

Scalable Sparse Linear Solvers using Task-based paradigm

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PROGRAMME
DE RECHERCHE
NUMÉRIQUE
POUR L'EXASCALE

CONTEXT OF THE PH.D.

Thesis title: Scalable Sparse Linear Solvers using Task-based paradigm

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WP4: Portable, scalable numerical
building blocks and software.

Abdou Guermouche (U.Bordeaux, Inria)

Alfredo Buttari (CNRS, IRIT)

Emmanuel Agullo (Inria)

CONTEXT OF THE PH.D.

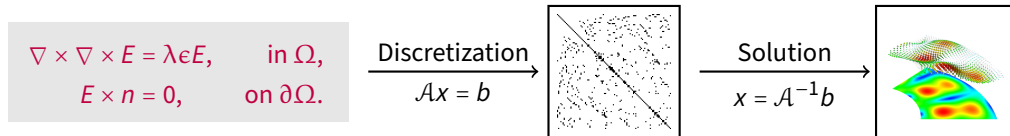
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Solution of sparse linear systems from the discretization of PDEs.

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using Task-based paradigm

WP3: Runtime Systems at Exascale

Samuel Thibault (U.Bordeaux, Inria)

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WP3: Runtime Systems at Exascale

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From the WP3

- **Programming model:** Sequential Task Flow (STF)
- **Runtime system:** StarPU [Augonnet et al., 2009].

Example: Solharis ANR (2019-2023) → extension of STF in StarPU with **RANK_REDUX** [Agullo et al., 2023]

- dense linear algebra algorithms (GEMM, SYMM, POTRF, ...).

ONGOING WORK

Thesis title:	<u>Scalable Sparse Linear Solvers</u>	using	<u>Task-based paradigm</u>
	WP4: Portable, scalable numerical building blocks and software.		WP3: Runtime Systems at Exascale
	Abdou Guermouche (U.Bordeaux, Inria) Alfredo Buttari (CNRS, IRIT) Emmanuel Agullo (Inria)		Samuel Thibault (U.Bordeaux, Inria)

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Current focus (2025-09-01): **RANK_REDUX** for sparse factorization methods

- Literature survey [Ashcraft, 1993, Rothberg and Schreiber, 1999, Sao et al., 2018]
- Numerical prototype in Julia [Bezanson et al., 2017].

REFERENCES

- [Agullo et al., 2023] Agullo, E., Buttari, A., Guermouche, A., Herrmann, J., and Jeco, A. (2023). **Task-based parallel programming for scalable matrix product algorithms**. *ACM Transactions on Mathematical Software*, 49(2):Pages 1 – 23.
- [Ashcraft, 1993] Ashcraft, C. (1993). **The fan-both family of column-based distributed cholesky factorization algorithms**. In George, A., Gilbert, J. R., and Liu, J. W. H., editors, *Graph Theory and Sparse Matrix Computation*, pages 159–190, New York, NY. Springer New York.
- [Augonnet et al., 2009] Augonnet, C., Thibault, S., Namyst, R., and Wacrenier, P.-A. (2009). **StarPU: A unified platform for task scheduling on heterogeneous multicore architectures**. In Sips, H., Epema, D., and Lin, H.-X., editors, *Euro-Par 2009 Parallel Processing*, pages 863–874, Berlin, Heidelberg. Springer Berlin Heidelberg.
- [Bezanson et al., 2017] Bezanson, J., Edelman, A., Karpinski, S., and Shah, V. B. (2017). **Julia: A fresh approach to numerical computing**. *SIAM Review*, 59(1):65–98.
- [Rothberg and Schreiber, 1999] Rothberg, E. and Schreiber, R. (1999). **Efficient methods for out-of-core sparse cholesky factorization**. *SIAM Journal on Scientific Computing*, 21(1):129–144.
- [Sao et al., 2018] Sao, P., Li, X. S., and Vuduc, R. (2018). **A Communication-Avoiding 3D LU Factorization Algorithm for Sparse Matrices**. In *2018 IEEE International Parallel and Distributed Processing Symposium (IPDPS)*, pages 908–919.