Parallel hybrid solver for multiple right-hand sides for the wave propagation simulation in the frequency domain for 3D domains with heterogeneity and topography

Proposers: Henri Calandra (TOTAL), Luc Giraud and Jean ROMAN (INRIA).

The numerical simulation of wave propagation in complex three-dimensional regions in the frequency domain leads to the solution of very large sparse linear systems. The matrices do not exhibit any structural pattern due to underlying unstructured meshes used for classical or discontinuous Galerkin finite element discretization.

Due to the huge meshes handled in the petroleum industry, parallel solvers have to be implemented on massively multicore parallel platforms. The forthcoming peta/exaflop computers have a hierarchical structure that must be taken into account by algorithms; they must exhibit a hierarchy able to express several levels of parallelism with various computational grains. The methodological design of such parallel algorithms is challenging for frontier simulations.

In that framework, hybrid linear solvers based on domain decomposition philosophy appear as good candidates to tackle this challenge. The data partitioning naturally exploits a medium grain parallelism that complies nicely with the cluster structure of the modern computers. Parallel local direct solvers should exploit the fine grain parallelism at the multicore level. Those ingredients should enable the efficient design of flexible and numerically robust preconditioners. In addition, the solution of linear systems with multiple right-hand sides appears in many applications of petroleum industry. Efficient parallel implementations of block Krylov solvers combined with efficient recycling or incremental preconditioners should be considered to address this situation.

The objective of this PhD is to design and implement on massively parallel platforms a linear solver that should be generic and flexible enough to be applied in many simulations based on different discretization schemes. This solver will be used in oil reservoir simulations, in inverse problem solutions, etc …