Design of a generic parallel domain decomposition solver based on PDE-based interface operators

Post-doctoral project - 2017/2018
HiePACS*project-team, Inria Bordeaux-Sud Ouest
Nachos†project-team, Inria Sophia Antipolis-Méditerranée

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1 Scientific context

The HiePACS team at Inria Bordeaux-Sud Ouest has been developing a parallel hybrid iterative/direct solver package over the past few years [1]. This solver is fully algebraic and relies on state-of-the-art dense and sparse direct solvers such as Mumps and PasTiX. While scalable schemes can be designed using only algebraic techniques for symmetric positive definite problems [4], which result for instance from the discretization of elliptic PDEs, the situation is much harder for other linear systems. Relying only on the knowledge of the matrix coefficients might no longer be enough for the effective solution of linear systems arising from other types of PDEs such as those coming from wave propagation models. Not surprisingly, in a recent study [3], it was illustrated that a PDE-based domain decomposition algorithm [2] can be much more efficient than a generic algebraic domain decomposition for large-scale electromagnetic wave propagation simulations relying on the numerical solution of the system of frequency-domain Maxwell equations. In this latter approach, which has been studied and developed by the Nachos team at Inria Sophia Antipolis-Méditerranée, appropriate transmission conditions that are compliant with the characteristics of the underlying PDE system are imposed on the artificial interfaces introduced by the domain decomposition.

2 Objective of the work

The objective of this post-doctoral project is twofold. First, the formalism that has been considered for the design of the PDE-based domain decomposition algorithm for the system of frequency-domain Maxwell equations will be extended to other classes of PDEs, in particular the system of frequency-domain elastodynamic equations modeling seismic wave propagation problems. Second, the software infrastructure available in the MaPHyS package will be exploited to design a new functionality of the package where boundary transfer conditions will be supplied by the user through a suitable API. The performance and flexibility of this new capability of the parallel software will be validated through its coupling with existing simulation software for the frequency-domain Maxwell and elastodynamic equations. Numerical experiments will be performed on the Plafrim cluster at Inria Bordeaux-Sud

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Ouest and a supercomputer from the PRACE infrastructure. The goal of these simulations will be to demonstrate that the computational efficiency of the new version of the algebraic domain decomposition algorithm at the heart of the MaPHyS package is competitive with a PDE-based algorithm such as the one considered in [2].

3 Bakground

This position is intended for candidates with a strong background in computational sciences, preferably holding a PhD in applied mathematics, with some knowledge in numerical linear algebra or PDE analysis. A knowledge/experience of parallel programming would also be appreciated.

4 Supervision and starting date

The postdoc will work closely with Emmanuel Agullo and Luc Giraud (HiePACS project-team), and Stéphane Lanteri (Nachos project-team). Some meetings with other Inria teams (current or potential users of the MaPHyS software) will be organized as well to fully assess the decision made in the numerical and implementation design.

This one year position is planned to start on October 1st, 2017.

In order to apply, send a CV, reference letter and the contact details of 2 or 3 academic references to Luc.Giraud@inria.fr/Emmanuel.Agullo@inria.fr/Stephane.Lanteri@inria.fr

5 References

[1] S. Nakov
On the design of sparse hybrid linear solvers for modern parallel architectures
PhD thesis, Université de Bordeaux (2015)
See also https://gitlab.inria.fr/solverstack/maphys

[2] L. Li, S. Lanteri and R. Perrussel
A hybridizable discontinuous Galerkin method combined to a Schwarz algorithm for the solution of 3d time-harmonic Maxwell's equations
J. Comput. Phys., Vol. 256, pp. 563-581 (2014)

[3] E. Agullo, L. Giraud, M. Kuhn, S. Lanteri and L. Moya
Scalable high order HDG solver for frequency-domain electromagnetics
http://www-sop.inria.fr/nachos/tmp/hdgfd_maxw.pdf
Preprint (2017)

[4] E. Agullo, L. Giraud and L. Poirel
Robust coarse spaces for Abstract Schwarz preconditioners via generalized eigenproblems,
Research Report RR-8978, Inria Bordeaux. 2016