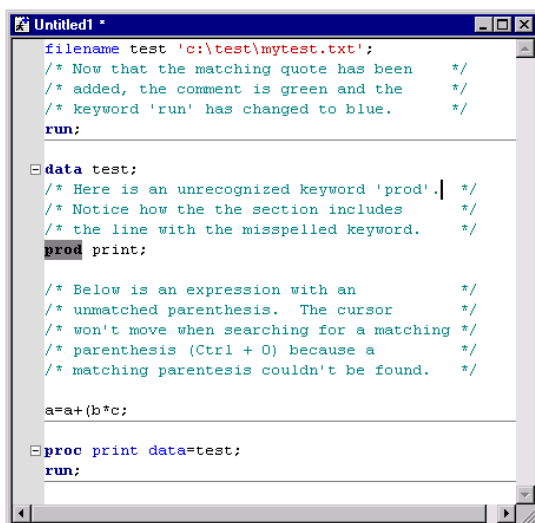
SAS Enhanced Editor

New for Version 8 of the SAS System is an important addition called the Enhanced Editor. It can be recognized by the icon shown here.

The Enhanced Editor includes many of the features from the standard SAS Program Editor in addition to the following:

- SAS program elements are color-coded, including procedures, keywords, informats and formats, dates, numeric and string constants, macro keywords, undefined keywords, and more.

- SCL programs, HTML documents and text documents can be color-coded.

- You can create your own color schemes or use schemes provided with the Enhanced Editor.

- The Enhanced Editor can automatically indent the next line when you press the Enter key.

- You can view the high level flow of your SAS program or see each detailed statement by expanding or contracting sections of SAS procedures, data steps, and macros.

- Using the keyboard macro recorder, you can create macros that record and play back program editing commands.

- Abbreviations let you create shortcuts for entering text.

- Bookmarking lines allows easy access to different sections of your program or document.

- You can customize keyboard shortcuts for most Enhanced Editor commands.

- Multiple instances of the Enhanced Editor can be open at one time.


Figure 5: Sample SAS program code in the Version 8 Enhanced Editor.

Terminal Services Operation

Terminal Services is built into Windows 2000 Server platforms to better facilitate its use for larger numbers of users. This is a definite improvement over Windows NT 4 Terminal Server Edition, which remained a separate version of Windows NT, requiring separate service pack updates and specific application compatibility.

When run on Windows 2000 Advanced or DataCenter Server, Terminal Services is enhanced by the availability of Enterprise Memory Architecture (EMA) which benefits users running on computers with over 4GB of physical RAM. On this type of server, multiple users can each be running very large tasks and not necessarily swap other applications out of physical memory. As an example, on a Windows 2000 Advanced Server equipped with 8GB of RAM, four users, each of which could be running separate large SAS applications, could share the entire 8GB of RAM, say by allowing each application to have 2GB of the physical memory. This is an improvement over Windows NT4 Terminal Server, which would have limited all concurrently-running applications to a shared 4GB memory limit. In the example described above, all four users would likely experience much slower throughput due to inter-application paging, also known as thrashing.
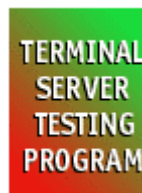
During 1999, Version 8 of the SAS System was tested by Veritest, an independent testing laboratory, to demonstrate that it is a "Terminal Server Compatible" application. Veritest verified that Version 8:

- Installed and uninstalled easily and correctly on Terminal Server systems. This means that an administrator was able to install the SAS System and without added intervention make it available to all users of the Terminal Server. If the administrator allows the SAS Setup application to make its default choices, the Setup program will properly configure private user and work areas and share common application settings appropriately for all users.

- Functioned properly in the Terminal Server environment. This testing ensured that a test case of 15 concurrent user sessions with constant activity functioned without incident during a test period of 20 hours. This testing showed that there were no inappropriate inter-user problems. In addition, the testing found no length-of-operation problems in the application such as memory leaks that could cause server and user performance to degrade over time.

As a result of passing this testing, Version 8 of the SAS System has proven itself to be Terminal Server Compatible, so enterprises

considering SAS application deployment for large numbers of users should consider Terminal Server as a deployment option.

Data Access - ODBC and OLE-DB

The SAS System provides open data access support. The SAS ODBC Driver, which provides access to SAS data through the SAS System (either a local SAS System session acting as an ODBC Server or to a remote SAS/SHARE® Server) is the read/write solution included with Base SAS Software.

For applications requiring read-only access to data, the Universal ODBC Driver can be used. This driver does not require any access to SAS System Server software and instead can read SAS data file formats itself. The Universal ODBC Driver is available as a separately purchased product.

OLE-DB is a newer standard for accessing data from external applications. New in Version 8 is the ability to use the ShareProvider to view and update data through a direct connection to a SAS/SHARE*NET server. ShareProvider implements the Microsoft OLE DB specification and can be used by any OLE DB- compliant or ADO-enabled application.

These drivers are distinctly different from the SAS/ACCESS products SAS/ACCESS Interface to ODBC and SAS/ACCESS Interface to OLE-DB (which is a new product for Version 8) in that the drivers are intended for use when an external application wishes to run as the controlling program requesting data from the SAS System. The SAS/ACCESS products are used when the SAS System is the controlling program that initiates the data request.

Interoperability

In addition to OLE Automation, which has been present in the SAS System for Windows for several years, Version 8 of the SAS System adds support for more granular access to and control of SAS functions through Enterprise Integration Technologies. Please refer to the paper, "Enterprise Integration Technologies - What is It and What Can It Do for Me?", also in these Proceedings.

PERFORMANCE IMPROVEMENTS

Every release of the SAS System since 6.12 has been performance tuned by SAS Institute, with the assistance of Intel Corporation. The Institute uses tools that help pinpoint potential performance issues in the application code so they can be addressed. In addition, the Institute has endeavored to utilize any reasonable capability of the operating system or machine hardware that results in more optimal performance on the Windows platform. This covers areas such as application code as well as the internal compiler used to build the system. Recent improvements have capitalized on exploitations of processor optimizations, memory utilization, and parallelization.

For more information about these improvements, please refer to the following papers, also in these Proceedings:

- "V8 Base SAS Performance: How does it Stack-Up?", by Robert Ray. This paper illustrates the areas in which performance of the SAS System for Windows has improved since 6.12. For example, procedures that perform large amounts of sequential data access show marked improvement. However, more work remains to be done for the random access pattern cases, in which performance isn't yet superior to 6.12.

- "Multiprocessing with the Version 8 SAS System", by Cheryl Garner. This paper discusses MP-CONNECT, a facility for enabling multi-processing on larger server systems such as Windows NT servers.

- See the SAS Online Documentation for information on In-memory file support in Version 8.1. Called IMF (In Memory Files), it takes advantage of machines with large amounts of real memory. It reduces I/O and file open operations by persisting a SAS data file in memory across step boundaries.

Performance and tuning efforts are also undertaken on other platforms. Two other papers in these Proceedings, "Taking advantage of the SAS System on the OS/390 Platform", and "Tuning The SAS System For UNIX and Tuning UNIX For The SAS System" should also be reviewed for an overview of the state of these other platforms.

CONCLUSION

For optimal performance of the SAS System, it is important to stay current with operating system and hardware developments. Windows 2000, Terminal Services, and current microprocessors are currently the best way to get the most out of the SAS System on the Windows platform. In the near-term future, 64-bit computing will become a choice for users to evaluate. SAS Institute will continue investing in research and development for the Windows family and will embrace new technologies as they become available.

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