Optimizing the Design of Large Assemblies in Mechanical Design
Taking Advantage of 64-bit Technology
with PTC® Pro/ENGINEER® Wildfire™

Sun microsystems

> Several factors have recently aligned to enable a shift in designer productivity and usher in a new era in mechanical design. Product quality and overall time to market can be greatly improved in a 64-bit environment where designs of very large assemblies are not artificially constrained to the 2 or 4 GB dataset limitations of 32-bit systems. Today's 64-bit design solutions enable these large assemblies to be portrayed in full fidelity without the *simplifications* that can be required to fit them within the 32-bit memory size. In addition to advances in 64-bit design tools, the recent introduction of Sun x64 workstations featuring AMD Opteron™ processors has also brought a big jump in price/performance for 64-bit hardware platforms, making 64-bit modeling solutions affordable to a broader range of designers. Through widespread adoption of 64-bit systems that support very large assemblies, businesses can dramatically improve designer productivity and achieve greater efficiency in the collaborative design process.

Benefits of Sun x64 workstations for designers

- High-end performance at affordable prices
- Large memory capacity (up to 16 GB)
- CPU performance among the fastest on the market for MCAD applications
- High performance 3D graphics for fast rendering of textured surfaces
- Choice of operating system including Microsoft Windows, Red Hat and SuSE Linux, and of course, the Solaris™ Operating System
- Smooth 64-bit migration path

Breakthrough Innovations in Design

Like many industries, mechanical design has experienced occasional breakthrough innovations that dramatically change the way design tools are used. Some of these innovations such as advancements in processor speed, memory speed, and memory capacity are evolutionary and follow Moore's law.

In 1996, the state of the technology was a 300Mhz CPU, but 10 years later we have processors that are 10 times faster. Memory speed, memory capacity and price/performance have shown even more dramatic increases in this same time period. Even more important are some of the revolutionary changes that have changed the dynamics of mechanical design.

One of the early revolutionary innovations in mechanical design was solid modeling which allowed designers to create a digital model that could be used as a virtual prototype of the part, thus reducing costs and accelerating the design process. PTC's release of Pro/ENGINEER in 1988 was a tipping point because it was the first solid modeling tool to provide real-time performance and 3D capabilities for assembly designs containing 40 or 50 parts, a large assembly in those days.

Industry-wide adoption of a common graphics standard, OpenGL®, was another breakthrough. OpenGL greatly simplified the interface between software solutions and the underlying hardware and enabled software vendors to more efficiently support multiple hardware platforms with different proprietary graphics subsystems.

The industry-wide adoption of this standard brought a new level of innovation that, over a period of just a few years, delivered orders of magnitude increases in price/performance of graphics hardware. As hardware vendors such as NVIDIA continued to deliver increased graphics performance, software vendors could create innovative new design solutions to take advantage of the performance using the same graphics application programming interfaces (APIs) as before.

With each new technology advancement designers were given greater freedom to incorporate more information into their designs. More details and greater numbers of parts were added to designs until the practical limits of the software and hardware solutions were reached.

"Prior to the Sun Ultra 20 Workstation, we had completed extensive TCO comparisons for engineering workstations at Bombardier that show by a wide margin, the Solaris 10 OS is an optimal platform for Pro/ENGINEER. The reliability, performance and ease-of-maintenance of the Solaris OS is unmatched. We are very much looking forward to the release of Pro/ENGINEER Wildfire on Solaris 10 for the AMD64 platform. The price performance of the Sun Ultra 20 Workstation will make what is a very good TCO, all that much better."

Robert R. Parotto
Manager, CAE Systems and Technology,
Bombardier Recreational Products, Inc.

By the mid to late 1990's, memory capacity became the biggest constraint. Designers had to be conscious of the memory footprint of their design (the number of bytes of memory the design would consume when fully loaded into memory) versus the available memory within their workstation in order to obtain reasonable performance. When a design's memory footprint would grow bigger than the available physical memory, performance would radically degrade because of paging to disk to access virtual memory locations that could not be held in physical memory. Memory prices at that time were several orders of magnitude higher than they are today, so managers had to balance a designer's increasing appetite for more memory against the cost of purchasing more memory capacity.
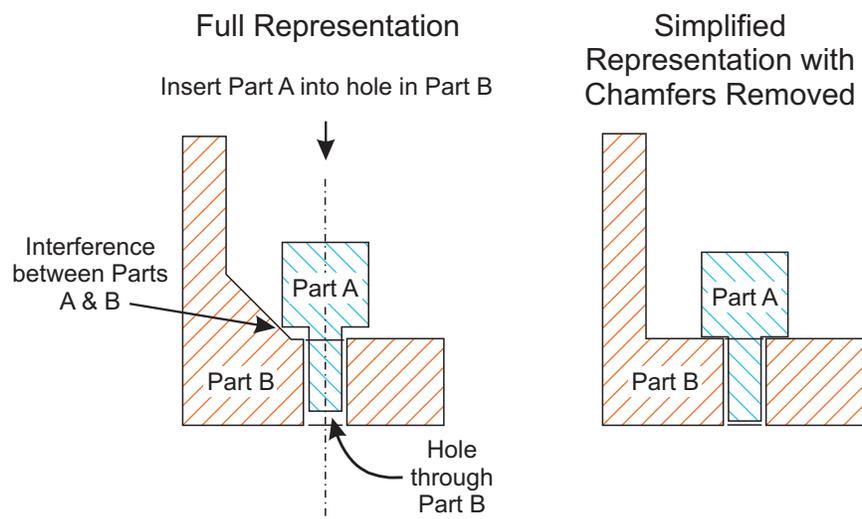
Hitting the 32-bit Wall
Eventually the evolutionary improvements in hardware memory capacity and in 3D modeling tools allowed designs to reach the limit of most 32-bit machines which could not access more than 2GB of virtual address space[1]. Sun was in a unique position at that time because the Solaris OS offered support for approxi-

mately 4GB address space, nearly double the capacity for competitive OS's.

Many users who hit the 2GB limitation in the late 90's migrated to Sun to gain nearly a 100 percent increase in addressable memory. Sun workstations were often purchased for PTC® Pro/ENGINEER® power users who absolutely needed the extended memory to work on larger designs. The majority of designers, however, still worked on commodity 32-bit Windows systems that stifled productivity by forcing users to work with smaller subsets or highly simplified versions of their designs to fit within the 2 GB memory limitation.

Challenges in Using Large Assembly Modeling Tools
Mechanical design software vendors such as PTC responded to these memory limitations by delivering advancements in large assembly modeling tools which supported design best practices while helping users limit the memory required to manipulate their designs. These tools enhanced designer productivity by enabling larger designs and better system performance for a given memory footprint, but they also represented a compromise.

Full Representation

Insert Part A into hole in Part B

Interference between Parts A & B

Part A

Part B

Hole through Part B

Simplified Representation with Chamfers Removed

Part A

Part B

If not used carefully, simplified representations of assemblies can hide design inaccuracies by allowing interference conditions such as shown above (left) to go undetected (right).

To effectively use these large assembly model-ing tools, users must become proficient with the best practices for employing the tools and consistent standards must be adopted throughout the user base to avoid confusion between users. Perhaps most importantly, improper use of these tools can introduce inaccuracies in the design, as illustrated in the simple design example in the previous figure.

The left side of the diagram shows a Full Representation of the design where it is easy to see that inserting Part A into Part B causes an interference with the 45 degree chamfer. The Simplified Representation shown on the right side of the diagram shows the same design with chamfers suppressed. Removing all rounds (fillets) and chamfers is a common technique to simplify the assembly, but as is evident in the figure, the simplified assembly masks the interference problem.

If not used properly, simplified assemblies can lead to design inaccuracies that may go unde-tected until later stages of the design or even until later stages of the product lifecycle. This can prolong time-to-market for a new product and can increase costs throughout the product lifecycle. Furthermore, as the design grew larger and more complex, the implementation of these tools had to become more aggressive (making the parts more simplified) in order to avoid the 32-bit memory limitation.

Today's Integrated Design Environments Add to the Performance Challenge
In addition to memory constraints, other stresses on system performance occur in today's integrated design environments where design tools are integrated with office produc-tivity tools and data management environ-ments such as PTC® Windchill. Thus designer productivity is also impacted by performance of the overall Product Lifecycle Management (PLM) solution and not just the performance of a local workstation.

An integrated design environment utilizes more memory than the stand-alone design tools of the past and also creates additional I/O and background tasks since users can continue to work on designs while data is being retrieved or processed in the background. This environment lends itself to a system architecture that can simultaneously process multiple application threads.

The First Mechanical Design Software Vendor to Introduce a 64-bit Solution
In 2000, PTC was the first mechanical design software vendor to release a 64-bit 3D model-ing tool with their Pro/ENGINEER application. This was a breakthrough event in that users could now manipulate designs of virtually any size and hold an entire design in a single digital model that could be manipulated on one system.

Until recently, however, the cost of 64bit sys-tems has relegated them to a limited number of power users. When configured with enough memory to hold large designs, these systems were too expensive to enable widespread adoption. While commodity priced 32-bit workstations did not really offer adequate performance for large assemblies, most organi-zations simply could not afford to purchase 64-bit systems for all of their designers.

Sun x64 Workstations Bring Commodity Pricing and Extreme Performance
Another major breakthrough in price/perform-ance of 64-bit workstations is making the power of 64-bit solutions available to a wide-spread base of users. Sun x64 workstations featuring AMD Opteron processors offer break-through performance for 64-bit applications such as PTC Pro/ENGINEER Wildfire™ at prices that compare to those of traditional 32-bit systems.

Sun x64 systems offer a balanced architecture that is designed for performance while leverag-

ing innovative aspects of AMD Opteron proces-sor technology:

- *Proven 64-bit performance* when the 64-bit AMD Opteron processor is combined with the Solaris OS which has included 64-bit addressing for several generations. 32-bit x86 instructions also run native (no emula-tion) on the AMD64 architecture and in many cases they run faster on this 64-bit environment than on a 32-bit x86 processor. This claim can not be made by all 64-bit architectures.

- An *integrated DDR DRAM memory controller* on each processor provides lower memory latency for shorter runtimes. Both available memory and memory bandwidth can scale with the number of processors — enabling the system to provide adequate bandwidth for large jobs and large assemblies. Because PTC Pro/ENGINEER Wildfire is highly depend-ent on memory access speed, the low memory latency achieved by putting the memory controller on the AMD Opteron processor (as opposed to Intel architectures which share a common bridge for both CPU and I/O) is a big factor in why Sun x64 work-stations have been able to achieve signifi-cantly better performance than competing systems.

- I*nnovative point-to-point HyperTransport™ technology* eliminates the I/O bottlenecks present in the front-side bus (FSB) Intel Xeon architecture, increasing overall system performance since I/O does not compete for bus bandwidth.

- *High I/O throughput* including PCI-Express graphics interface to enable faster response for visualization and high performance disk drives for storing and retrieving large data sets.

Industry-leading Benchmark Results
These architectural strengths are already yielding substantial performance benefits along with record setting results on standard benchmarks.

Sun x64 systems consistently outperform the competition on the OCUS (Olaf Corten's Utilities) benchmark for PTC Pro/ENGINEER Wildfire and have claimed top spots on the OCUS benchmark site[2]. OCUS is an industry accepted, independent benchmark that compares the performance of top workstations running Pro/ENGINEER.

Sun x64 systems have also claimed top spots in well-recognized industry standard and application benchmarks. Additional information about benchmarks for Sun AMD Opteron systems can be found at www.sun.com/amd.

Choice of Operating Systems

One of the greatest benefits of Sun's x64 platforms is the flexibility that results from their ability to run multiple operating systems and their support for both 32-bit and 64-bit applications. Sun's x64 workstations offer the highest degree of flexibility for organizations that need to run existing 32-bit operating systems and applications, and be able to gracefully migrate to 64-bit when they are ready.

Users can choose to run Sun x64 systems with the S*olaris Operating System*, Linux, or Windows including the new Windows XP Professional x64 Edition:

* *Solaris Operating System (x86 Platform Edition)*
* *Linux*: Red Hat Enterprise Linux is supported by both Sun and PTC.
* *Microsoft Windows*: Sun x64 systems are Windows Catalog Certified, enabling organizations to run applications on Windows XP or Windows XP Professional x64 Edition.

Next Generation Visualization

Sun provides a range of graphics options to offer both affordable and high-end graphics solutions designed to meet the complex imaging and visualization requirements of MCAD applications such as PTC Pro/ENGINEER Wildfire.

NVIDIA Quadro graphics accelerators used in Sun x64 systems range from mid-range 3D graphics cards to ultra high-end 3D visualization solutions with dual-display capabilities. When using dual displays, NVIDIA SLI technology takes advantage of the increased bandwidth of the PCI Express bus architecture to enable multiple GPUs (graphics processing units) in a single system to deliver increased graphics performance and visual quality.

Continuing the Process of Innovation

If history is any guide, designers will be quick to use the full extent of today's design tools on 64-bit systems such as the Sun Ultra 20 and Ultra 40 workstations and will be awaiting the next innovations when they arrive. Today's integrated design environments already take advantage of the multiprocessing capabilities of Sun workstations by virtue of the fact that they utilize multiple software tools which can each run in separate threads.

Other requirements such as faster loading and manipulation of large assemblies can be handled more efficiently if applications are written to utilize multiple execution threads, thus allowing parallel processing on systems that have multiple CPUs or multiple CPU cores (multiple processors within the same die).

More information about multi-core technologies can be found at *multicore.amd.com/* and *sun.com/processors/UltraSPARC-T1/*.

As with 64-bit systems, software vendors will gradually adapt their applications to take advantage of the parallel processing capabilities in multi-core systems. Vendors such as PTC who began using multi-threading to enhance performance of specific sections of PTC Pro/ENGINEER as early as 1997 have a head start in taking advantage of multi-core processors. The recent release of PTC PRO/ENGINEER Wildfire 3 includes another step in that direction with multi-threaded I/O for assembly retrieval.

Sun x64 workstations are available with single-core or multi-core processors and can be configured with up to 4 cores in a single system. As mechanical design applications reach for their next performance boost, Sun systems will provide the right architecture to optimize the execution of integrated design environments and software tools that utilize multi-threading.

Sun and PTC will continue to work together to advance the productivity of mechanical designers through innovative technologies such as high performance graphics, cost-effective 64-bit solutions, and architectures that take advantage of multi-core processors.

Learn More

For more information on Sun x64 systems, visit sun.com/x64 or talk to your local Sun representative.

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(1) Windows XP enabled an extension to 3GB of addressable memory, but this was still not enough for many designers.
(2) As of Feb. 12, 2006, the Sun Ultra 40 and Ultra 20 workstations claimed the top 2 spots among PTC supported configurations on the OCUS benchmark site, www.proesite.com. The Sun Ultra 40 workstation equipped with two dual-core Opteron Model 280 CPUs and an Nvidia Quadro FX 3450 graphics card achieved a score of 584 seconds on the OCUS V4 benchmark. This result demonstrates superior performance and is nearly 7 percent faster than the competing HP XW9300 workstation and up to 30 percent faster than the closest competing Intel Xeon-based workstation, the Dell Precision 670 which had a score of 845 seconds. For the latest OCUS benchmark results, visit http://www.proesite.com/OCUSB4/.