Application of PDSLin to the magnetic reconnection problem *

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Magnetic reconnection is a fundamental process in a magnetized plasma at a high magnetic Lundquist number, which occurs in a wide variety of laboratory and space plasmas, e.g., magnetic fusion expriments, the solar corona and the Earth's magnetotail. An implicit time advance for the two-fluid magnetic reconnection problem is known to be difficult because of the large condition number of the associated matrix. This is especially troublesome when the collisionless ion skin depth is large so that the Whistler waves, which cause the fast reconnection, dominate the physics [1].

For small system sizes, a direct solver such as SuperLU can be employed to obtain an accurate solution as long as the conditioner number is bounded by the reciprocal of the floating-point machine precision. However, SuperLU scales effectively only to 100s of processors or less. For larger system sizes, it has been shown that physics-based [2] or other preconditioners can be applied to provide adequate solver performance.

Recently, we have been developing a new algebraic hybrid linear solver, PDSLin (Parallel Domain decomposition Schur complement based Linear solver) [3]. This is based on a non-overlapping domain decomposition technique called the Schur complement method, whereby subdomain problems can be solved by the direct solver SuperLU and the Schur complement system corresponding to the interface equations is solved using a preconditioned iterative solver. The enhanced scalability is attributed to the ability of employing hierarchical parallelism, namely, solving independent subdomain problems in parallel and using a subset of processors per subdomain. This requires only modest parallelism from SuperLU for each subdomain, and only a handful of iterations for the Schur complement system, because the Schur system is often better conditioned than the original system.

In this work, we demonstrate that the new hybrid solver is scalable to tens of thousands of processors while maintaining the same robustness as a direct solver. We will also provide comparative study of different solvers applied to this problem.

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3. I. Yamazaki and X. S. Li, "On techniques to improve robustness and scalability of the Schur complement method", *Proc. of VECPAR 2010*, 421-434, 9th International Conference on High Performance Computing for Computational Science, June 22-25, 2010, Berkeley, California.

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