PARALLEL FINITE ELEMENT SIMULATION OF INCOMPRESSIBLE FLOWS ON THE CRAY X1

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In this paper, we will present recent results of our incompressible flows simulation on the new Cray X1 supercomputer. The flow simulations are carried out using our stabilized finite element formulations. The stabilizations are based the Streamline-Upwind/ Petrov-Galerkin (SUPG) and pressure-stabilization/Petrov-Galerkin (PSPG) techniques. Navier-Stokes equations for incompressible multi-fluids are integrated in time and space in an arbitrary Lagrangian-Eulerian domain. This allows us to handle the motion of the time dependant geometries. In mesh-moving scheme, we assume that the computational domain is made of elastic materials. The linear elasticity equations are solved to obtain the displacements for each computational node. In some applications, the nonlinear rigid body dynamics equations are coupled with the governing equations of fluid and are solved simultaneously to update the position of the moving objects.

The numerical simulations are large-scale and are carried out using the Cray T3E and Cray X1 supercomputers. In one numerical example, the fully implicit simulations are performed on an unstructured mesh with more than one billion tetrahedral elements. At every nonlinear iteration, a coupled linear system of equations with more than 875 million unknowns is solved. The numerical examples include 3D simulation of dispersion of chem./bio agents in urban areas and many 3D free-surface flows.