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Component-averaged DD: a parallel, problem-independent solution to the cross-point issue

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Abstract

A major issue in domain decomposition (DD) is that of eliminating problems caused by integrating the subdomain solutions across subdomain boundaries. An even harder problem arises in the case of cross points, at which three or more subdomains meet. This topic has received a lot of attention in recent years, with several problem-specific solutions. It is shown that these problems do not exist with the block-parallel CARP-CG algorithm [G & G, PARCO 2010], which is the prototype of component-averaged domain decomposition (CADD). This is due to the fact that in CARP-CG, both the local processing and the merging of the local solutions are, in effect, solved in a certain superspace in a unified manner. Furthermore, there is no need for any problem-specific adaptation. In CADD, the domain is partitioned by boundaries passing between grid points. Every grid point next to a subdomain boundary is cloned in the processor(s) operating on adjacent subdomain(s), and the clones are treated as if they were the actual grid points. After the parallel processing of the subdomains, every boundary grid point and its clones are averaged and redistributed to the neighboring subdomains. In CARP-CG, the interior algorithm is Kaczmarz and the averaging is equivalent to Kaczmarz projections in a superspace, so an external CG can be used to accelerate the process. CARP-CG is particularly efficient for problems with very large off-diagonal elements and/or discontinuous coefficients, such as convection-dominated PDEs and high-frequency Helmholtz equations.