Benefits of generic software: Convenient parallelization of micro-scale DG-CFD simulations

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ABSTRACT

Traditionally, numerical analysis software was designed and developed with a specific application area in mind, i.e. there exists a wide range of mature computational fluid dynamic (CFD) codes. Extending these codes to new problems, or coupling them with other processes, e.g. fluid structure interaction, requires the incorporation of new methods and models. While the code base grows, this often becomes a tedious job. Modern programming techniques can help coupling or extending codes without sacrificing efficiency and thus reduce the average time to solution.

In this paper we will discuss different advanced programming techniques on the example of the DUNE framework [1,2]. The DUNE framework is written in C++ and make heavy use of generic programming techniques. We will emphasize on the grid interface and especially on the parallelization. And describe the parallelization of an existing sequential code.

We have developed a micro-scale DG-CFD code. The code implements the Unfitted Discontinuous Galerkin method, which is a new discretization method for solving partial differential equations on complex shaped domains [3]. The method offers a higher-order discretization where the mesh is not required to resolve the complex shaped boundary. And it was successfully used to simulate flow and transport through on the pore-scale of porous medium [4] and to do numerical upscaling [5].

When dealing with experimentally measured structures, e.g. micro X-ray CT scans, the problem size grows quickly. Thus it is necessary to allow parallel computations.

We will describe the parallelization of this micro-scale DG-CFD code. The code is base on the DUNE grid interface, which offers sequential and parallel grid managers. The design of the DUNE grid interface allowed an easy parallelization without the need to deal with MPI directly.

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