White Paper

Livermore Software Technology Corporation: Leading-edge Crash Simulation Solutions

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1.0 Solution Summary

For engineers in product design analysis settings, today's competitive business climate means delivering more complex analysis in less time than ever before. Nowhere is this more critical than in the area of automotive crash simulation. Over 60 standard simulation cases are required by regulatory agencies, and many others are now considered essential business requirements. To meet these growing needs, Livermore Software Technology Corporation (LSTC) delivers leading-edge crash simulation with its LS-DYNA* solution. Together with the SGI® Altix® platform running on Intel® Itanium® 2 processors, this solution opens up dramatic new possibilities to design engineers by greatly reducing the time needed for crash analysis, and enabling them to simulate longer and more complex events.

2.0 Challenge: Accelerating and Improving the Simulation Process

Companies face a daunting array of product design and manufacturing challenges today. They need to deliver innovation and quality while also cutting product cost and getting to market faster. This puts pressure on automotive engineering design analysis teams to study more options and tests in a shorter amount of time, including a wide range of crash simulations.

Growing rapidly in size and sophistication over the past two decades, crash simulation has become part of the critical design path for the industry – an important decision-making tool. In addition to those tests mandated by government, insurance companies need simulations to evaluate risks, including specific car-to-car and car-to-passenger cases. To be of greatest value, all cases must be simulated in both the design and post-design phases, and repeated anytime a model is modified.

What's more, a number of automotive manufacturers are using superior passenger safety in collisions as a differentiator and powerful marketing element. This is yet another reason for companies to make greater use of crash simulations in vehicle design. In servers alone, automotive companies have roughly 50 teraflops of installed computing power, more than 60 percent of which is used for crash simulation. The key to enabling more timely and extensive simulation is making effective use of these computational resources through fast, accurate and affordable engineering solutions.

3.0 Solution: LS-DYNA* Crash Simulation on the SGI Altix Platform

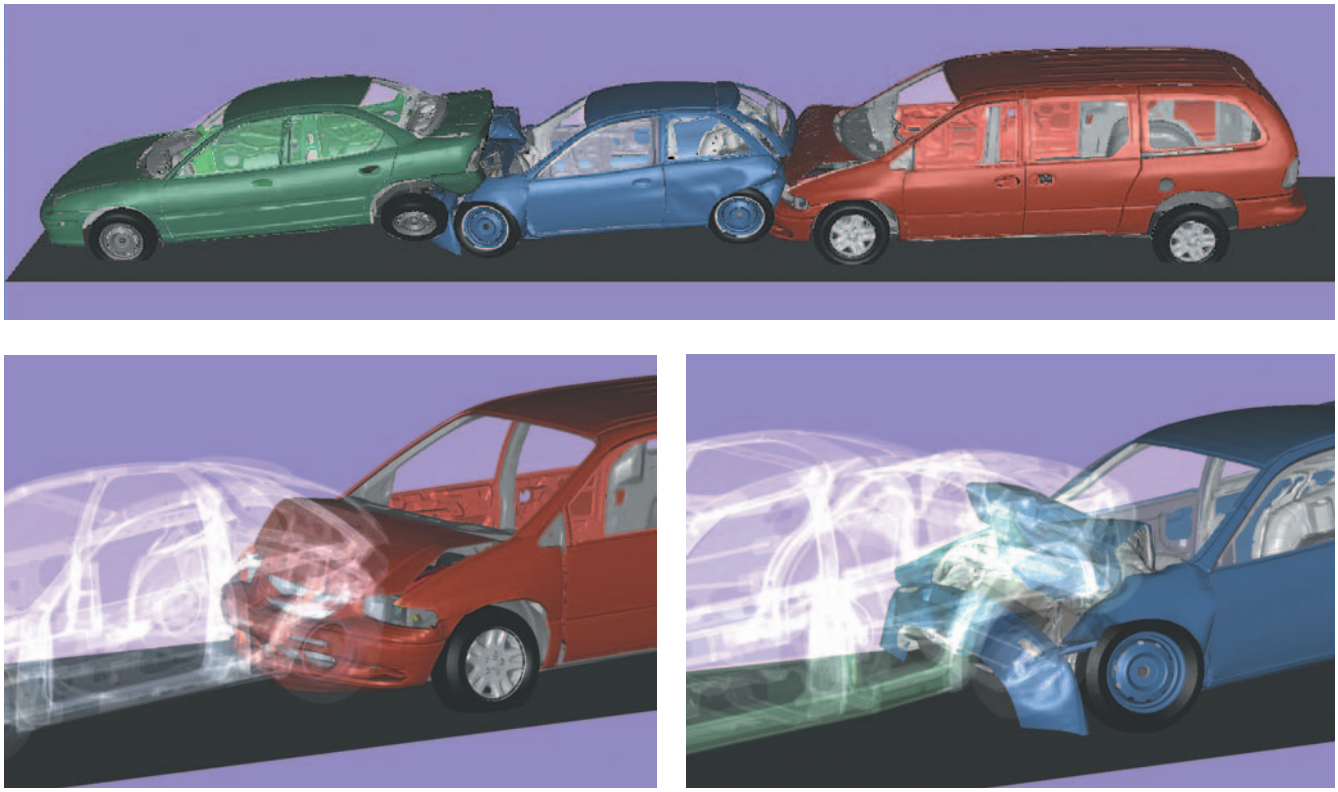
A solution that more than meets those requirements is the LS-DYNA* Crash Simulation program from LSTC, running on the Altix platform from SGI. LS-DYNA is an advanced general-purpose nonlinear finite element program that is capable of simulating complex real world problems. LSTC provides two additional analysis tools that work seamlessly with LS-DYNA. These tools include LS-OPT for optimization and LS-PREPOST for pre and post processing.

The most prominent application area is crashworthiness. LS-DYNA is able to handle the large deformations, the sophisticated material models, and the complex contact conditions that are needed for crashworthiness analysis. It can simulate the different types of car crash events that commonly include finite element or rigid body occupants: frontal and frontal offset impact, side impact, rear impact, and rollover. Among the many useful features are arbitrary spot welds, a choice of fully integrated and under integrated elements for shells and solids, and multi-body dynamics.

The Altix system, with its global addressable memory and high-speed backplane, minimizes the communication latency that is inherent in cluster architecture using commodity interconnects such as Gigabyte Ethernet. On the Altix system every processor sees the total memory at all times, whereas in a cluster each processor sees only local memory and must use explicit communication over an interconnect. The MPP (Distributed Memory Parallel) Version of LS-DYNA can take full advantage of the increased communication speed which is necessary to scale on large systems, say 128 CPUs.

"Another clear advantage of the Altix platform for LS-DYNA crash simulation is its ability to hold very large simulations in shared memory," says Christian Tanasescu, SGI Director of Engineering, Compute-Intensive Applications. SGI is currently developing an environment that will enable engineers to retain a complete automotive design in memory, perform a simulation using LS-DYNA, retain the results in memory, and visualize the results using LS-PREPOST.

"Visualization will always be the key to understanding complex models," Tanasescu said. "This simulation environment built around the Altix platform will enable engineers to focus on problem-solving rather than computer science."



150-millisecond three-Car collision model consisting of 791k elements, in a 150-millisecond simulation, run on the Altix® 3700 platform using 2-128 CPUs (149881 cycles).
"Model(s) developed by FHWA/NHTSA National Crash Analysis Center of the George Washington University."

4.0 Flexibility to Break Through Engineering Bottlenecks

The large shared memory of the Altix platform provides other benefits in the automotive engineering environment. LS-DYNA is demanding in terms of compute resources, and engineering departments may have many projects under development at any given time. This invariably means that the compute server must be shared between engineering teams. At times, however, some projects become urgent and must be given immediate priority. What then?

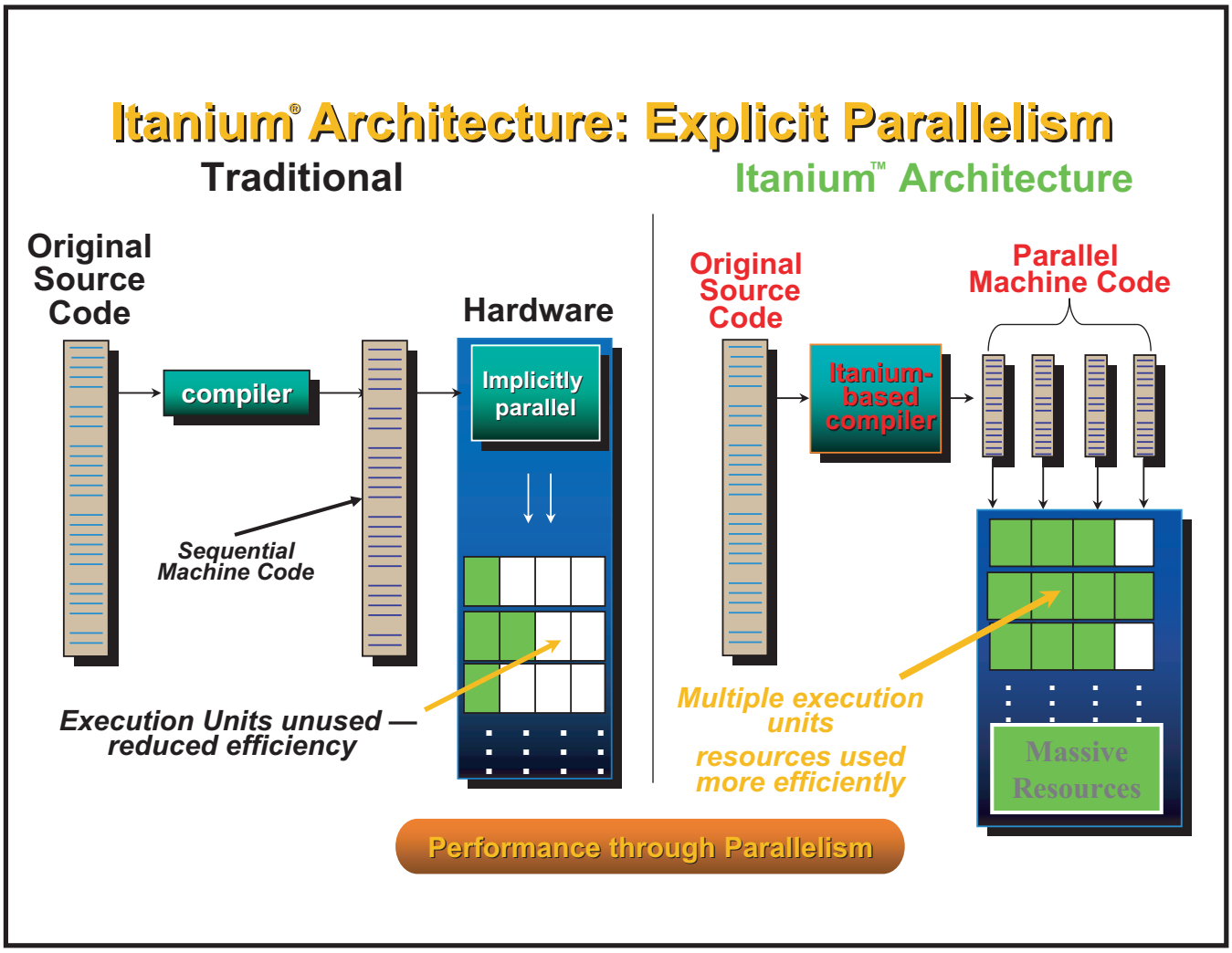
The scalable Altix shared-memory platform enables the department to assign more CPUs and memory to the urgent job to complete it more quickly. Other jobs running concurrently may take longer to complete, but the bottleneck is broken and the deadline is met. This ability to dynamically allocate resources enables engineering departments to be far more flexible and effective in the use of its server platform. The system can be running a mix of jobs, including LS-DYNA and other applications, that have differing requirement for CPU and memory resources. They draw on pooled resources according to their needs.

Automotive companies today need more than a productive platform. They need a platform that will make the other two cost factors – applications and engineers – more productive as well. The shared memory and high-speed communication architecture of the Altix platform was designed with that goal in mind.

5.0 Intel® Itanium® 2 Processors – Meeting the Need for Speed

The effects of a typical real-world crash on a vehicle, including deformation and energy absorption, are complete in about 120 milliseconds. A simulation of a 120-millisecond crash using a model of a million elements can now be run in about one hour with the right high-performance processors. The Intel® Itanium® 2 architecture that provides the processing power for the SGI Altix platform is Intel's highest-performance flagship server processor, and LS-DYNA is already tuned for the Itanium architecture.

This compute power opens up new possibilities for design engineers. Given the dramatically shorter simulation run time, they can now consider running additional simulations, including hypothetical "what-if" scenarios. These opportunities continue to power the growth of simulation in automotive design.



EPIC (Explicitly Parallel Instruction Computing) architecture enables the Itanium 2 processor to execute more instructions per clock cycle.

"We designed the Intel Itanium architecture from the ground up for enterprise and HPC-class assignments, including the kind of challenges represented by crash simulation," says Lisa Graff, director of Intel's Itanium Processor Group.

"It combines parallel architecture, a massive set of internal resources, and high bandwidth processing, I/O and memory to give it the highest available performance for compute-intensive applications. The reliability of its processors and systems, the scalability that gives it increasingly higher performance across a larger number of processors, and its inherent high performance combine to make it the ideal choice for HPC computing applications like crash simulation."

The explicitly parallel architecture of the Intel Itanium 2 processor, including its massive execution resources, gives it the ability to execute multiple instructions simultaneously, providing faster online transaction processing and enabling more users to access compute resources. Calculations and data analysis are accelerated and large CAD and CAE models can be moved and stored more quickly.

Parallel architecture also provides faster simulation and rendering times for automotive designs. Scalability is built into the design, with the ability to seamlessly add execution resources and issue ports to increase performance on demand. The Intel Itanium processor's internal resources include a massive on-die cache, 128 floating-point registers, and memory management features that enable more efficient management of large data sets.

The enterprise-hardened design of the Intel Itanium 2 processor includes features that provide high reliability, availability, serviceability, and manageability. The Advanced Machine Check Architecture provides extensive error management in hardware, firmware, and operating systems to minimize data loss, data corruption and downtime.

6.0 Looking Ahead: Teamed for Success

Intel 32-bit technology has proven to be highly cost-effective for automotive crash simulation and is the dominant platform across the industry today. However, with the development of larger models and the increased runtime required for rollover and multi-vehicle collision simulations, there is a need to run in double-precision. The Itanium 2 processor architecture with 64-bit addressable memory provides the platform to run these problems in a reasonable amount of time and with the necessary accuracy to obtain valid results.

The number of crash simulations required in the design process will continue to grow, as well as the complexity of the models. Intel's commitment to meeting this demand is demonstrated by its strong roadmap. Multiple Intel design teams currently have six Itanium processors in simultaneous development with the goal of increasingly higher performance at reduced cost. By 2007, Intel expects to ship Itanium processors with twice the performance levels of the Intel Xeon* processor line at the same system price.

In harmony with this goal is the recent introduction of a second SGI Altix product line: Altix® 350. The initial Altix product line, the Altix® 3000 series, has outstanding scalability. SGI is the only computer hardware vendor that has published results from scaling LS-DYNA up to 128 processors. Typically, LS-DYNA users run crash simulations in distributed processing mode on 12-16 processors. Each Altix 350 fat-node cluster scales up to a maximum of 16 processors, providing shared-memory connectivity advantages and a single system image in a highly cost-effective architecture. Multiple Altix 350 systems can be clustered to reach whatever capability levels are needed.

"We're pleased to be working closely with Intel and SGI to enable our customers to take advantage of the powerful combination of the Intel Itanium 2 processor architecture and the SGI Altix server," says John O. Hallquist, President and CEO of LSTC.

"As the size and number of crash simulations increase, automotive engineers need to be able to work with computing platforms that provide greater performance and scalability," he said. "One of the reasons we've optimized LS-DYNA to run on the Altix platform is to enable them to build more complex simulations that will run in an acceptable time."

7.0 Lessons Learned

Manufacturers combining LS-DYNA and the SGI Altix platform with Intel Itanium 2 processors are finding that:

- The shared-memory architecture and the high speed interconnect of the SGI Altix platform enables users of LS-DYNA for crash simulation applications to extract maximum performance from the Intel Itanium 2 processor and dramatically improve application performance and productivity.
- The Altix platform permits a better analysis of physical phenomena, and at the end of the day enables better automotive engineering.
- The Altix and Intel Itanium architectures give automotive companies a clear road map for cost-effective growth.

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