EXCELLERAT

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TARGET AUDIENCE

- Code developers
- R&D engineers from aeronautics sector

Enabling parallel mesh adaptation with Treeadapt

CHALLENGE

Advanced meshing software is limited to sequential or shared memory architectures. To bypass bottlenecks, codes have turned to mesh adaptation as a solution, but massively parallel mesh adaptation workflows remain scarce and require efficient load balancing, interpolation and remeshing techniques.

SOLUTION

Treeadapt is a library for massively parallel mesh adaptation developed by CERFACS. It generates a partitioned domain where the mesh generation tool MMG can be employed while freezing the parallel interfaces. **Rebalancing and adaptation then occur iteratively until converged within a user defined tolerance**.

BENEFITS

- Time reduction from three days to one hour to generate a one billion element mesh
- Reduce result quality dependency on user experience
- Improve high fidelity results

UNIQUE VALUE

<u>AVBP</u> with the library Treeadapt offers the possibility to use unstructured grids than can be automatically adapted to the flow at runtime allowing for automatic tracking of the zones of interest. Additionally **mesh quality criteria in AMR can compensate for any defects on the original grid that might lead to numerical issues**.

PRODUCTS / SERVICES

- Treeadapt is part of an open source package
- Code Simulation AVBP open source
- Training on Enabling parallel mesh adaptation with Treeadapt
- Consultancy on mesh adaptation methods applied to aeronautics and combustion
- Best practice guide on Enabling parallel mesh adaptation with Treeadapt

CONTACT INFORMATION

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TARGET AUDIENCE

- Code developers
- R&D engineers in aeronautics sectors

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Bringing combustion design industrial end-users to Exascale computing

CHALLENGE

Some physical processes such as soot formation are so CPU-intensive and non-deterministic that it is not yet possible to apply predictive modelling techniques to them, which limits our insights to ad hoc correlations and preliminary assumptions. Moving these runs to Exascale level computing systems will allow **simulations that are longer by orders of magnitudes, and will achieve the compulsory statistical convergence that is required for a design tool**.

SOLUTION

<u>CERFACS</u> developed a **predictive model to port, benchmark and optimise the AVBP code** for Arm and AMD architectures. This will ensure early access to these new architectures and prepare our codes for the widespread availability of systems equipped with these processors.

BENEFITS FOR INDUSTRIAL END USERS: ENGINEERS, ACADEMIC RESEARCHERS, AND CODE DEVELOPERS

- Code ready for the widespread access of the Arm Rome architecture
- Strong and weak scaling measurements up to 128,000 cores
- Initial optimisations for Arm architectures

UNIQUE VALUE

<u>AVBP</u> offers the possibility of using unstructured grids than can be **automatically adapted to the flow at runtime, allowing for automatic tracking of the zones of interest**. Additionally, mesh quality criteria in adaptive mesh refinement can compensate for any defects on the original grid that can lead to numerical issues.

PRODUCTS / SERVICES

- Code Simulation AVBP open source
- Training on MPI/OpenMP high performance computing
- Consultancy on code optimization and porting
- Best practice guide on bringing industrial end-users to Exascale computing
- An industrial-level combustion design tool on 128,000 cores.

CONTACT INFORMATION

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TARGET AUDIENCE

- Industrial R&D engineers
- R&D experts from aeronautics industrial sectors

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Enabling HPC through a Data Exchange & Workflow Portal

CHALLENGE

Today, organisations and smaller industry partners face various problems in dealing with HPC calculations, HPC in general, or even access to HPC resources. In many cases, the calculations are complex and the potential users do not have the necessary expertise to fully exploit HPC technologies without support.

SOLUTION

SSC and **RWTH** is developing **a secure data exchange and transfer platform and tool** as part of the EXCELLERAT project to facilitate the use of HPC and to make data transfer more efficient.

BENEFITS

- Reduction of HPC complexity due to web frontend
- Time and cost savings due to a high degree of automation
- Efficient, user-friendly and secure post-processing/data analytics

UNIQUE VALUE

- Provision and operation/support of the platform in order to significantly facilitate the use of HPC
- "Automatic" accounting and pre-calculation of resources
- Providing a user-friendly and scalable data analytic tool to efficiently perform modal decomposition of large-scale simulation data

PRODUCTS / SERVICES

- <u>Alya</u>, <u>BSC</u>: Multiphysics simulation code available under license, available as Open Source / SaaS, and Consultancy about parallel mesh adaptation strategy based on the use of Gmsh library for re-meshing
- Modal decomposition toolkit, <u>RWTH</u>: Scalable data analytic tool: modal decomposition of large-scale simulation data
- <u>SSC platform</u>, <u>SSC</u>: Data exchange and transfer platform
- HPC resources to run the simulation including Data Exchange & Workflow
- <u>SSC</u> & <u>RWTH</u>: Consultancy, best practice guide, workshop and training about modal decomposition of simulation data

CONTACT INFORMATION

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TARGET AUDIENCE

- Industrial design engineers
- Experts from aeronautics industrial sectors

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Full Airplane Simulations using Alya on Heterogeneous Architectures

CHALLENGE

Many of the future Exascale systems will be heterogeneous and include accelerators such as GPUs. With the explosion of parallelism, the expected performance of the various computing devices is more variable and the performance of the system components will be less certain. Therefore, leading-edge engineering simulation codes, such as Alya, need to be malleable enough to adapt to the new environment.

SOLUTION

- Alya rises dynamic load balancing to increase the parallel efficiency
- The load balancing method is an efficient in-house space filling curve partitioner
- Focused on maximising the parallel performance of the mesh partition process **to minimise the load balancing overhead**

BENEFITS

- Well-balanced co-execution using both the CPUs and GPUs simultaneously
- 23% faster than using only the GPUs
- Increased resilience of the software to system performance variability

UNIQUE VALUE

- Parallel mesh adaptation strategy for re-meshing
- Design for massively parallel supercomputers
- Open source package

PRODUCTS / SERVICES

- R&D Services
- R&D joint collaborations
- <u>Alya</u> (in-house HPC based multi-physics software) as a benchmarking tool
- Training on HPC optimization

CONTACT INFORMATION

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ABOUT EXCELLERAT

The EXCELLERAT project is a single point of access for expertise on how data management, data analytics, visualisation, simulation-driven design and Co-design with high-performance computing (HPC) can benefit engineering, especially in the aeronautics, automotive, energy and manufacturing sectors.

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