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On the Modified Non-Galerkin Algebraic Multigrid Method Applied To Reservoir Simulation

Commercial reservoir simulators have to be very robust, scalable and fast. However, due to the different geological structures and properties of oil and gas reservoirs and the use of enhanced oil recovery (EOR) techniques, the governing equations are strongly non-linear and hard to solve. The Jacobian system is solved by FGMRES preconditioned by the two-level Constrained Pressure Residual (CPR) preconditioner [1]. The driving force of the CPR preconditioner is the solution of the pressure equation. The industry standard for solving the pressure equation is the Algebraic Multigrid (AMG) solver. AMG is well known for its parallel efficiency when increasing the problem size (weak scalability). However, this does not hold for a fixed problem size when increasing the number of computing nodes (strong scalability). This degradation in scalability is due to the increased level of communication in the algorithm.

The Non-Galerkin method has been introduced in [2]. The aim of the method is to reduce the overall communication in algebraic multigrid by enforcing a predefined nonzero pattern on each multigrid level and thus limiting and prohibiting new connections between computational domains. In this talk we will discuss the application of the Non-Galerkin method on a Ruge-Stuben algebraic multigrid solver [3] used in the context of reservoir simulation. We will compare the parallel scalability of the default solver with the Non-Galerkin solver and discuss its optimal values. Moreover, we will introduce the Modified Non-Galerkin method that ensures that the matrices solved for are M-matrices [4]. We will discuss the results of the Modified Non-Galerkin method for a variety of test cases based on real life reservoir simulations.

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