Vehicle Crash Using ANSYS LS-DYNA in the Opin Kerfi Cloud

An UberCloud Experiment

With Support From:

UberCloud Case Study 205

http://www.TheUberCloud.com

July 18, 2018

Welcome!

The UberCloud* Experiment started in July 2012, with a discussion about cloud adoption in technical computing and a list of technical and cloud computing challenges and potential solutions. We decided to explore these challenges further, hands-on, and the idea of the UberCloud Experiment was born, and since then generously supported by Hewlett Packard Enterprise and INTEL.

We found that especially small and medium enterprises in digital manufacturing would strongly benefit from technical computing in HPC centers and in the cloud. By gaining access on demand from their desktop workstations to additional and more powerful computing resources in the cloud, their major benefits became clear: the agility gained by shortening product design cycles through shorter simulation times; the superior quality achieved by simulating more sophisticated geometries and physics and by running many more iterations to look for the best product design; and the **cost** benefit by only paying for what is really used. These are benefits that obviously increase a company's innovation and competitiveness.

Tangible benefits like these make computing - and more specifically technical computing as a service in the cloud - very attractive. But how far are we from an ideal cloud model for engineers and scientists? At first, we didn't know. We were facing challenges like security, privacy, and trust; traditional software licensing models; slow data transfer; uncertain cost & ROI; lack of standardization, transparency, cloud expertise. However, in the course of this experiment, as we followed each of the 200 teams closely and monitored their challenges and progress, we've got an excellent insight into these roadblocks, how our teams have tackled them, and how we are now able to reduce or even fully resolve them.

The aim of this UberCloud Experiment #205 is to demonstrate the cloud performance of a frontal crash simulation of a vehicle against a rigid wall to examine injury risk and potential of safety with various FE models and to perform contact–impact nonlinear dynamic analysis of rigid wall with vehicle. In this study the ANSYS LS-DYNA Explicit solver is used to simulate the crash of the vehicle with a rigid wall. The main objective of this project is to understand vehicle crash behavior under dynamic conditions. The simulation framework is developed and executed in UberCloud HPC containers in the Opin Kerfi Cloud to achieve accurate result prediction.

We want to thank all team members for their continuous commitment and contribution to this exciting project. And we want to thank our main sponsors **Hewlett Packard Enterprise** and **INTEL** for generously supporting all the 203 UberCloud experiments.

Now, enjoy reading!
Wolfgang Gentzsch and Burak Yenier

) UberCloud is the online community & marketplace where engineers and scientists discover, try, and buy Computing Power as a Service, on demand. Engineers and scientists can explore and discuss how to use this computing power to solve their demanding problems, and to identify the roadblocks and solutions, with a crowd-sourcing approach, jointly with our engineering and scientific community. Learn more about UberCloud **HERE.*

Team 205

Vehicle Crash Using ANSYS LS-DYNA in the Opin Kerfi Cloud

> *"Combination of Opin Kerfi Cloud with UberCloud ANSYS LS-DYNA containers provide a powerful platform for accurate simulations that involved impact physics."*

MEET THE TEAM

End-User/CFD Expert: Praveen Bhat, Technology Consultant, India
Software Provider: ANSYS 19.0 with finite element code LS-DYNA
Cloud Provider: Tryggvi Farestveit, Richard Allen, Anastasia Alexandersdóttir, Opin Kerfi, Iceland
HPC Expert and Service Provider: Ender Guler and Ronald Zilkovski, UberCloud.

USE CASE

There are many severe and fatal crashes that result from vehicles colliding each other or to any stationary object. These cause extremely high impact forces and deformation on the frontal area of the car. The objective of the study is to demonstrate the frontal crash simulation of vehicle against a rigid wall to examine injury risk and potential of safety. In particular, various FE models are used to perform contact–impact nonlinear dynamic analysis of rigid wall with vehicle. In this paper ANSYS LS-DYNA Explicit solver is used to numerically simulate the crash of the vehicle with a rigid wall. The main objective of this project is to understand Vehicle crash behaviour under dynamic conditions. The simulation framework is developed and executed in the Opin Kerfi Cloud with UberCloud ANSYS containers to achieve good accuracy in result prediction and also with respect to the solution time and resource utilization.

Process Overview

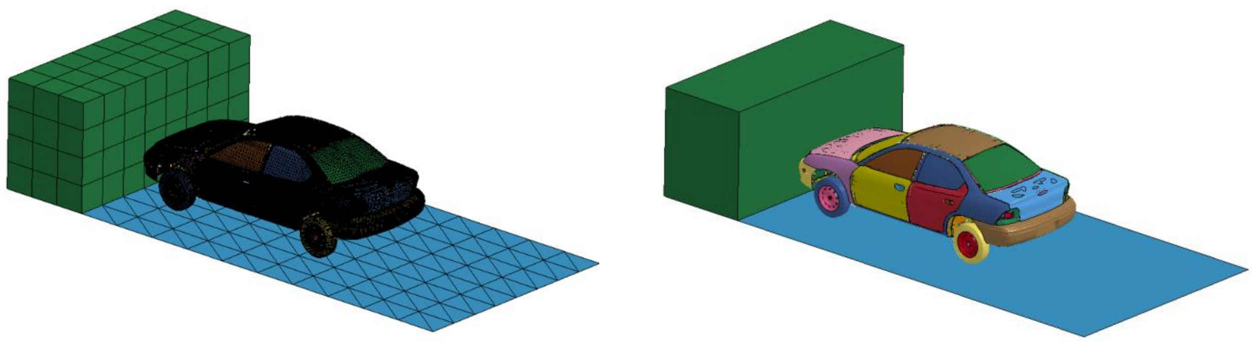

Figure 1: Geometry & Mesh model for a car crash analysis

1. The car model is meshed using the 2D quad mesh elements. The contacts and interactions between different components in the car assembly is defined.
2. The material properties for different parts of car is defined. The section properties are defined which involved thickness definition for different components in the assembly.
3. The next step in the model setup is defining the model boundary conditions and assigning load curves. The rigid wall is considered for the car assembly impact and the speed for impact for the car is defined as a load curve.
4. The solution algorithm and convergence criteria are defined along with the output parameters and results to be written for post processing.
5. The model is solved in ANSYS LS-DYNA in parallel and once the solution is converged, the final result is used to visualize the output of the simulation result, and the respective result components are captured using the post-processing software tool in ANSYS.

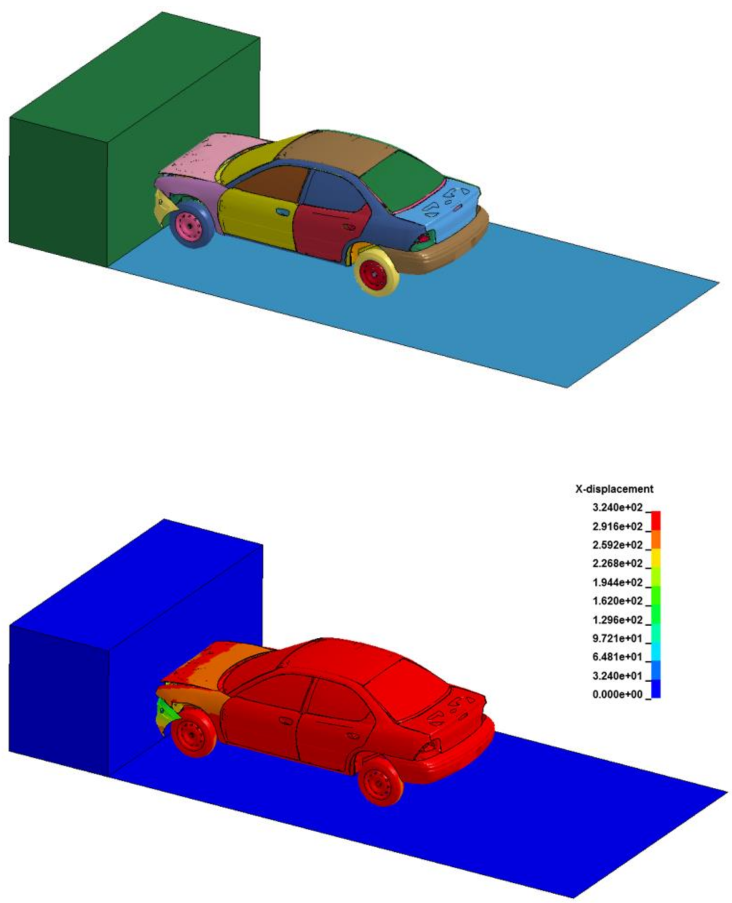

Figure 2: Deformation plot of the car assembly and the rate of progressive damage during impact to rigid wall

The car impacts to the rigid wall, and the damage is progressive and depends on the rate and velocity at which the vehicle impacted the wall. Damage due to impact on the car components is shown in Figure 3 with the rate of damage which can be compared visually:

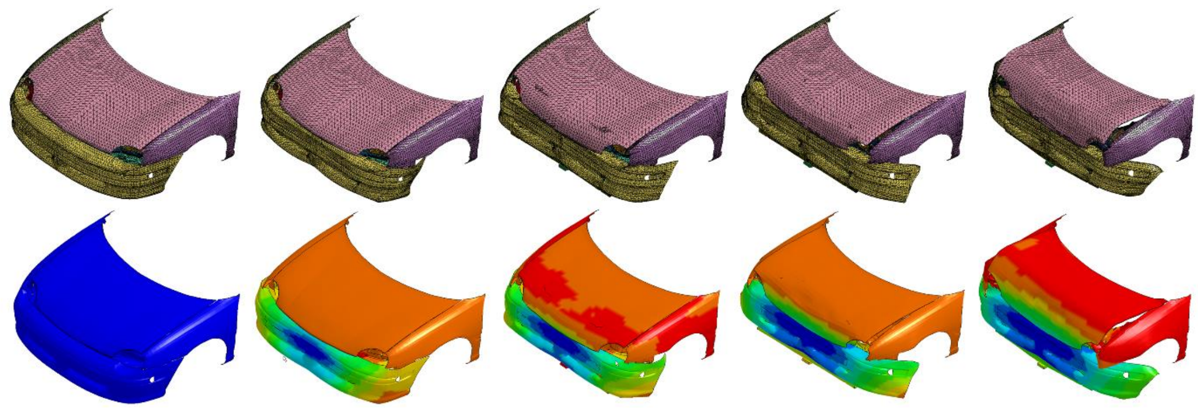

Figure 3: Rate of damage due to frontal impact of the car to the wall

HPC Cloud Simulation

The HPC system is a 256-core system with 130 GB RAM having centos Operating system. The car assembly is simulated using ANSYS LS-DYNA in the UberCloud HPC container, which is integrated with the Opin Kerfi cloud platform. The model is evaluated for the impact behaviour of the vehicle and also determine the rate of damage and the stresses developed on the car assembly.

Different finite element models are developed by developing both fine and coarse meshes. The models are submitted to ANSYS LS-DYNA. The time required for solving the model with different mesh intensity is then captured to benchmark the HPC performance in solving high density mesh models. The boundary conditions, solution algorithm, solver setup and convergence criteria remain the same for all the models developed.

Figure 4 & 5 provides the comparison plot of the solution time required for different mesh density model with and without parallel processing. The comparison of the solution time with single core processor and 128-core processor shows that the solution time required is significantly less when compared with running the same simulations with single core.

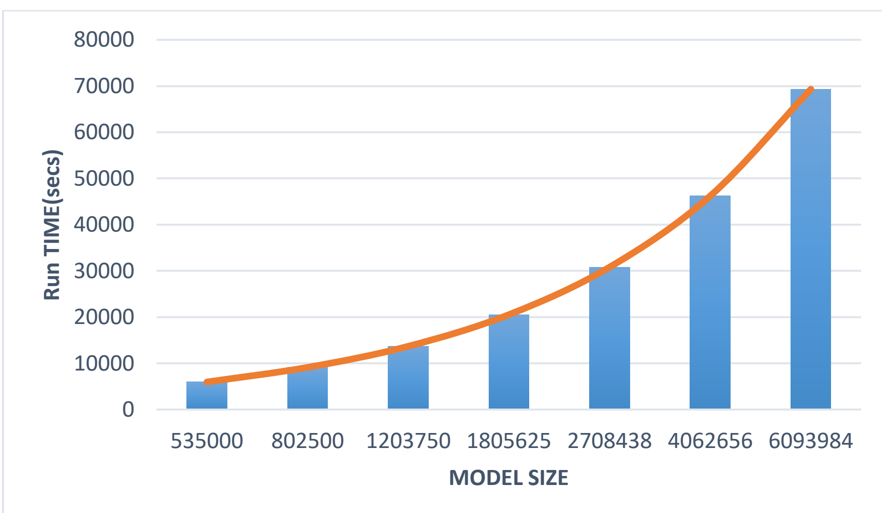

Figure 4: Solution time required for different mesh density with single CPU Core

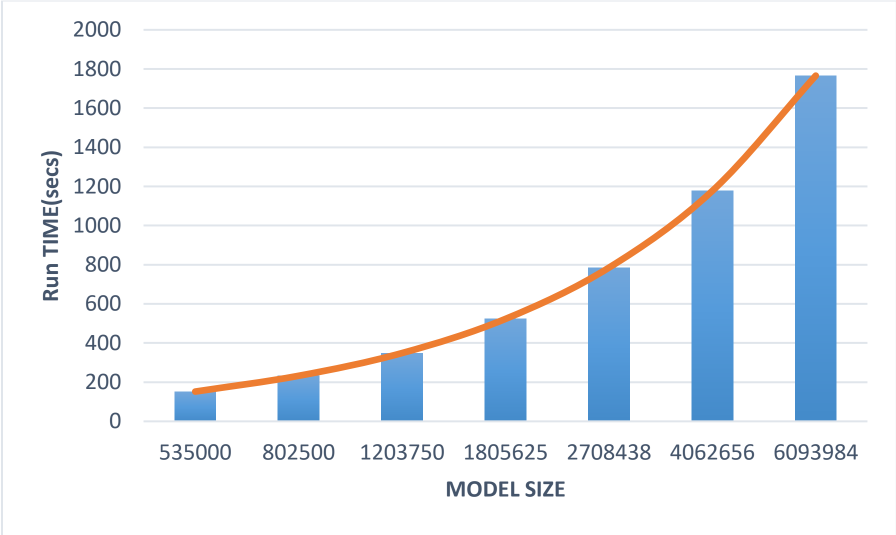

Figure 5: Solution time required for different mesh density using 128 CPU Core

Figure 6 shows the comparison plot on the solution time required for a model with 535K elements which are submitted with different CPU Cores. Figure 7 provides the comparison on the solution for different Fine mesh models submitted using different CPU Cores. Parallel computing provides the advantage of solving highly fine mesh model for a complex simulation like car frontal crash with a very lower solution time.

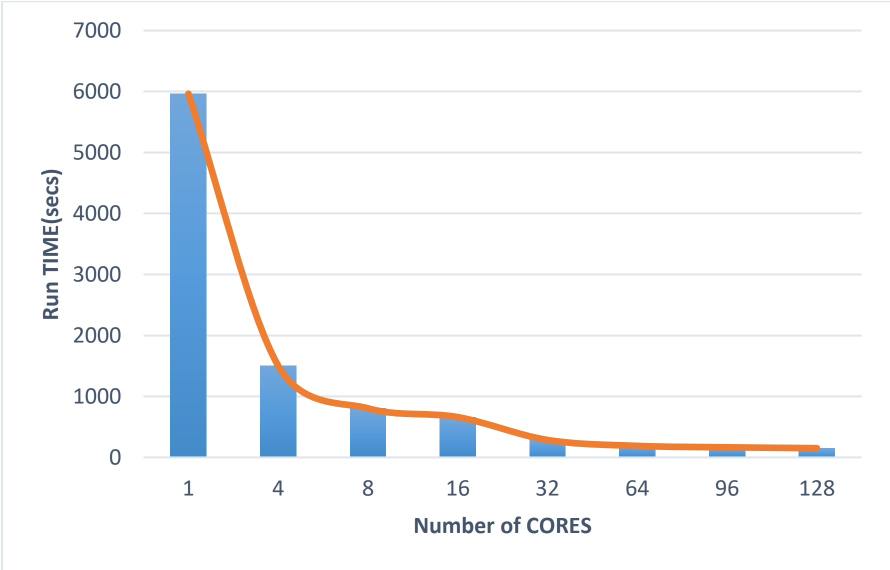

Figure 6: Solution time for a model with 535K elements solved using different HPC Core configuration

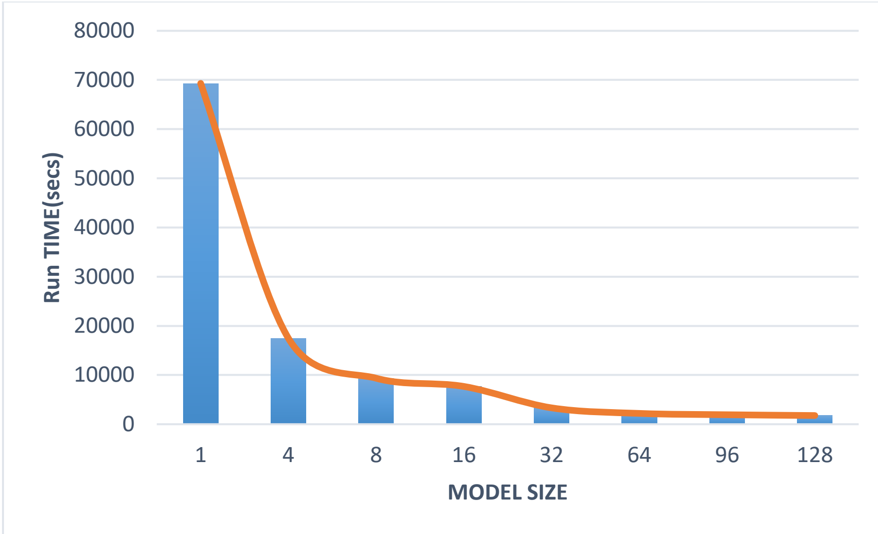

Figure 7: Comparison in solution time for different mesh densities models solved using different HPC core configuration

Effort Invested

End user/Team Expert: 70 hours for simulation setup, technical support, reporting and overall management of the project.

UberCloud support: 1 hours for monitoring & administration of the performance in the host server.

Resources: ~3000 core hours were used for performing various iterations in the simulation experiments**.**

CHALLENGES

The project challenges were related to technical complexity and ability to run the dynamic simulation with very short period of execution time. Hence it was necessary to perform trials with different mesh density model to accurately capture the air bag behaviour. The finer the mesh the better is the simulation result accuracy, but the higher obviously is the simulation runtime required and hence it was necessary to perform the simulation within the stipulated timeline. Getting exposure to the UberCloud LS-DYNA container and Opin Kerfi cloud platform consumed some time as this required learning and understanding how simulation work can be performed in the browser environment.

BENEFITS

1. The HPC cloud computing environment with Opin Kerfi, UberCloud, ANSYS Workbench & LS-DYNA made the process of model generation easier with process time reduced drastically along with result viewing & post-processing.
2. The mesh models were generated for different cell numbers where the experiments were performed using coarse – to – fine to highly fine mesh models. The HPC computing resource helped in achieving smoother completion of the simulation runs without re-trails or resubmission of the same simulation runs thereby helping the user to achieve highly accurate simulation results.
3. The computation time requirement for a fairly fine mesh (~535K cells) is high, which is near to impossible to achieve on a normal workstation. The HPC cloud provided this feasibility to solve highly fine mesh models and the simulation time drastically reduced thereby providing an advantage of getting the simulation results within acceptable run time (~30 min).
4. The experiments performed in this HPC Cloud environment showed the possibility and gave extra confidence to setup and run the simulations remotely in the cloud. The different simulation setup

tools were installed in the HPC environment and this enabled the user to access the tool without any prior installations.

5. With the use of VNC Controls in the Web browser, The HPC Cloud access was very easy with no installation of any pre-requisite software. The whole user experience was similar to accessing a website through the browser.
6. The UberCloud HPC containers helped with smooth execution of the project and with easy access to the server resources. The UberCloud environment integrated in the Opin-Kerfi platform proved to be powerful as it facilitates running parallel UberCloud containers, and the secured data connections for transfer of the simulation data from and to the local system proved to be robust and fast.

CONCLUSION & RECOMMENDATIONS

1. The HPC Cloud environment with UberCloud containerized ANSYS Workbench with LS-DYNA in the Opin Kerfi platform was a good fit for performing complex simulation that involved huge hardware resource utilization with high number of simulation experiments.
2. Opin Kerfi with UberCloud HPC containers was an excellent fit for these advanced computational experiments that involve high technical challenges with complex geometries and cannot be solved in a normal workstation.
3. ANSYS Workbench with LS-DYNA in this HPC environment helped us to solve this problem with minimal effort in setting up the model and performing the simulation trials.
4. The combination of Opin-Kerfi, HPC Cloud, UberCloud Containers, and ANSYS Workbench with LS-DYNA helped in speeding up the simulation trials and also completed the project within the stipulated time frame.

APPENDIX: About Opin Kerfi

Since 1985, Opin Kerfi has been a leading IT sales and service partner operating both in the Icelandic and international market, providing substantial financial benefits due to the green, low-cost energy grid especially to high-performance computing users. The company has consistently and successfully provided innovative and efficient services to its clients, focusing on consultation, integration, operations and subscription-based cloud- and Software-as-a-Service solutions.

Case Study Author – Praveen Bhat

Thank you for your interest in our free and voluntary UberCloud Experiment!

If you, as an end-user, would like to participate in an UberCloud Experiment to explore hands-on the end-to-end process of on-demand Technical Computing as a Service, in the Cloud, for your business then please register at: http://www.theubercloud.com/hpc-experiment/.

If you, as a service provider, are interested in building a SaaS solution and promoting your services on the UberCloud Marketplace then please send us a message at https://www.theubercloud.com/help/.

2013 Compendium of case studies: https://www.theubercloud.com/ubercloud-compendium-2013/
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2018 Compendium of case studies: https://www.theubercloud.com/ubercloud-compendium-2018/

The UberCloud Experiments and Teams received several prestigious international Awards, among other:

- HPCwire Readers Choice Award 2013: http://www.hpcwire.com/off-the-wire/ubercloud-receives-top-honors-2013-hpcwire-readers-choice-awards/
- HPCwire Readers Choice Award 2014: https://www.theubercloud.com/ubercloud-receives-top-honors-2014-hpcwire-readers-choice-award/
- Gartner Cool Vendor Award 2015: http://www.digitaleng.news/de/ubercloud-names-cool-vendor-for-oil-gas-industries/
- HPCwire Editors Award 2017: https://www.hpcwire.com/2017-hpcwire-awards-readers-editors-choice/
- IDC/Hyperion Research Innovation Excellence Award 2017: https://www.hpcwire.com/off-the-wire/hyperion-research-announces-hpc-innovation-excellence-award-winners-2/

If you wish to be informed about the latest developments in technical computing in the cloud, then please **register at http://www.theubercloud.com/** and you will get our free monthly newsletter.

ANSYS

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