Potential Applications For Domain Decomposition Methods At Lloyd's Register ATG

Abstract:

For 40+ years, Lloyd's Register (LR) ATG has been performing numerical simulations of engineering problems, including structural, fluid, thermal, and acoustical applications. Our Chinook computational fluid dynamics (CFD) software solves large compressible flow problems, such as explosive and supersonic turbulent flow problems, using domain decomposition (DD) methods to solve the 3-D Euler and Navier-Stokes equations. Problems are run using Beowulf clusters with MPI, and Metis for computing load-balanced partitions.

For problems involving adaptive mesh refinement (AMR) or discrete particle analysis, it is difficult to maintain grid load balancing, due to the changing problem topology. It is of interest to investigate strategies which minimize repartitioning time. It is also desired to determine whether there have been significant advances in other DD technology from Chinook's current status.

LR ATG performs finite element (FE) analyses of large ship problems using our flagship structural solver, VAST, which involves the inversion of a large, sparse matrix system. To reduce the number of degrees of freedom, ship models are usually composed of degenerate geometry in the form of shell and beam elements. These elements have high ratios of membrane to bending stiffness, which cause convergence difficulties for iterative solvers. No preconditioners have been found which adequately deal with all problems, hence the continued use of direct solvers in commercial FE packages.

There have been many advances in direct solvers in the last 20 years, including the invention of the supernodal method, which allows fast computation of dense matrix structures. The current linear solver in VAST utilizes Intel's Math Kernal Library (MKL) to perform this dense arithmetic. However, new methods utilize Schur decomposition, in which the structural mesh is broken into partitions that are initially solved independently. The second phase then involves the solution of the mesh region connecting the partitions. These methods are of interest to LR ATG, since they are applicable to both shared and distributed computing environments, and are almost directly scalable.