# ASYNCHRONOUS ITERATIVE DOMAIN DECOMPOSITION METHODS

FRÉDÉRIC MAGOULÈS*

Existing numerical algorithms face their limits when running on a large number of cores. For instance, parallel iterative methods meet serious scalability limitation due to the synchronization procedure occurring between the processors at the end of each iteration. The traditional scheme for parallel iterative algorithms is synchronous iterations. This describes a method where a new iteration is only started when all the data from the previous one has been received. These iterative algorithms have been widely studied and are often simply called parallel iterative algorithms, synchronous being omitted. Another kind of iterative scheme, called asynchronous iterations, can help solve these scalability problems, but lead to several convergence issues.

Domain decomposition methods, through artificial subdivisions of the domain, is a means for introducing parallelism. Iterative domain decomposition strategies include in one way or another the following ingredients : (i) a decomposer to split a mesh into subdomains ; (ii) local solvers to find solutions for the subdomains ; (iii) interface conditions enforcing compatibility and equilibrium between subdomains ; (iv) an iterative solution strategy for the interface problem. Synchronization during iterations of the interface problem, leads to intrinsic scalability limitations of iterative domain decomposition methods.

This talk addresses asynchronous parallel iterative domain decomposition methods (in space and in time). The iterative scheme is here modified, and asynchronous iterations are proposed for the solution strategy of the interface problem. After the presentation of the methods and their convergence properties, numerical experiments are performed in parallel on large scale computational fluid dynamics problems to illustrate the robustness and efficiency of the proposed method which outperform their synchronous counterparts. Besides, the programming library developped is proved stable and powerful for the implementation of any asynchronous iterative methods.

[1] G. Gbikpi-Benissan, F. Magoulès, , *Asynchronous sub-structuring method with alternating local and global iterations*. Journal of Computational and Applied Mathematics, 113531, 2021
[2] F. Magoulès, G. Gbikpi-Benissan, *Asynchronous Parareal time discretization for partial differential equations*. SIAM Journal on Scientific Computing, 40 :6, C704-C725, 2018.
[3] F. Magoulès, D.B. Szyld, and C. Venet. *Asynchronous optimized Schwarz methods with and without overlap*. Numerische Mathematik, 137(1) :199-227, 2017.
[4] A. Frommer and D.B. Szyld. *On asynchronous iterations*. Journal of Computational and Applied Mathematics 123(1-2) :201-216, 2000.

* CentraleSupélec, Université Paris-Saclay, France. frederic.magoules@hotmail.com.