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ParaSiF_CF: A Partitioned Fluid-Structure Interaction Framework for Exascale

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Fluid-structure interaction (FSI) occurs in many areas of engineering. Due to its non-linear, time-dependent and multi-physical nature, numerical simulations of FSI problems require greater computational resources relative to pure fluid or structural dynamics problems. For instance, many billions of cells would be required for a scale-resolving FSI simulation of a floating offshore wind turbine farm, or the core of a nuclear power plant. These are highly ambitious simulations that are only recently becoming affordable. But to perform such simulations, an efficient and highly scalable FSI simulation tool is needed. The existing state-of-the-art partitioned FSI frameworks usually use direct solvers for the structure domain, which typically scale up to 128 MPI tasks, severely limiting their applicability to handle extremely large structural meshes (many billions) especially on distributed memory machines. In this study, a new massively parallel partitioned fluid-structure interaction simulation framework, ParaSiF_CF is presented. It relies on a partitioned approach and involves two highly optimised software namely Code_Saturne [1] for computational fluid dynamics (CFD) and FEniCS [2] for computational structure mechanics (CSM). Both linear elastic and hyper-elastic structure solvers developed within the FEniCS library have been coupled with Code_Saturne using the MUI coupling library [3]. The MUI library allows an arbitrary number of codes to communicate with one another over MPI using a cloud of point data. Both Fixed Relaxion and Aitken's implicit FSI coupling method have been developed for the framework to achieve a tight and stable coupling. The parallel performance of the framework has been assessed on an HPE-Cray tier-1 machine (ARCHER2 [4]). It shows up to 85% of parallel efficiency for a modelled 3-D FSI simulation, as shown in Figure 1, using both the linear and nonlinear structural solver going from 2 to 34 nodes of the machine.

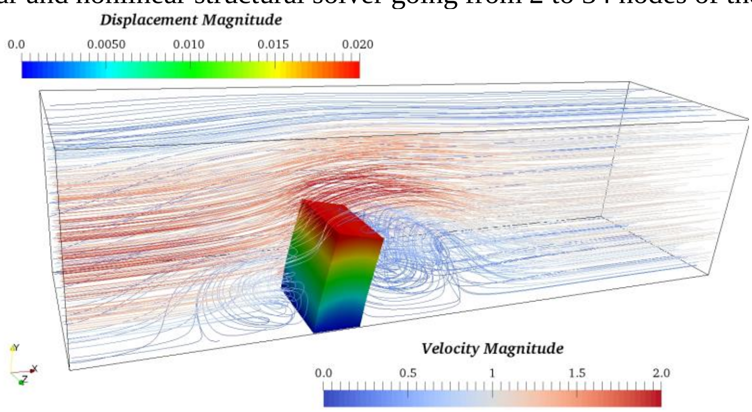

Figure 1 Streamlines and contour plot for 3-D flow past elastic beam.

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