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LOCAL/GLOBAL NON-INTRUSIVE PARALLEL COUPLING FOR LARGE SCALE MECHANICAL ANALYSIS

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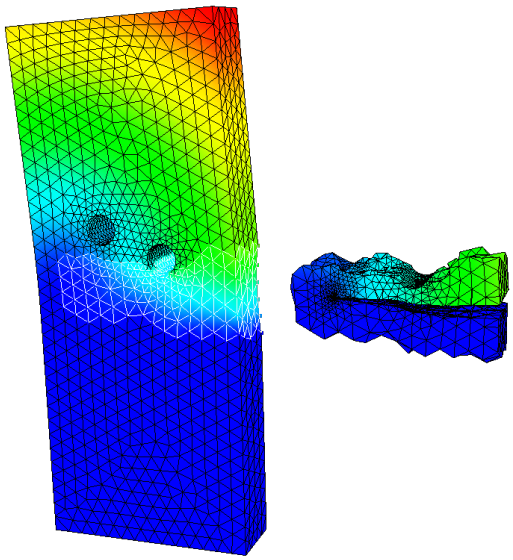
The permanent increase in available computing resources can achieve more and more ambitious numerical simulations. Structural analysis often involves multi-scale physics defined on very large models, in which must be represented localised (possibly non-linear) phenomena. The use of certain complex models in very large structures fatally leads to considerable cost in terms of computer resources, often beyond what is currently available. Recently, a new class of numerical methods is tackling with this problem: the non-intrusive coupling [1, 2, 3, 4]. The principle of non-intrusive coupling is to dissociate those two different scales, and to take into account a local feature in any initial global model without modification on the last one. From a practical point of view, that means to use two different solvers, one dedicated to the structure, the other to the local behavior.

In this talk, a two scale finite element mechanical simulation consists in two coupled overlapping models: a global one $M = M_1 \cup M_2$ (involving the full structure $\Omega = \Omega_1 \cup \Omega_2$, *i.e.* including a large number of nodes) and a local one $\tilde{M}_2$ (involving only a small part of the structure Ω_2). Thus the global model will be treated as a coarse linear one, whereas the local one will take into account the localised (potentially non-linear) behaviour. As an example, we consider here a FEM model coupled with a X-FEM model to simulate crack propagation. The non-intrusive coupling makes it possible to represent the effect of the crack on the remainder of the global structure Ω_1, without modifying its initial model.

Basically, the idea is to reach the equilibrium between the global M_1 and the local $\tilde{M}_2$ models at the interface by the mean of an iterative algorithm, similar to those used in domain decomposition methods, *i.e.* solving alternately the Dirichlet (*resp.* Neumann) problem on the local (*resp.* global) model until convergence. Also, Quasi-Newton methods allow us to get a fast convergence even if the stiffness gap between the global and local models become significant.

Actually, we seek to replace the global solution M_2 on Ω_2 by the one we would get with $\tilde{M}_2$.
It may be noted that meshes do not have to be conforming, as it is possible to enforce fields continuity in a weak sense (*via* mortar like methods). Nevertheless, coupling several models in a non intrusive way requires additional assumptions. For instance, the structural analysis software we used (Code_Aster, a structural engineering software developed by Électricité de France) treats Dirichlet boundaries in a black box way, so that we cannot have access to the nodal reaction forces as such: we can only get the virtual work resulting from it instead. A nodal forces recovery step is thus necessary.



The non-intrusive coupling can thus be seen as a flexible tool allowing us to locally modify a structure characteristics without modifying its initial model. The direct consequence of such a method is the possibility to merge industrial and research codes.
Moreover, several local models $\tilde{M}_i$ can easily be managed, each one being computed independently, allowing for an efficient parallel solver to be set up. A MPI communication can thus be set up between the global and each local solver, enabling high performance computations.

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