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TOWARDS PARTITIONED FLUID-STRUCTURE INTERACTION ON MASSIVELY PARALLEL SYSTEMS

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Multi-physics simulations, such as fluid-structure interaction (FSI), have a natural need for high performance computing, since the smaller modelling error you get when switching from a single-physics to a multi-physics model is useless if you cannot sustain a high resolution. The simulation of blood flow in the human cardiovascular system to predict calcification and aneurysms, for example, profits only from an elastic wall model if boundary layers of the flow are carefully resolved.

We aim to develop partitioned coupling approaches between a black-box fluid and a black-box structure solver to possess a maximum of flexibility to choose the right solver for a particular application. This allows, e. g. , for an easy switch between an Eulerian, immersed boundary flow solver, and an arbitrary-Lagrangian-Eulerian flow solver. We developed the coupling environment `preCICE`([1]) for this purpose. Furthermore, partitioned solvers do often already possess a decent parallel efficiency, since decades of know-how and work has been invested to optimize them.

However, for a partitioned coupling of such solvers on massively parallel systems, starting already with 100 to 1000 processors, new challenges arise. In our talk, we want to discuss three of them:

1. If fluid and structure are simulated in the classical staggered way, the overall parallel efficiency is limited up to 50%, because of the lower scalability of the structure solver compared to the fluid solver. In [2], we developed new coupling algorithms that allow to simulate fluid and structure simultaneously, overcoming, thus, the parallel efficiency limitation.

2. To prevent the coupling from being the bottleneck of the simulation, we have to guarantee an efficient communication between the coupling partners. Therefore, a point to point communication scheme at the interface between the solvers is to prefer over a single server processor. Since the interface moves, an update scheme of the mapping between the solver processors is necessary. Overall, we want as little as possible or even no alteration in the domain decomposition of the single-physics solvers, to sustain the black-box flexibility.

3. As a consequence of the last point, we have to implement the coupling algorithms on distributed memory. Therefore, all classical coupling approaches have to be reconsidered in terms of internal scalability of the coupling environment.

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