SIMULIA

3DEXPERIENCE®

ABAQUS SIMULATIONS POWERED BY 3DEXPERIENCE CLOUD

DASSAULT SYSTEMES

As products get more complex, simulations have become an integral part of the product development process. Complex products mean that simulation models are moving from analyzing single components to the more complex, closer to lifelike models of assemblies, sub-systems and systems. Advances in simulation technology and fewer modeling abstractions are enabling large-scale simulation models to be the de-facto standard for providing accurate data that companies can reliably act upon.

In the context of structural simulations performed using the Abaqus implicit solution technique, model sizes are constantly increasing and now reaching up to 100M degrees of freedom (DOF) due to the advent of iterative solvers. For the Abaqus explicit solution technique commonly used in highly dynamic applications such as crash worthiness simulations, model sizes are now reaching 350M DOF. Increasing levels of fidelity in simulation models requires access to powerful workstations and high performance computing (HPC) resources, which can enable timely delivery and reporting out of results. Furthermore, easy access to increased computing capacity enables even more design changes to be evaluated through "what-if" design optimization studies, further improving feedback to design programs based on the performance of their products.

3DEXPERIENCE® Cloud provides easy access to the necessary, on-demand computing power for all types of simulation workflows. If you are an Abaqus user who,

- spends significant time to reduce model sizes to fit on your available hardware resources,
- waits too long for simulation jobs to start in the on premise HPC queue,
- wants to model more variants emanating from design changes, but lack the computing resources to execute them,
- faces project delays or lost contracts due to lack of timely access to required hardware capacity, or
- simply looking for an option to off-load work from your local hardware to a performant HPC solution,

then leveraging Abaqus on **3DEXPERIENCE** Cloud can enable you to meet your technical and business goals, on time and on quality.

USER EXPERIENCE

The **3DEXPERIENCE**® Cloud user experience is simple and the user interface (UI) is easy-to-use. Users have access to a lightweight, browser-based App called Simulation Manager (Figure 1). In Simulation Manager, users can add their Abaqus input files via a simple drag-and-drop interface or through Abaqus/CAE itself.

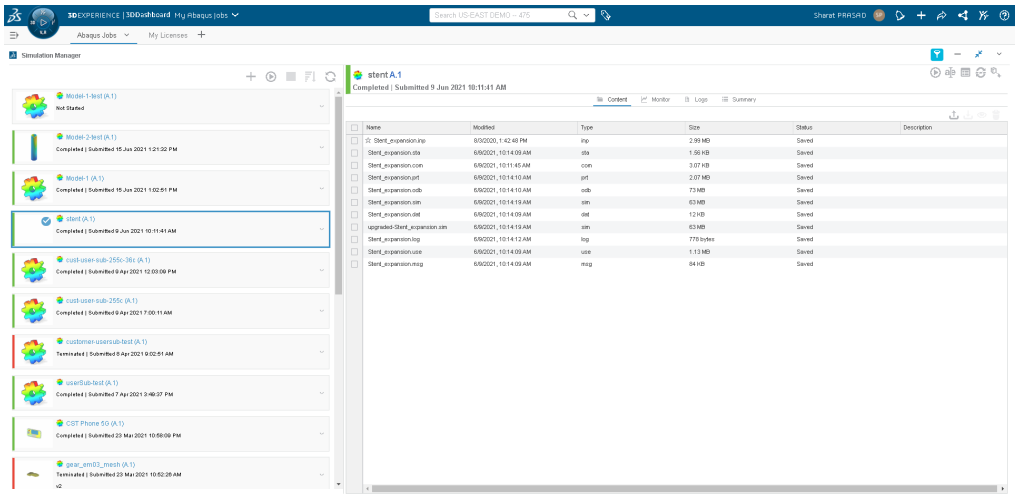


Figure 1: Simulation Manager User Interface

For users who prefer to build their models in Abaqus/CAE, they can save their input files from Abaqus/CAE directly to the Simulation Manager App. On selecting "Save to **3D**EXPERIENCE," users are asked to logon to **3D**EXPERIENCE Cloud with their credentials and files are then automatically uploaded (Figure 2). Users can also choose to save their CAE model files to the Cloud for secure storage and collaboration. This interface also allows users to import CAD models directly from **3D**EXPERIENCE Cloud.

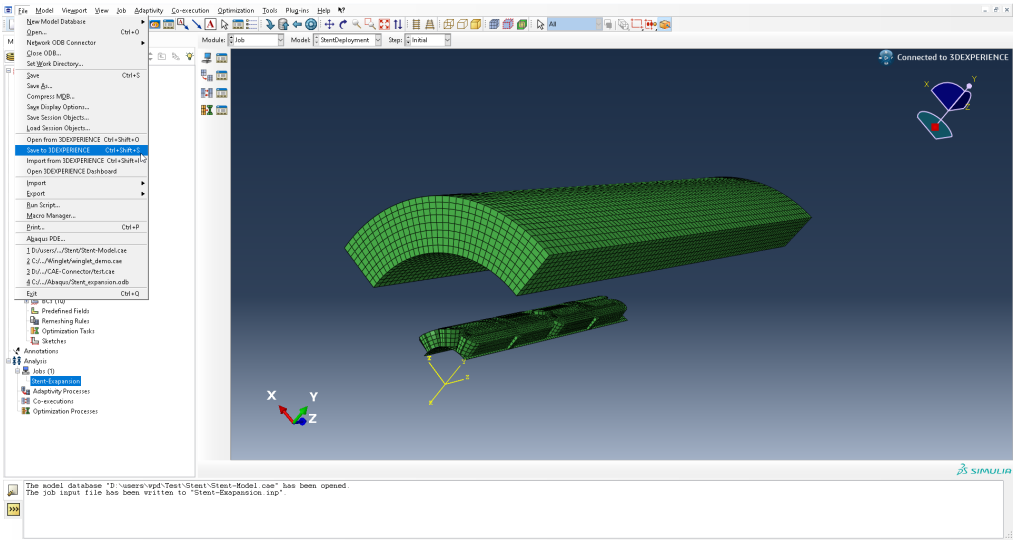


Figure 2: Direct access to **3D**EXPERIENCE Cloud from Abaqus/CAE

Once in the Cloud, the jobs can be executed on any of our available pre-configured compute configurations starting from 4 cores all the way up to 144 cores. **Users also have the choice to choose the Abaqus version they want to run the model with.**

When the results are available, users have several convenient options to visualize results:

1. Download results to desktop and visualize in Abaqus/CAE or Abaqus/Viewer
2. Quickly visualize lightweight simulation results in the browser itself with no downloads
3. Perform in-depth analysis of the results in a fully featured visualization App (Physics Results Explorer) that efficiently streams simulation results from the cloud to your desktop with no download of results data. This option is recommended for larger simulation models that can benefit from high performance, parallel visualization framework on the cloud.

PERFORMANCE

Abaqus performance on **3D**EXPERIENCE Cloud is as good, if not better, than typical on-premise deployments. We present some examples of performance of Abaqus on **3D**EXPERIENCE Cloud.

For small-to-medium model sizes, users can benefit significantly from utilizing larger core configurations on cloud. For example, stent deployment simulation turnaround time (TAT) can be reduced by 75% when going to 8 core configuration on cloud (Figure 3). Similarly, for bushing stiffness simulation, TAT is reduced by 54% (Figure 5) when utilizing 18 core cloud configuration. Utilizing the larger core configurations on cloud allows users to benefit from improved scalability of Abaqus Implicit Solver. The time savings are even more dramatic for Abaqus Explicit Solver, which scales very well. For example, the fluid filled bottle drop scenario TAT is reduced by 69% on a 36 core cloud configuration vs. 4 core local baseline (Figure 4). Similarly, the camera drop scenario TAT is reduced by 91% on 36 core cloud configuration vs. 1 core local baseline (Figure 6). While these models can still be run locally, doing so would result in reduced performance of users' primary system potentially impeding other parallel tasks. In this case, users want to run many model variations to study design change impact, time saved on cloud becomes a compelling return on investment (ROI).

For medium-to-large Abaqus jobs, cloud may be the only alternative if users lack high-end hardware, or have access to limited local HPC capacity. This can result in long wait times in the HPC queue. For the large Abaqus models, cloud HPC has been tuned to provide best possible turnaround time without any user intervention. For example, a large Abaqus powertrain model would require a powerful workstation with significant memory to run. As can be seen from Figure 7, these models can be run efficiently with 144 core cloud configuration resulting in 95% reduction in TAT compared to baseline run with 8 core, on a workstation with 128GB of memory. Similar, a large crash test model can benefit from 91% reduction in TAT on 144 core cloud configuration compared to baseline run with 18 core, on a workstation (Figure 8).

Overall, users will get significant improvement in turnaround times:

- Access to higher core configuration on cloud allows users to benefit from significant improvements in Abaqus Solver scalability.
- Cloud allows users to benefit from the latest generation hardware, which can additionally improve turnaround times. On premise, hardware, in spite of being acquired at significant cost, quickly becomes outdated as hardware technology evolves.
- Cloud hardware is pre-configured to deliver best Abaqus Solver performance.
- Small models

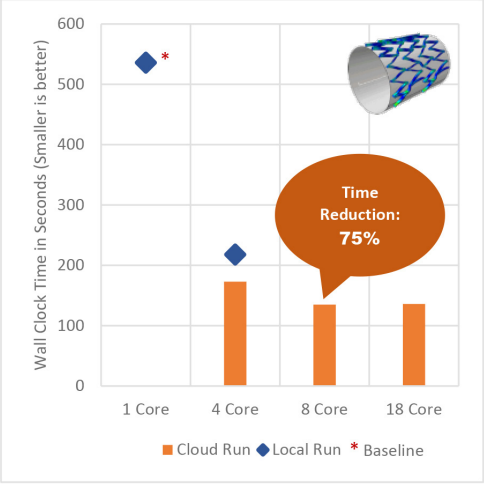


Figure 3: Stent expansion, Abaqus Implicit with contact (181,692 DOFs)

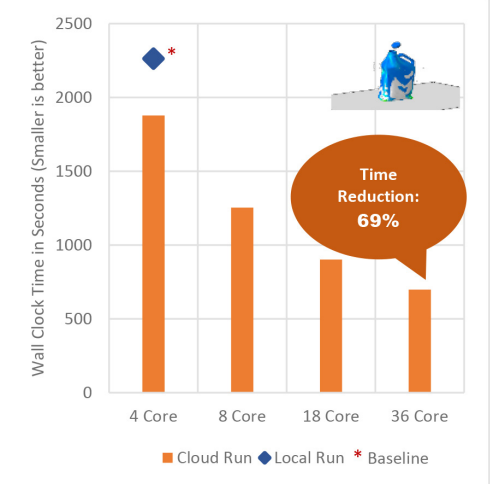


Figure 4: Fluid filled bottle drop: Abaqus explicit, coupled Eulerian-Lagrangian with contact (416,292 DOFs)

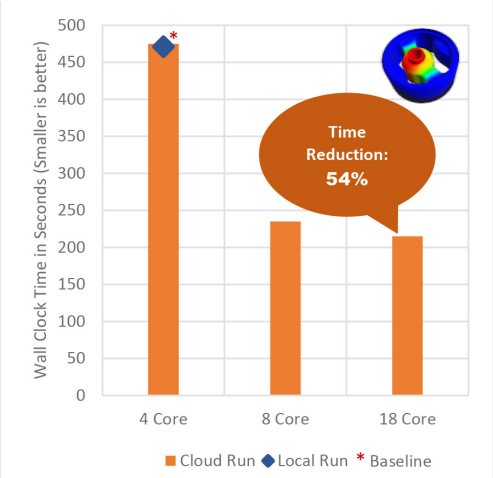


Figure 5: Bushing stiffness: Abaqus Implicit with contact (331,853 DOFs)

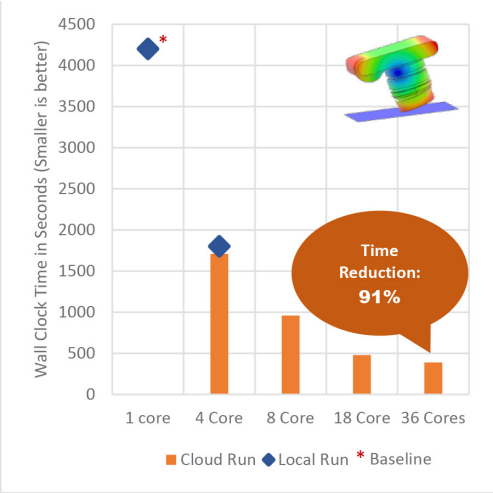


Figure 6: Camera drop test scenario: Abaqus Explicit with general contact (340,827 DOFs)

Large models

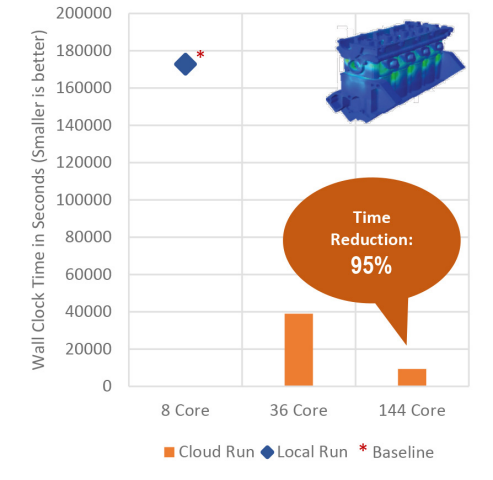


Figure 7: Bolting a cylinder head onto an engine block: Abaqus Implicit with contact (17,101,105 DOFs)

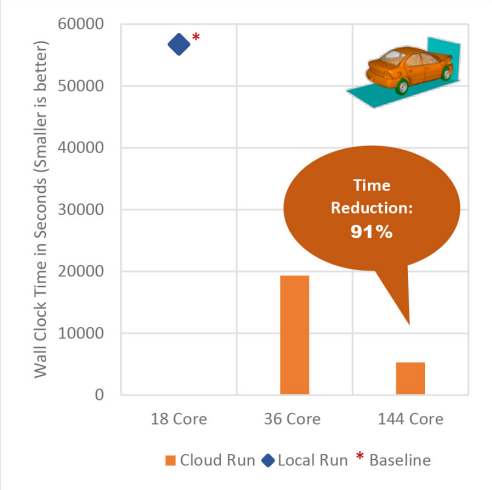


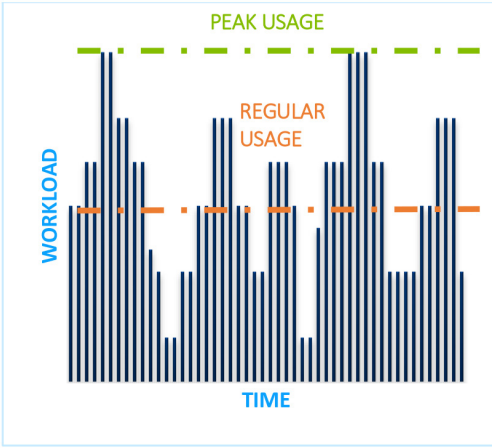
Figure 8: Frontal crash simulation: Abaqus Explicit with general contact (28,688,932 DOFs)

SIMPLE LICENSING

Users have the flexibility to choose from two different license models, or even to use a combination of both to meet their Abaqus compute needs exactly:

- Token based—These are reusable compute licenses suitable for sustained use. It allows users to run a certain number of jobs concurrently for the licensing term. A certain amount of tokens are checked-out of the license pool or "frozen" while a simulation is running and checked back in the pool or "released" when the simulation completes to be reused for the next simulation. The actual token usage depends on the compute configuration chosen. This kind of compute license is best for any regular compute workloads.
- Credit based—These are consumable compute licenses that are suitable for pay-per-use cases, as well as burst compute needs. It allows users to run as many jobs as possible, until the credits are consumed. Credits are consumed as the simulation is running and cannot be used for the next simulation. The credit consumption rate depends on the compute configuration chosen for a particular job. It is best for low-frequency, high priority variable workloads.

In order to meet the compute needs exactly, users can choose tokens to match their sustained average needs and address spikes in compute requirements with credits.



Whether running with tokens or credits, users just see one convenient usage or consumption rate that pays for both software and hardware. This eliminates the worry about dealing with software and hardware costs separately or paying to third-party cloud hardware providers.

KEY BENEFITS OF LEVERAGING CLOUD FOR ABAQUS SIMULATIONS

1. Innovate without hardware barriers

Innovating products require that design alternatives are evaluated quickly and "what-if" studies are performed. Cloud gives access to unlimited compute resources to run as many simulation jobs as possible at the same time.

2. Simulate with more details

CAE Analysts spend hours simplifying their models, deciding on what model details need to be excluded to arrive at a model size that fits their workstations or local HPC, and deliver results in acceptable time. The need to run mesh convergence studies and design change impacts make this process even more arduous. Cloud-powered simulation with access to unlimited compute power can alleviate these challenges. One can use the CAD geometry as-is, without simplifications. With cloud, the time spent to reduce the model size can be reduced significantly and it opens up the doors to run as many jobs in parallel as needed.

3. Meet compute needs exactly

With a combination of token and credit-based licensing, users can meet their compute needs exactly.

4. Avoid HPC set up times in a pre-configured cloud environment

3DEXPERIENCE Cloud provides a preconfigured environment to users, which provides optimal turnaround time for models. Users can select from a range of compute configurations.

5. Securely store simulation model and results on cloud and access them from anywhere

Users can also store their Abaqus input files, CAE models and results securely on **3D**EXPERIENCECloud. This gives them the advantage of accessing these files from anywhere and allows them to collaboratively share these files with other project stakeholders.

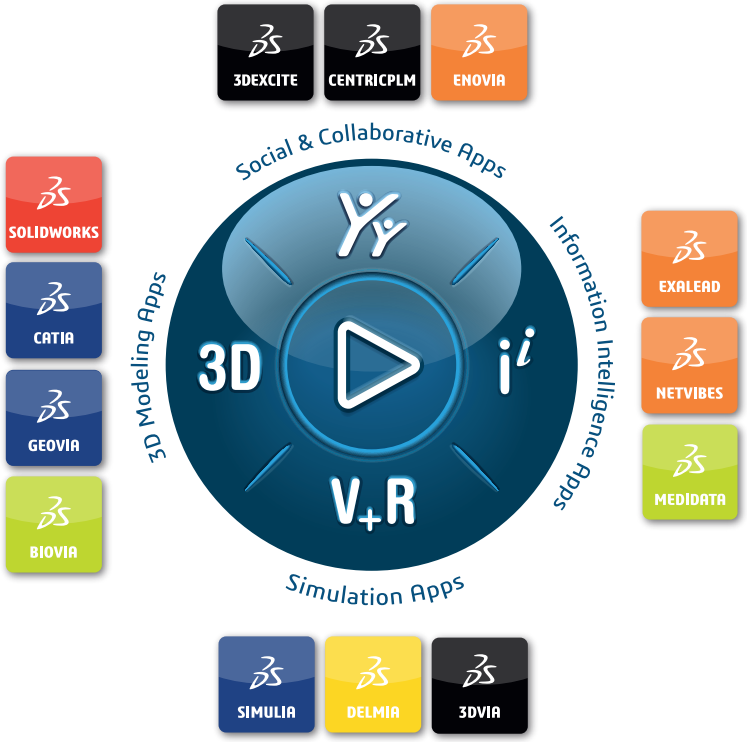
6. No need to acquire or maintain HPC assets

With **3D**EXPERIENCE Cloud, capital investments for HPC hardware purchase or replacement are no longer required. The cloud also gives you access to the latest, most reliable hardware without having the responsibility of researching and replacing your own equipment.

CONCLUSION

Structural simulation using SIMULIA Abaqus offers significant competitive advantages during product development. For companies that sometimes need very demanding or complex simulations, the **3D**EXPERIENCE Cloud gives them the latest generation high-performance computing resources they need to perform simulations effectively, without needing to purchase and maintain large computing clusters in-house.

The **3D**EXPERIENCE Cloud is scalable thanks to a token system that allows users to meet their computing needs exactly, without having to excessively simplify their models. **3D**EXPERIENCE is pre-configured to allow faster set-up, and offers a secure way to store and access results and data from anywhere. Running Abaqus on the **3D**EXPERIENCE Cloud can reduce simulation times by 95% compared to running them locally and significantly reduce product development times.



Our **3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3D**EXPERIENCE platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **www.3ds.com**.

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