# FEniCS-HPC mesh adaptivity on the heterogeneous architecture

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FEniCS-HPC is an open source framework for automated solution of PDE on massively parallel architectures, providing automated evaluation of variational forms given a high-level description in mathematical notation, duality-based adaptive error control, implicit parameter-free turbulence modeling by use of stabilized FEM and strong linear scaling up to thousands of cores. FEniCS-HPC is a branch of the FEniCS framework focusing on high performance on massively parallel architectures.

Finite element methods (FEM) are based on a variational form of the NSE, and if the method satisfies certain conditions on stability and consistency, the FEM solutions converge towards a weak solution to the NSE as the finite element mesh is refined [1]. We refer to such FEM as a General Galerkin (G2) method, or a Direct Finite Element simulation (DFS).

In recent years, all supercomputers are based on heterogeneous architecture, which has a accelerators. At the moment, FEniCS-HPC can not use any of these accelerators (for example, such as CPU based co-processors and GPU).

We present Omega_h/FEniCS and Omega_h/FEniCS-HPC environment using GPU and performance analysis in terms of solution accuracy and computational cost. In this study we couple or integrate Omega_h[2]into FEniCS-HPC, which will be using posteriori error estimates from the FeniCS-HPC (DFS) for mesh refining. But for coarsening mesh, we use the one of the Omega_h coarsening methodology, which is based on the single edge collapses approach. Omega_h uses the both CPU and GPU, this will enable us to utilize use of accelerators on heterogeneous supercomputer architecture, for science and real world applications [3] in FEniCS-HPC.

## References

[1] Johan Hoffman and Claes Johnson. *Computational Turbulent Incompressible Flow*. Vol. 4. Applied Mathematics: Body and Soul. Springer, 2007.

[2] Daniel Alejandro Ibanez. "Conformal Mesh Adaptation on Heterogeneous Supercomputers". In: *Ph. D. thesis, Rensselaer Polytechnic Institute* (2016).

[3] Johan Jansson et al. "Time-Resolved Adaptive Direct FEM Simulation of High-Lift Aircraft Configurations". In: *Numerical Simulation of the Aerodynamics of High-Lift Configurations*. Springer, 2018, pp. 67–92.