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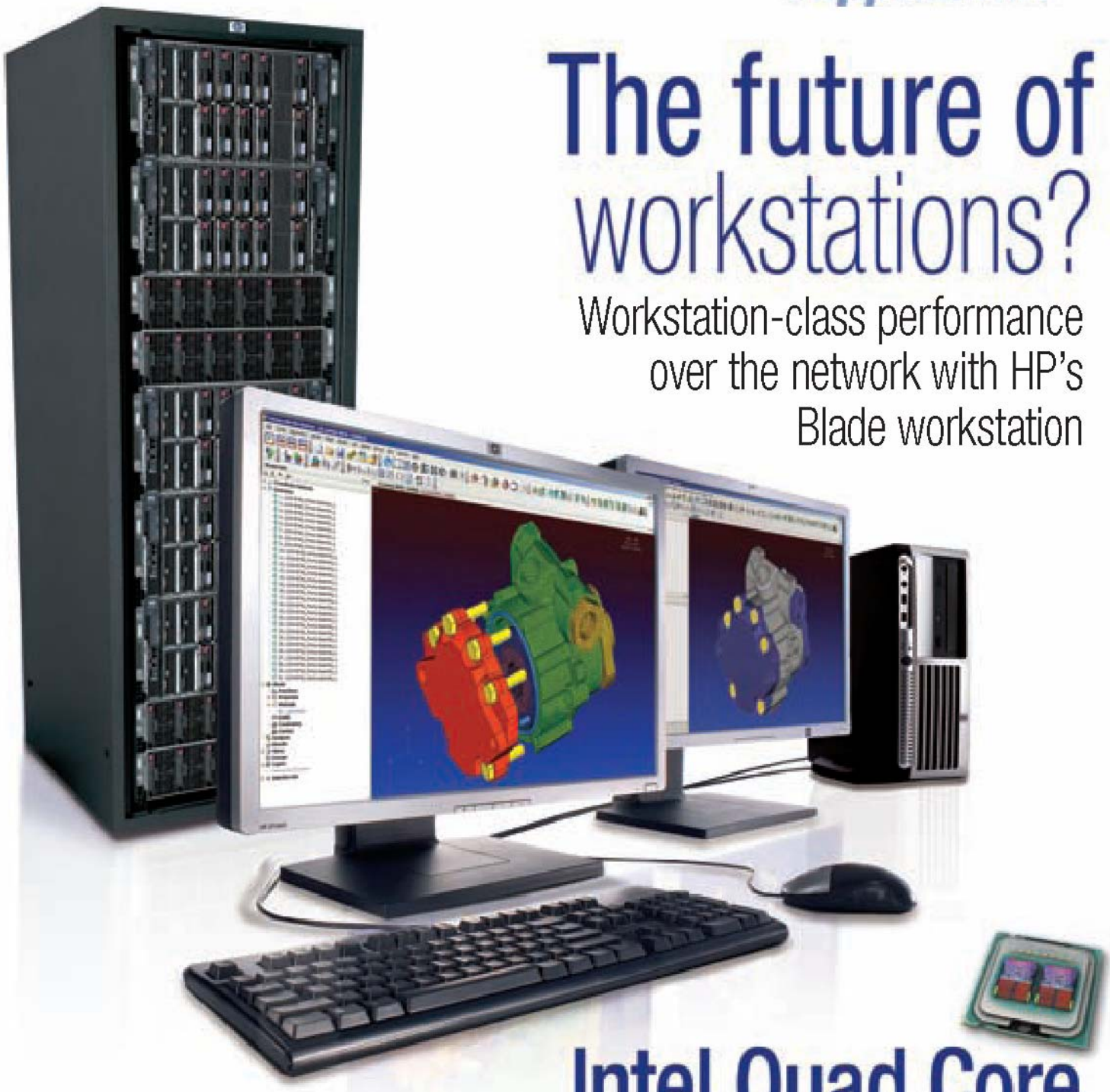
MCAD

Workstation supplement



The future of workstations?

Workstation-class performance over the network with HP's Blade workstation

Intel Quad Core

Laying the foundations for process change in CAD/CAM/CAE

Multi core workstations: we test four of the best from CAD 2, Scan, HP and XWorks

Quad Core for CAD

Quad Core processors have arrived, but there's a whole lot more to Intel's latest generation chips than boosting performance. The tools are in place to transform the whole product development process says Greg Corke.

EIGHTEEN MONTHS AGO all CPUs were single core and most workstations only had one processor – one processor that did absolutely everything inside the machine. If users wanted to carry out two tasks at the same time, they simply had to wait for the CPU to finish the first task before starting the second. Intel's HyperThreading technology, which uses spare CPU cycles to run two processes concurrently, smoothed this process a little, and there was always the option of a dual processor workstation. Based on Intel's Xeon or AMD's Opteron 200 series this enabled true multi-tasking, but the machines were often expensive and were really seen as high end workstation solutions.

This all changed with the introduction of Dual Core technology, where two processor cores are placed on a single piece of silicon. It brought multi processors (cores) to the mainstream, but the first generation chips disappointed, simply because they ran at a slower speed than the previous generation single core chips. Performance under most CAD applications went down and with the graphics card only communicating with one core, 3D graphics got slower. Despite having two chips for the price of one, most CAD software did not know how to make use of the extra chip as multithreading, a way of spreading computational load over multiple processors, was only implemented in a handful of CAD applications. Mainstream workstations could now do two things at once, but most individual tasks still took longer than they had before.

During 2006 CPU clock speeds increased and with new architectures, such as Intel's Xeon 5100 Series (Woodcrest), Dual Core processors matured into processing powerhouses. However, Intel is not content with simply putting two CPUs on a single piece of silicon, it has now given us Quad Core, which as it sounds is four chips on a single piece of silicon. And with dual socket workstations, where you can put two processors in a single machine, that means a total of eight cores! But what exactly are we supposed to do with all these cores?

Multithreaded software

Users of multithreaded software will be the immediate beneficiaries of having up to eight cores at their disposal – at least they will be if their software scales well over multiple cores. Multithreading lends itself best to software that needs to carry out substantial calculations that last minutes or hours, and this is mainly in the areas of analysis, CAM, or rendering. Most CAD applications, except some of the very high-end tools, are not multithreaded.

> "With Quad Core it's easy to analyse variations on a theme, whereas in the past you might have been content just to verify that your design wouldn't fail."

Even with applications that are multithreaded in certain areas of code, it is important to know that not all software uses multiple cores effectively. With the majority of FEA (Finite Element Analysis) and CFD (Computational Fluid Dynamics) software most analysis jobs will scale well over two cores, but users will derive much less additional benefit when utilising four or eight cores.

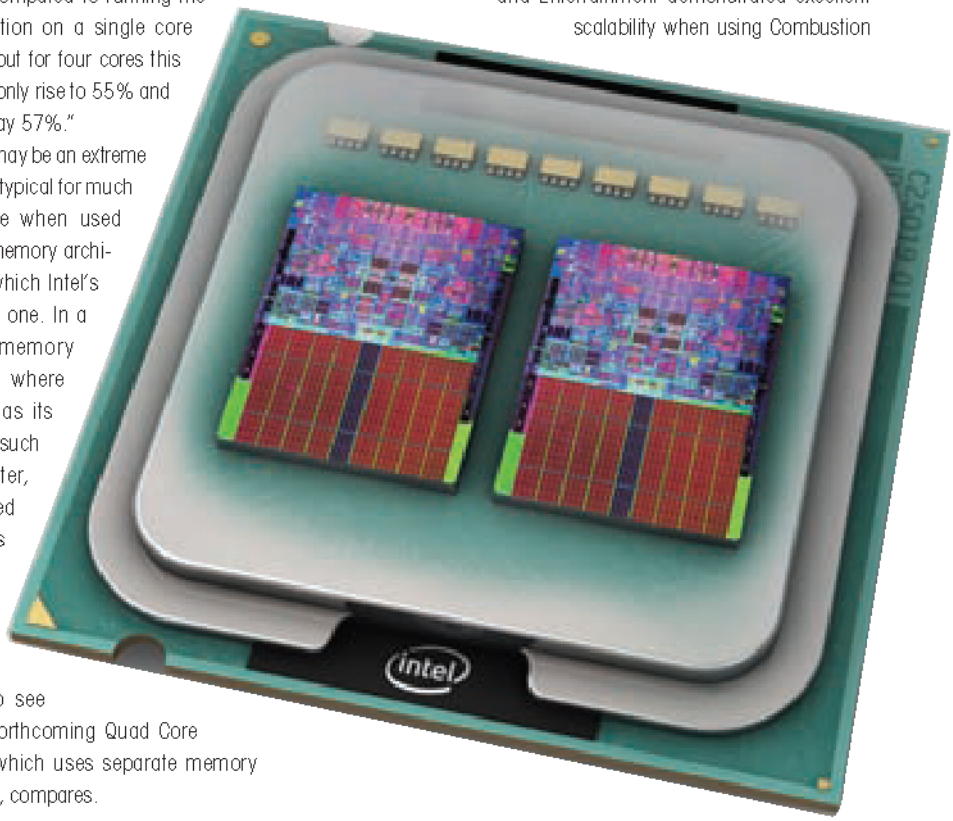
"Flo/Therm scales well over two cores," explains Peter Hall, Flomerics, about the company's thermal analysis software. "For two cores users typically get a 50% performance boost compared to running the same simulation on a single core workstation, but for four cores this will probably only rise to 55% and eight cores, say 57%."

While this may be an extreme example, it is typical for much CFD software when used with shared memory architectures, of which Intel's Quad Core is one. In a distributed memory environment, where each node has its own memory such as in a cluster, multithreaded applications tend to scale much better. It will be interesting to see how AMD's forthcoming Quad Core technology, which uses separate memory per processor, compares.

"Today we are using a threaded model that supports shared memory only," says Jim Spann Blue Ridge Numerics, developer of CFdesign for CFD. "This would be the case with multi-core machines which do not really scale well due to the memory addressing bandwidth. We expect to see about 25% speed up for Dual and approximately 40% for Quad Core machines. However, this will be much better in a distributed environment, which will be supported in the next release of CFdesign."

The ability to scale well over multiple cores is also dependent on the type of analysis and the size and nature of the problem. In Abaqus, the specialist Finite Element Analysis (FEA) application, the time taken to solve a simulation using multiple cores can vary greatly depending on whether the user is performing a linear or non-linear analysis. In rare circumstances, if the problem is of a certain complexity or type, using more cores can even increase the solve time!

However, some software is very much suited to multi core environments and is able to make use of all the power at its disposal. At the recent Quad Fest event, held in Colorado and hosted by HP and Intel, Autodesk's Media and Entertainment demonstrated excellent scalability when using Combustion



With the introduction of multi core processors, engineers are being given the capacity to carry out multiple compute intensive tasks in the background, while still designing in the foreground.

for video compositing. This kind of computing task works almost exclusively in CPU caches, so there's not so much pressure on the Front Size Bus or disk I/O. This is also true for most rendering applications, including 3ds Max and those built into CAD applications such as Autodesk Inventor, though memory bandwidth can become an issue at some point.

Multitasking

While multithreading is the most obvious way for software to take advantage of multi core architectures, more excitingly Quad Core is also laying the foundations to change the way engineers work. The ability to multitask using multiple cores for different computational tasks can help significantly optimise the product development workflow, a process that has traditionally been very fragmented.

Talking at HP and Intel's Quad Fest event, Dr. Andreas Vlahinos, principal of Advanced Engineering Solutions, a virtual resource for rapid new product development, explained this fragmentation. "Someone would build a CAD model, and then they would take the model and give to somebody else to do the meshing in preparation for the simulation," he said. "That mesh would then be passed on to another guy who would do the simulation, which may take a couple of weeks, and come up with some good suggestions as to how to improve the design. The CAD guy would then respond by saying 'now you're telling me!' I've already progressed with the design."

For many organisations this still rings true. Much of this analysis work is carried out on supercomputers or clusters, where there is always strong competition for compute resources and feedback is often too late. With Quad Core, engineers are being handed huge compute resources at their fingertips with the opportunity to carry out multiple analysis jobs at the same time. For example, two concurrent simulations taking two cores apiece in an eight core workstation would still leave plenty of resources for the engineer to prepare or mesh other simulations, or load up the design in the CAD application and rework it.

With this so-called analysis driven design, the engineer can get feedback on a design which traditionally would not have been available until much further downstream in the product development process. For example, the system could tell you 'don't make the hole that big or it will break; don't make it that small or there won't be enough airflow'. This is invaluable in the conceptual stages of design so the engineer can get closer to the right solution before going down the wrong path. It also means that they can investigate and optimise aspects of their designs that they always wanted to know more about but didn't have the time to do so. With Quad Core it's easy to analyse multiple variations on a theme, whereas in the past you might have been content just to verify that your design wouldn't fail.

And that has implications for the industry as a whole. "Time to market is not good enough any more, it's now about time to quality," says Vlahinos. "You need to be able to explore multiple design alternatives easily to get to the best design."

Naturally, running all of these processes concurrently requires a lot of memory and of course a 64-bit Operating System to utilise it. However, users are also likely to find bottlenecks in memory bandwidth or disk I/O. Generating new workflows on multi core workstations is still going to involve trial and error to find the optimum mix of processes – and Windows XP is not always the best at ensuring that applications run on separate cores (though this will improve with Windows Vista). From experience, we have all pushed our workstation to the limits in the past and ended up cancelling one task to save overall calculation time. Quad Core is no different except there is much more capacity before a tea break becomes inevitable.

The super engineer

But with the advent of Quad Core and the ability to perform multiple operations from design to analysis to manufacturing on a single workstation, does this mean you need to produce a 'super engineer', who is an expert in several areas? Not necessarily says Vlahinos, whose company exploits the Behavioural Modelling capabilities of Pro/Engineer and uses experts in areas such as thermal or structural analysis to help build intelligence into a base model which is then used by the engineer as the starting point for new designs. "Because performance attributes are built in, when the engineer starts generating geometry he can get instant feedback on his design," Vlahinos says. "At this stage he may only be interested in the maximum or minimum figures so there is not so much to interpret – is the temperature too high, is it too heavy, etc. Then, if it falls outside of this he can easily change it. It is so much easier to change things at the conceptual CAD stage if you know the performance of your design."

The graphics invasion

It is not just multi core CPUs that can offer new computational avenues for the CAD/CAM/CAE software developers to exploit. Graphics specialists Nvidia and ATI (AMD) are developing technologies that enable software vendors to harness the power of Graphics Processing Units (GPUs) in other areas than just graphics. When used as a general purpose co-processor these are called General Purpose Graphics Processing Units (GPGPUs), and offer high performance massively parallel processing capabilities. GPGPUs can be programmed to carry out a number of computational tasks usually done by CPUs, from physics effects in games to scientific research. It is also understood that the technology is currently being investigated by CAD/CAM/CAE software vendors as a means of offloading computationally intensive tasks such as FEA or CFD to GPUs rather than additional CPU cores, with some potentially staggering performance results.

Nvidia's Quadro Plex (top) and ATI's (AMD's) FireStream (bottom): technologies are now in place to enable GPUs (Graphics Processing Units) to be used for tasks normally reserved for CPUs.

In addition to taking over tasks traditionally carried out by CPUs, the graphics card manufacturers are also looking to exploit multiple cores to improve 3D graphics performance. Currently, graphics cards are limited by the speed of a single CPU core. However in the future it is likely that graphics cards will be able to communicate with multiple cores, reducing the CPU bottleneck which restricts 3D performance in many CAD applications and releasing their full potential. This could also help make technologies like Nvidia's SLI and ATI's Crossfire more viable in the long term.

Conclusion

It is an extremely exciting time for CAD/CAM/CAE software. Developments in workstation technology over the past months have laid solid foundations for future software development. With 64-bit computing and now multi core CPUs, software designers are not only developing for extended memory architectures, but looking for ways to harness the power of multiple processors. For years we have had dual processor workstations, but most CAD/CAM vendors failed to exploit this additional power by not making their software multi-threaded. CAE and rendering software applications are the exception.

With the introduction of multi core technology, there is a huge opportunity for CAD developers to integrate their software much more tightly with the simulation and manufacturing tools. High-end software can already assess the performance and manufacturability of a product, but by streamlining code to work effectively over spare CPU cores (or GPGPUs) we are moving closer to doing this in real time - or at the very least slashing design time by streamlining product development workflows.

The engineering community also needs to adapt, but in doing so there is a huge opportunity to improve time to market. In the past engineers would have to tailor the design process based on the tools they had. Now the tools are in place to help them take control of the design process.

www.intel.com / www.amd.com
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