Project Team INRIA: **HiePACS**

Author of the post-doctoral research subject:

L. Giraud in collaboration with E. Darve (Stanford Univ.) and S.X. Li (LBNL)

Title of the post-doctoral research subject:

On the use of H-matrix arithmetic for the design of hierarchical parallel sparse linear solvers

Scientific priorities:

Computing the future: models, software and numerical systems
Calculer le futur : modèles, logiciels et systèmes numériques

Scientific Research context:

In many large scientific and industrial applications, one has to solve large sparse linear systems that arise from the discretization of a PDE with a smooth kernel. Using an appropriate ordering of the mesh nodes/unknowns, it can be shown that some dense blocks appearing during the sparse factorization of the matrix have low ranks. Consequently, they can be stored and applied using a lower computational cost than using regular dense representation, significantly lowering the computational complexity of the sparse factorization. The pioneering work is due to W. Hackbusch and co-workers who introduced the concept of Hierarchical matrices primarily in the framework of boundary element simulations.
In a recent work, X.S. Li and colleagues have considered the HSS-matrix representation in the context of a sparse multifrontal factorization technique to design an efficient sparse parallel direct solver for the solution of 3D Helmholtz equations.

Post-doctoral researcher work description:

The candidate will primary study how the H-matrix algorithms can be implemented in a supernodal sparse direct solver such as PasTiX (Inria) or SuperLU (LBNL). In a second stage, she/he will investigate possible variants to compute approximate Schur complement matrices such as those appearing in the hybrid solvers such as MaPHyS (Inria) or PDSLin (LBNL).
The robustness of the design of these parallel numerical schemes will be assessed on large challenging applications and the simulations will be performed on large computing platforms.
These research activities will be conducted in the framework of the FAST-LA associate team, that involves the HiePACS Inria research team, LBNL (X.S. Li and E. Ng) and Stanford University (E. Darve); it will require visiting periods in the three groups.

Required knowledge and background:

The successful development of the scientific work described above requires a strong background in applied mathematics (to design/adapt numerical schemes) and in computer science (to perform an efficient parallel implementation); therefore a PhD in computational sciences (applied maths and/or computer science) would be ideal.
A strong interest in large-scale numerical simulations would surely be an additional asset.

References:

1. M. Bebendorf, «Hierarchical Matrices», LNCSE, Springer, 2008.
2. S. Börm, «Efficient Numerical Methods for Non-local Operators $\mathcal{H}^2$-Matrix Compression, Algorithms and Analysis », EMS Tracts in Mathematics Vol. 14, 2010
3. S. Wang, X. S. Li, J. Xia, Y. Situ and M. V. de Hoop, « Efficient scalable algorithms for

solving linear systems with hierachically semiseparable structures », SIAM J. Sci. Compt. 2012. (revised http://www.math.purdue.edu/~xiaj/papers.html)
4. A.K. Saibaba, S. Ambikasaran, J. Y. Li, P. K. Kitanidis, and E. F. Darve, "Application of Hierarchical Matrices to Linear Inverse Problems in Geostatistics," *Oil & Gas Science and Technology – Rev. IFP Energies nouvelles,* Vol. 67 (2012), No. 5, pp. 857-875

Keywords: Numerical linear algebra, H-matrix arithmetic and variants, sparse direct solvers, hybrid iterative/direct solvers.

Duration: 16 months

Application:
Review of applicants will begin immediately and will continue until the position is filled. For further information about the position, please contact Luc Giraud (luc.giraud@inria.fr)
or visit
http://www.inria.fr/en/institute/recruitment/offers/post-doctoral-research-fellowships/post-doctoral-research-fellowships/campaign-2013