6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Avoiding communication by nonlinear domain decomposition methods

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Keywords: *nonlinear FETI-DP and BDDC, nonlinear domain decomposition, nonlinear elimination, Newton's method, nonlinear problems, parallel computing*

Parallel Newton-Krylov domain decomposition (Newton-Krylov-DD) methods are fast and robust solvers, e.g., for nonlinear implicit problems in solid and fluid mechanics. In these methods, the nonlinear problem is first linearized and then each linearized problem is deocmposed, i.e., is solved by a Krylov space method using a domain decomposition preconditioner. In nonlinear domain decomposition methods, by changing the order of these operations, first the nonlinear problem is decomposed and then the nonlinearly decomposed problem is linearized. This allows for the design of new parallel nonlinear FETI-DP and BDDC domain decomposition methods with increased locality and reduced communication. Such nonlinear domain decomposition methods have been successful in reducing the time to solution for different nonlinear problems compared to Newton-Krylov-DD approaches. Since the nonlinear domain decomposition methods are based on a decomposition of the global nonlinear problem into many local nonlinear problems, strongly local nonlinearities can be resolved by a small number of local nonlinear problems or computational cores, respectively. The remaining cores which are not busy with those local, strongly nonlinear effects can wait and save energy. In classical Newton-Krylov-DD approaches, this is not possible since all nonlinear effects, wheter local or global, interfere with the global convergence of Newton's emthod and keep all cores busy all the time.