

Abstract

Advanced AMG Application for Solving CPR-Type Pressure Systems

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Fully implicit petroleum reservoir simulations result in huge, often very ill-conditioned linear systems of equations to solve for different unknowns, such as pressure and saturations. While the sub-system related to saturation is of hyperbolic type, the pressure part is known to have nearly elliptic properties. Since the solution of the coupled system is mainly determined by the solution of their elliptic (pressure) components, constrained pressure residual (CPR) two-stage preconditioning methods still belong to the most popular approaches to tackle coupled systems. After a suitable extraction of pressure sub-systems, the numerically most costly step in such two-stage methods consists in solving these pressure systems. It is known that algebraic multigrid (AMG) provides a technique to solve elliptic linear equations very efficiently. The main advantage of AMG-based solvers – their numerical scalability – makes them particularly outstanding for solving huge linear systems.

Unfortunately, there are many ways to extract pressure sub-systems for preconditioning as part of a CPR method. Depending on the application, the system's properties range from simple (positive definite) to highly indefinite. Consequently, in complex industrial simulations, the application of AMG to pressure sub-systems may not be straightforward at all. In fact, an important goal in defining an efficient CPR strategy consists in extracting pressure sub-systems that are suitable for an efficient AMG solution and, at the same time, ensure a fast overall convergence of the CPR approach.

In this talk, we will demonstrate the importance of this for several industrial cases. In particular, some of these cases are very hard to solve by AMG if applied in a standard way. We will investigate more advanced possibilities to select the pressure preconditioner which regain the typical AMG efficiency. We will compare the resulting approach – based on the multigrid package SAMG – with one-level approaches, like in CMG's PARASOL solver, showing that AMG gives significant acceleration.

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