Domain Decomposition Methods and Parallel Software Development for Nonlinear Partial Differential Equations

Domain decomposition (DD) is one of the important classes of techniques for designing algorithms for solving scientific and engineering problems on large scale supercomputers. Because of the distributed-memory nature of most modern supercomputers, any problems to be solved have to be decomposed properly into, potentially, a large number of smaller problems allocated to independent processors. Many physical problems can be formulated in terms of partial differential equations (PDE) defined on a domain. DD obtains the independent subproblems by decomposing the domain on which the problem is defined. Such a technique has been used successfully for solving many practical problems on parallel computers with tens or hundreds of thousands of processors.

In the course, we discuss some recent development of parallel numerical methods for solving linear and nonlinear PDEs arising from some computational engineering applications, such as fluid dynamics, solid mechanics, climate modeling, as well as some design optimization problems constrained by PDEs. Hands-on parallel programming sessions will be provided and students will be expected to implement some of the algorithms on a parallel computer and submit a report in the end of the course. The main topics of the course include:

- Nonlinear PDEs and their applications in scientific and engineering computing
- Basic algebraic tools and parallel software development
- Iterative substructure methods
- Overlapping domain decomposition methods
- Nonlinear preconditioning techniques
- Applications of domain decomposition methods in bio-mechanics and climate modeling

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