Benchmark Study:

Optimized Drop Testing with Dell, Intel and Altair

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Introduction

Impact analysis or drop testing is one of the most important stages of product design and development, and software that can simulate this testing accurately yields dramatic cost and time-to-market benefits for manufacturers. Dell, Intel and Altair have collaborated to analyze a virtual drop test solution with integrated simulation and optimization analysis, delivering proven gains in speed and accuracy. With this solution, engineers can explore more design alternatives for improved product robustness and reliability. As a result, manufacturers can significantly reduce the time to develop high-performing designs, improving product quality while minimizing time to delivery..

Challenge:
Improving Drop Testing Speed and Accuracy

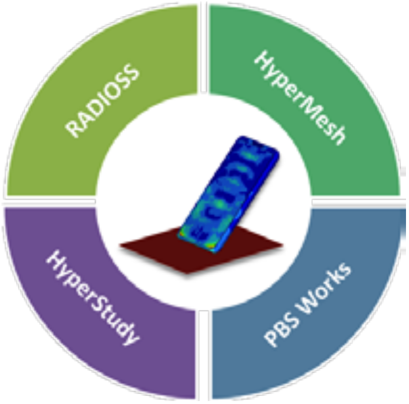
From smartphones to car parts, products need to be tested for their impact performance prior to production. It is the job of the manufacturer to design and develop products that perform as well as possible when dropped, crushed or otherwise placed in danger of permanent damage.

Drop test simulation software helps manufacturers by speeding up the time to test a product, enabling higher levels of design quality and reducing the need for physical testing. Such software replicates the complexity of the physical environment and materials, simulates the impact or drop event, and provides detailed technical information about how the product performs during this event.

In general, software for this type of problem is mature since both the demands of drop testing and the software solutions originate from car crash modeling. However, there are unique challenges when dealing specifically with phone drop testing, including the fact that phone drop testing includes a higher number of parts with many different materials and assembly techniques, all which must be carefully modeled to evaluate potential impact damage. In addition, engineers must manually set up the model and post processing, all of which is time consuming.

The end goal is to have a robust product that can withstand all drop angles and other types of loads (window pressure, bending, twisting etc.). This requires numerous simulations where a fast, scalable solver is required, as well as a software environment that allows engineers to explore more design alternatives to gain a deeper understanding of the physical behavior during the impact event. In addition, engineers need integrated, automated solutions with key elements like optimization embedded, to streamline processes and reduce risk of error.

Solution: Accelerated Drop Test Simulation with Dell, Intel and Altair



In this study, Dell, Intel and Altair have collaborated to test Altair's drop test simulation software on a Dell cluster powered by Intel processors. The infrastructure provided by Dell and Intel helps to accelerate simulation by increasing the performance of the impact analysis solver, RADIOSS, when running on a Dell high-end cluster equipped with the latest Intel E5 v2 processors. This solver, which is the critical compute-intensive component of the Altair Drop Testing solution, is used to perform the types of complex simulations that can benefit from very efficient hardware and fast processors.

Altair Drop Testing Solution

Altair's automated drop testing solution consists of a suite of integrated software tools engineered to optimize performance, throughput and usability:

- **HyperWorks** modeling, analysis and optimization software suite integrates the following components into a full drop testing solution:
  - High-performance finite element pre-processing product (HyperMesh) to prepare even the largest models, starting from import of CAD geometry to exporting an analysis run for various disciplines
  - Structural analysis solver (RADIOSS), which has been established for over 20 years as an industry standard for automotive crash and impact, with the highest levels of quality, robustness and scalability. With RADIOSS' Advanced Mass Scaling (AMS) technology, RADIOSS users can see even better performance.
  - State-of-the-art design exploration, approximation and optimization embedded software (HyperStudy) including shape optimization, direct parameterization, data mining, and direct RADIOSS results readers
  - Altair's Impact Simulation Director (ISD) to automate the laborious, manual tasks associated with model setup, analysis, post-processing and reporting
- **PBS Professional** workload management software for high-performance computing (HPC) job scheduling, with high scalability and usability, proven for over 20 years at thousands of customer sites.

Previous testing by Altair has shown this solution, with RADIOSS' AMS enabled, can reduce drop test runtimes from 65 to 36 minutes (45% improvement), compared to 64 minutes runtime produced by a leading alternative solver.

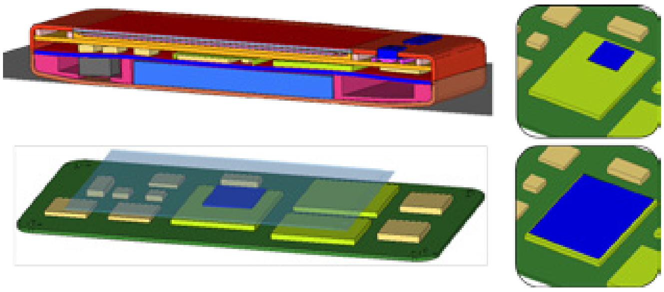
Dell HPC Solutions Based on Intel Technology

Dell provides HPC building blocks and turnkey solutions to enable organizations to harness the power of HPC technology and optimize their product innovation and development. Working with Intel and Altair, proven solutions for product development can be brought to market that improve productivity, decrease costs and simplify management of complex cluster environments.

In the case of this drop testing analysis, the Dell PowerEdge M620 blade servers were chosen based on the Intel Xeon processor E5-2600v2 product family. These powerful and energy-efficient processors provide 50% more cores and cache than the previous generation; along with faster memory and additional hardware enhancements over the previous generation of Intel Xeon processor-based servers.

Higher performance for HPC applications can be achieved through Intel® Advanced Vector Extensions (Intel® AVX). Intel® AVX speeds vector and floating point computations with support for 256-bit vectors and accelerated 32/64 bit data conversions. The Intel Xeon processor E5 v2 Family offer a comprehensive range of processor specifications from core count to frequency optimized models in order to match the user's application demands.

Benchmarking Project Overview



Introducing a gasket between PC board and LCD module to reduce deformations in case of a back drop – two different damper shapes are shown on the right side.

To test performance of the Dell-Intel-Altair solution, engineers focused on a specific use case testing whether the addition of a damper gasket would reduce stress on a phone design.

In this scenario, the gap between the phone shield and carrier plate causes bending and high stress levels in the LCD module in a back drop test. The goal was to find an optimized gasket design with ideal characteristic (thickness, size, flexibility etc.) that minimizes filtered stress in the edge elements of the LCD.

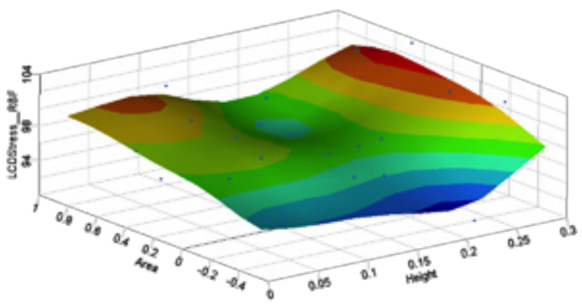
1. **Design:** In the first stage of the project, the concept was modeled in HyperMesh and design variables were generated with morphing technology as well as input file parameterization.

2. **Optimize:** A design-of-experiment (DOE) was performed to generate a response surface. Then, optimization was performed on the response surface instead of the finite element model.

3. **Verify:** The optimized design was evaluated/simulated with finite element analysis (FEA) and performance results verified.

These simulations were run on systems with the following components:

- 16x Dell PowerEdge M620 blade servers using Intel Xeon E5-2680v2, E5-2667v2, and E5-2697v2 processors, 128 GB memory per node, leveraging Mellanox FDR InfiniBand interconnects.



Result surface for LCD stresses as function of damper area and thickness.

Performance Results

Using Altair' RADIOSS software running on a Dell PowerEdge M620 blade system, engineers were able to run the 21 drop test simulations required in this optimization study and benchmark 3 different Intel processors (Intel Xeon E5-2680v2, E5-2667v2, and E5-2697v2 processors respectively) in 2-node configurations, with the following core and raw performance data:

CPU	Total cores for 2 nodes	Raw FP performance GFLOP/s	Single Run Mean Time (s)	Total Time For 21 runs (s)
E5-2680v2	40	896	719	15110
E5-2667v2	32	845	742	15598
E5-2697v2	48	1037	660	13868

Figure 1. Performance Summary

Clearly, the best-performing processor in term of elapsed time is the E5-2697v2, the product with lower frequency but higher core count. This performance is possible due to the excellent scalability of RADIOSS, since the lower frequency or intrinsic performance of each core does not negatively impact performance across the high number of cores.

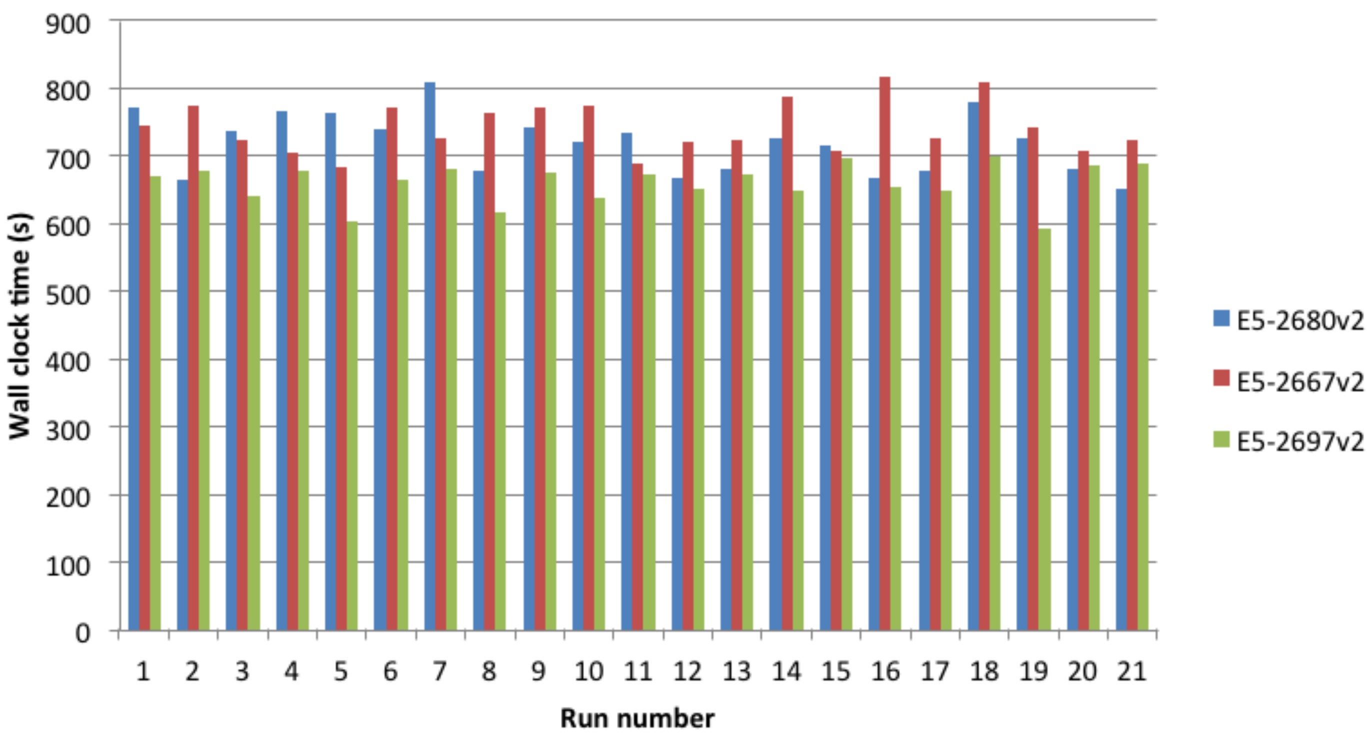


Figure 2. Performance Details

Compared to the reference time of 65 minutes (3900 seconds) achieved on a single node of Intel Xeon X5570@2,93 GHz (with a total of 8 cores), 2 nodes with E5-2697 v2 is about 6 times faster (660 seconds only for a single run). This allows the completion of the entire optimization study (21 simulation runs) in less than 4 hours (13,868 seconds).

In addition, with the RADIOSS' Advanced Mass Scaling (AMS) option, replace with: users can further accelerate time-to-solution while retaining the same accurate results. AMS provides an advanced solution for quasi-static problems and an alternative to implicit non-linear simulations where convergence is sometimes hard to achieve, for instance due to high non-linearity in the contacts, complex material behaviors, and rupture modeling.

The expected speedup with AMS is to be 1.7x, with a completion time of less than 2.5 hours (less than 400 seconds for a single run) using the fastest configuration based on Intel E5-2697v2.

Another aspect to consider when optimizing configurations is that scalability is not just a function of the Intel Xeon processor and the number of cores chosen but also of the number of nodes used. Owing to the parallel nature of these simulations, one can assume that by running approximately half of the 21 runs on the first 2 nodes and the rest on a second group of 2 nodes, a speedup of approximately a factor of 2 can be achieved. This logic can be used to extrapolate real-life results using more nodes to achieve the desired simulation time – for an 8 node simulation cluster for example. Such an approach could be simplified by the use of a tool like PBS Professional that automatically distributes the simulation jobs over the available resources to optimize computational efficiency and resource utilization.

Energy Efficency and Performance

In today's business strategy and planning processes, power and cooling has become an important aspect in making purchasing decisions. The energy efficiency of any simulation configuration can therefore be vital to organizations looking for optimal energy use as well as optimal performance.

While performing the simulation tests on the Dell PowerEdge blade system, the power consumption measured in total Watts was captured for each simulation run (see chart below). While the overall power consumption of the Intel Xeon E5-2667v2 and E5-2697v2 retains a similar level, the Xeon E5-2680v2 clearly requires less power when performing the 21 simulations as part of this test case.

Looking at it another way: For a 24x7 always-on production workload environment, the Intel Xeon E5-2680v2 consumes 21.3% less power per node than the Intel® Xeon® E5-2697v2 which is more than the TDP difference of 115W vs. 135W (17%).

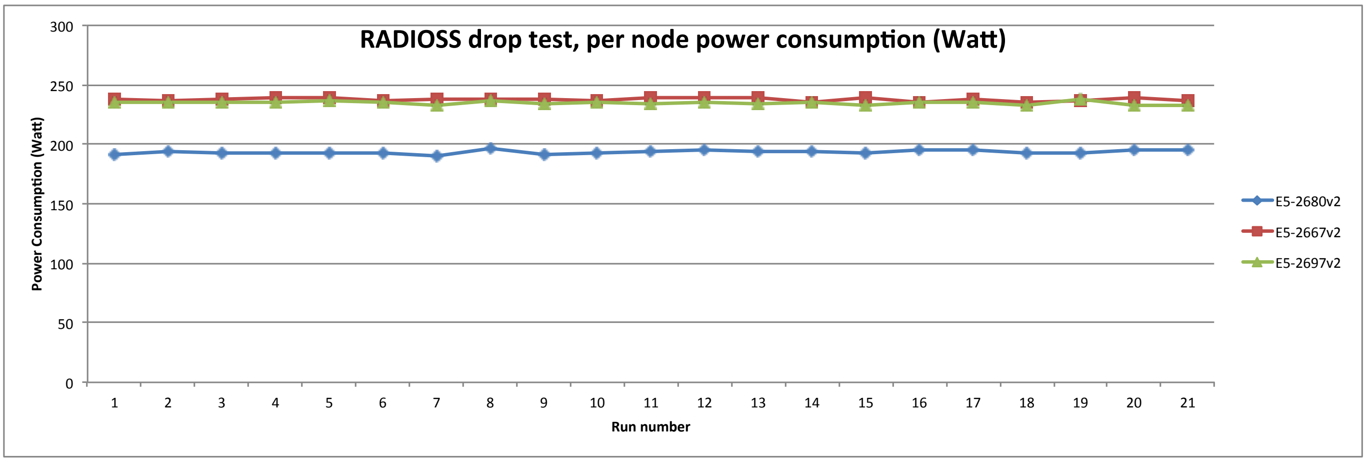


Figure 3.

Recommended Configurations

When looking at overall performance, price/performance, and energy efficiency, the following recommendations can be made for the nodes required to setup a simulation environment based on the drop test case scenario. The actual number of nodes will depend upon the overall workload requirements.

Maximum performance:

Dell PowerEdge compute node using Intel Xeon E5-2697v2 processors (total 24 cores per node),

- 64GB memory, and Mellanox ConnectIB card
- Minimum configuration: 2 nodes

High-end performance, maximum energy efficiency:

Dell PowerEdge R720 compute node using Intel Xeon E5-2680v2 processors (total 20 cores per node),

- 64GB memory, and Mellanox ConnectIB card
- Minimum configuration: 2 nodes

Entry-level system:

Dell PowerEdge R620 compute node using Intel Xeon E5-2667v2 processors (total 16 cores per node),

- 32GB memory, Intel NetEffect X520 iWARP card
- Minimum configuration: 2 nodes

Results Summary

In conclusion, the key results gleaned from this study are:

- The Dell-Intel cluster delivered a 6x speedup for RADIOSS drop test simulation compared to the reference case
  - Intel Xeon E5-2697v2 produced best speedup of the 3 processors tested
  - Less than 4 hours completion time for 21 simulation runs

- RADIOSS' Advanced Mass Scaling (AMS) can deliver additional 1.7x speedup
  - Estimated 1.7 times faster with AMS enabled
  - Completion time of less than 2.5 hours (less than 400 seconds for a single run)

- Intel Xeon E5-2680v2 delivers optimal energy efficiency
  - Intel Xeon E5-2680v2 requires less power when performing the 21 simulations in this test case
  - For a 24x7 always-on production environment, the Intel Xeon E5-2680v2 consumes 21.3% less power than the Intel Xeon E5-2697v2 which is more than the TDP difference of 115W vs. 135W (17%).

Using Altair's drop testing solution on Dell/Intel systems, design engineers can optimize phone impact performance and ensure warranty and customer satisfaction requirements are met. They can also improve design quality by exploring the effects of changes and gaining insight into the dynamic behavior of real world drop testing, with detailed data on how product components perform. With reduced product development timelines and costs, manufacturers have more time to focus on improved design -- resulting in a better final product.

Beyond drop testing, there are a range of technical computing applications within the Altair HyperWorks simulation suite that benefit from using high-end Dell clusters powered by the latest Intel processors, in fields like stamping, noise, vibration and harshness (NVH) simulation, computational fluid dynamics simulation, and more.

For More Information

- Learn more about Altair software:
  - HyperWorks suite: www.altairhyperworks.com
  - PBS Works suite: www.pbsworks.com
- Request a demo: www.altair.com/dell-intel-drop-test
- Learn more about Dell: www.dell.com and www.dell.co.uk/hpc
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  - blogs.intel.com.
  - www.intel.com/products/server/processor/xeonE5/index.htm

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