Cloud-Enabled CAE Solutions: Requirements, Basic Concepts and Usability

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Up-to-date, particularly commercial methods of numerical simulation are able to meet requirements of modern product development and optimisation processes. However, essential prerequisite is not only the application software but also the appropriate High Performance Computing (HPC) resources. Specific applications, like simulation of large models with a very high number of grid points, CFD-driven design optimisation with necessary innumerable variations as well as complex, multidisciplinary problems regarding the simulation of iterative interactive effects are typical examples of getting efficient, high-quality, prompt and precise results only through appropriate High Performance Computing.

Recent studies predict an annual growth rate of 7.4 per cent for High Performance Computing between 2013 and 2018, and in the field of computational fluid dynamics (CFD) a rate of 7.3 per cent is forecast for the same period.[1] This development is very evident, and the application of High Performance Computing (HPC), especially for CAE, is likely to rise by 9.4 per cent between 2011 and 2016.[2] Over the past four years there has been an increase of around 10 per cent in the number of companies transferring their HPC workloads to the Cloud.[1]

But not every company is in position to provide such resources in an appropriate amount or – if available at all – to use them continually and efficiently. The necessary infrastructure, especially with regard to technical and personal resources, is cost-intensive and time-consuming. Thus, own HPC infrastructures tie up a lot of capital given also the fact that technology is rapidly changing and improving. So why not renting required computing capabilities, in other words to make use of cloud-enabled CAE solutions?

Cloud-enabled CAE solutions allow users renting high performance computing hardware along with licenses to compute resource-intensive applications for a specified period of time in order to increase feasibility, accuracy and performance as well as efficiency of CAE simulations.
Furthermore, cloud-enabled CAE solutions can been seen as a reliable way to absorb project driven peak loads with as little effort as possible enabling companies of every size to activate and make intensive use of scalable computing resources.

But the whole field of outsourcing High Performance Computing resources to a cloud-based infrastructure still meets with considerable skepticism and their usage is still correspondingly limited. This is not surprising given the sensitivity of data that can have a decisive effect on competitiveness.
Besides, cloud services focusing on CAE vary significantly regarding their business models. The relatively new and rapidly growing cloud market makes it difficult for engineers to choose the appropriate CAE cloud provider.
From the end user's perspective it is crucial to make these services available in the most transparent, secure and efficient way, e.g. ownership of the hardware, additional communication providers/suppliers, virtualised environments, data transfer export rules etc.

Potential users in the B2B sector are inhibited in particular by various issues and concerns. Data security, cost, usability, adaptability, hardware and software, as well as support and remote connection, were identified as the most important factors.[3]

But these concerns can be handled or even removed if stakeholders understand what finally characterises a CAE cloud from a technical point of view and what happens with processed data.

This paper describes the progress in cloud-enabled CAE solutions. More precisely, it covers their requirements, the basic cloud concepts and their state-of-the-art utilisation in computer-aided engineering. Moreover, the paper shows the risk of non-transparent resource provider models when running simulations on different platforms.

Important criteria and challenges are always the underlying cloud infrastructure, scalability, bottlenecks (data transfer, network interconnection, licenses, etc.), security aspects and offered support models.

The following technical issues will be addressed in detail:
- Data security – Where is the data located and what security measures are being taken?
- Performance – What performance can be expected when running CAE simulation on an HPC cloud infrastructure? What about their scalability?
- Data Transfer – How can data be transferred both efficiently and effectively?
- Access – How are compute resources accessed and applications started? Is it possible to monitor a running calculation or to even analyse calculations results in the cloud?
- Parallel Computations – What is the best partitioning when considering queuing systems in reference to CAE applications?
- Storage – What storage system is the most efficient?
- Support – What about licenses, consulting and customising? What service and support can be expected?

Examples with *LS-DYNA* serve as evidence of all these aspects. Related benchmarks using CPU 24/7 dedicated bare metal servers of various generations indicate reasonable scalability and performance. The paper shows e.g. a downgrade between virtual machines and bare metal providers.

Furthermore, it it is shown that application-specific and –optimised HPC platforms are a viable alternative for small and medium sized enterprises to efficiently solve sophisticated CAE problems.

[1] International Data Corporation (IDC), 2014: IDC HPC Update at ISC'14.
[2] Earl Joseph, IDC, 2013: A Worldwide Overview of the HPC Market, Global Trends, Major Changes and Five Year Predictions.
[3] Technical University of Berlin et al, 2015: Abschlussbericht, Capital Cloud Infrastructure (CCI): Vertrauenswürdige Infrastruktur für Capital Cloud.