intel®

eΛi

get it right®

"The Intel® tools
provided an
excellent return on
investment. Intel®
Parallel Inspector
allowed the code
to be validated as
'data race-free' on
our validation suite,
and Intel® Parallel
Amplifier allows us
to focus efforts on
the hotspots."

Andrew Cunningham
Technical Staff Member

Designing Quiet Products Faster

ESI Group Achieves Up to 450 Percent Faster Performance on Quad-Core Processors

By optimizing its noise and vibration simulation software for a quad-core Intel® Xeon® processor, ESI Group used Intel® Parallel Amplifier to identify hotspots, improving overall performance by more than 400 percent on certain problems when compared with the previous performance on a single-core processor.

Company	ESI is a world-leading software vendor for the numerical simulation of prototype and manufacturing-process engineering in applied mechanics. ESI attributes its success to the use of realistic material physics, providing "as good as real" virtual solutions that can replace the lengthy trial-and-error processes on real prototypes.
	ESI has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing and real-life use. This empowers engineers to refine manufacturing processes to achieve desired product performance and evaluate the effect of the environment in which the product is deployed.
Mission	ESI's products provide a unique collaborative and open environment for end-to-end virtual prototyping, thus eliminating the need for physical prototypes during product development. This solution enables ESI clients to achieve increased productivity, accelerated innovation, and a significant cost reduction.
Product	VA One* is the industry standard simulation software for full-frequency noise and vibration design. It is used in virtually every industry in which noise and vibration performance is important. Applications range from making quieter disk drives to improving the noise and vibration performance of the International Space Station.
Challenge	Provide VA One users with a fast, interactive design environment by reducing simulation times on desktop machines through optimization of multicore processing capabilities.
Results	ESI Group improved single-core performance by 30 percent by using Intel® Parallel Amplifier to identify hotspots in the single-threaded code, and overall quad-core performance improved by more than 400 percent (when compared with previous performance on a single-core processor) for certain problem types.
Impact	VA One users can now solve larger models interactively and get faster answers to many noise and vibration problems using their existing multicore machines.

Intel® Parallel Studio 2011 is a comprehensive tool suite that provides Microsoft Visual Studio* C/C++ developers with an innovative threading assistant, compiler and libraries, memory threading error checker, and threading performance profiler.

Boasting an array of innovative features and capabilities, Intel Parallel Studio equips developers to enhance productivity and enable reliable applications that leverage legacy serial code, take advantage of multicore, and scale for manycores.

From one-person startups to enterprises with thousands of developers working on a single application, Intel Parallel Studio makes it simple for developers to achieve a quick start, a fast finish, and the best results for code quality, reliability, and performance for serial and parallel applications.

Intel Parallel Studio provides powerful tools that can be used independently or together to meet the needs of workflows and development teams, advancing all phases of the development lifecycle:

Design—Innovative Threading Assistant
Intel® Parallel Advisor
Simplify threading and transform code by identifying those areas in C/C++ applications that can benefit most from threading.

Build and Debug—Compiler and Libraries
Intel® Parallel Composer
Develop effective applications with easier and faster multithreading of serial and parallel applications, and parallel models that meet your needs.

Tune—Threading and Performance Profiler
Intel® Parallel Amplifier
Speed and simplify finding multicore performance bottlenecks, and remove the guesswork for faster, improved decision making.

Verify—Memory and Threading Error Checker
Intel® Parallel Inspector
Ensure application reliability—regardless of your parallelism programming model—with root-cause analysis of crash-causing bugs.

To enjoy a free 30-day evaluation of Intel Parallel Studio, download it here: www.intel.com/software/products/eval

How ESI Group used parallelism to optimize for quad-core processors

ESI Group helps engineers design lighter, faster, and quieter products with VA One, simulation software for predicting the response of vibro-acoustic (VA) systems across the full frequency range. By integrating VA One into their design process, engineers can help ensure that their finished products will meet government legislation, competitive pressure, and tight development schedules without the fear of unexpected noise or vibration problems.

At the early stages of the design cycle, models change rapidly and it is important to be able to quickly make adjustments and interactively see results in real time. As a design progresses, models become more detailed and solution times increase accordingly. However, being able to solve models interactively is important throughout the entire design cycle and ensures that engineers spend their time solving noise and vibration problems rather than waiting for models to solve. A key requirement for VA One is the ability to solve models quickly with various levels of detail throughout the entire design cycle.

Optimizing for multicore processors

The widespread adoption of multicore machines has opened up new possibilities for fast interactive noise and vibration analysis in the early stages of a design. ESI Group looked for ways to take advantage of this by reducing solution times through improved use of multicore processing capabilities.

The graphical user interface of VA One is optimized for Windows* and the core solver components run on both Windows and Linux*. ESI confirmed that increased performance on desktop machines did not come from dramatically faster clock speeds. Instead, performance was enabled by multicore CPUs.

Because of tight development schedules, it was not feasible to rewrite the existing C++ code. Multithreading would have to be retrofitted to the existing code with minimal disturbance, and the source code would need to compile without modification on Linux or Windows IA-32 and Intel® 64 architecture. The solution ESI adopted for VA One was OpenMP* threading.
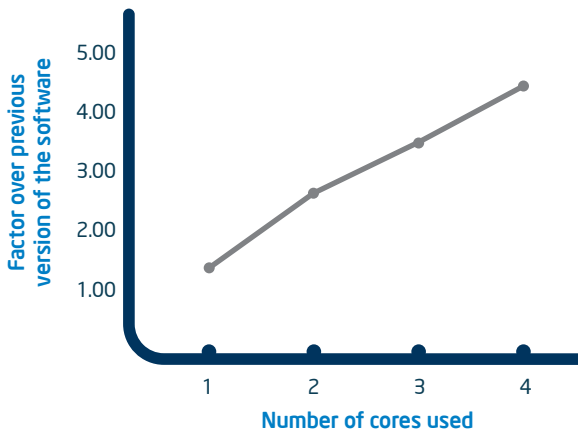
OpenMP threading

ESI knows that writing OpenMP multithreaded code that is both correct and efficient is very difficult without the correct tools.

"Naïve use of OpenMP threading constructs can end up with no benefit or even slower code than single-threaded code," said Andrew Cunningham, technical staff member at ESI Group. "Plus, the bugs are hard to find."

Underlying persistent storage of objects in VA One was not thread-safe, so all access to the database had to be protected with locks. The challenge was finding the balance in minimizing the use of locks and critical sections to reduce the impact on performance on core computations. In addition, legacy C code and C++ code used global variables and local static variables, which could not be accessed safely by multiple threads.

Execution times after optimization

Factor over previous version of the software (y-axis): 1.00, 2.00, 3.00, 4.00, 5.00
Number of cores used (x-axis): 1, 2, 3, 4

How Intel® Software Development Products enabled the solution

ESI profiled benchmark cases in VA One with Intel Parallel Amplifier, identifying the hotspots and where OpenMP threading would provide the greatest benefit. In addition, the Intel Parallel Advisor threading modeling tool was also used to validate potential areas to add OpenMP threading for best results.

At first, the OpenMP threading resulted in very little benefit in overall execution time. However, Intel Parallel Amplifier quickly identified locks and waits due to use of global mutexes and overuse of OpenMP-critical sections. ESI also discovered that Intel Parallel Inspector was crucial in finding data races and deadlocks that would have been very difficult to locate by simply running the code and waiting for an exception or other program error.

"The Intel tools provided an excellent return on investment," said Cunningham. "Threading bugs are notoriously difficult to locate and are subtle. Code will often run correctly 90 percent of the time and then randomly fail. Trial-and-error techniques are very time-consuming. Intel Parallel Inspector allowed the code to be validated as 'data race-free' on our validation suite, and Intel Parallel Amplifier allows us to focus efforts on the hotspots."

This resulted in significantly improved performance, enabling VA One users to account for noise and vibration right at the design stage, so they can manage risk by identifying and addressing possible problems that may need more detailed modeling or test-based development.

Benefits

- Improved single-core performance by 30 percent
- More than 400 percent performance improvement in quad-core processor performance (when compared with previous performance on a single-core processor)