# Implicit Parallel Time-Stepping for Fluid-Structure Interaction – Quasi-Newton and Radial Basis Functions

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## ABSTRACT

Two requirements for solvers for fluid-structure interaction scenarios at first sight seem to pose severe challenges in the development of partioned solvers for fluid-structure interactions: 1) Time discretizations usually have to be fully implicit in order to ensure stability. 2) The high accuracy requirements imply the need to perform the simulations on large massively parallel computers. For partitioned simulations using black-box flow and structure solvers that have been developed independent from each other and independent from their use in a coupled fluid-structure simulation, this means that we have to provide numerical and technical coupling solutions that can cope with both challenges. In particular, this requires powerful numerical coupling methods and efficient inter-code communication. Quasi-Newton methods as outer coupling iterations in each implicit time step as well as radial basis function mappings bridging the gap between non-matching solver meshes have been discussed and used in this field for quite a long time. Although their potential has been recognized and exploited very early, the commonly used variants still had several drawbacks: Quasi-Newton methods did not allow for inter-solver parallelism and required the tuning of unknown parameters in a costly try-and-error manner. Radial basis function mappings suffered from the global support of the basis functions resulting in a linear system with dense system matrix.

We present optimized and modified versions of both methods and their implementation in the coupling tool preCICE. They fully exploit parallelism within the solvers, within the coupling numerics, and between the solvers. Numerical results show the efficiency and robustness of the coupling, even beyond the field of fluid-structure interactions.