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Efficient Inter-Code Communication for Multi-Physics Simulations with preCICE

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We present the preCICE coupling library which has been developed to couple several black-box solvers to perform a partitioned multi-physics analysis. In multi-physics simulations, partitioned approaches have great advantages regarding flexibility and software development costs over monolithic approaches. However, they pose challenges in terms of numerical stability and parallel scalability. In addition, in these simulations high spatial and temporal resolution are crucial to meet accuracy requirements. Therefore, it is necessary to run these simulations on massively parallel computers, which inevitably results in a need for inter-code communications between different solvers. The number of communication links increases when more accurate results or a deeper insight into complex problems are required. In such a case, using central communication would result in serious runtime bottleneck which can kill the code performance. Therefore, to do a partitioned multi-physics simulation, a powerful coupling tool is needed that handles the communication between different solvers efficiently and provides data mapping and iterative equation coupling for surface coupled problems. The preCICE coupling library fulfills all these requirements in a modular way[1]. Up to now, preCICE has been used to couple various open-source solvers such as Open-FOAM, SU2, foam-extend and Calculix and commercial solvers such as Fluent, FEAP, and COMSOL. The applications studied by preCICE include, but are not limited to fluid-structure interaction, fluid-structure-acoustics interaction and heat transfer problems [2].

This presentation, however, is aimed to introduce important features of preCICE with focus on new communication schemes. The central communication in time-stepping has been already replaced with a fully parallel process-to-process intercommunication model [3]. The next step is to implement the bounding-box communication initialization approach instead of the current method. The new method introduces a two-step initialization in which there is no need to communicate the whole mesh via master ranks to build a communication map. In the first step, only bounding-boxes, which contain information about the physical range of vertices owned by each rank, are communicated through master ranks to find possible communication links between each solver's ranks. These connected ranks can then communicate their mesh partition to build the final communication map. These new features along with other improvements in data mapping and equation coupling schemes make preCICE an ideal coupling tool for investigating complex physical phenomena such as FSI problems.

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