Development of Parallel Algorithm by Lattice Boltzmann Method

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1 A Background and Purpose

If Particle Method is a method of seeing the flow from microscopic standpoint, we can consider that conventional method such as Finite Differrence Method, Finit Element Method which utilizing discrete equation derived from Navier-Stokes equation is Macroscopic Method. Lattice Boltzmann method(LBM) positions just osculant.

LBM is a relatively new, kinetic theory-based, numerical technique for studying fluid mechanics. This method saw that fluid is a aggregation of vitual paticles iterate streaming and colliding. This method that regards virtual particle as minimum structure constitute physical fluid, treats particle action microscopic standpoint, so that can calculate difficult programs by convectional methods. Application have been done using LBM for hydorodynamics, flow through prous media, magneto-hydrodynamics, multiphase flow, and the reaction-diffusion equation.

Additonally, the lattice Boltzmann algorithm is well suited for parallel computation. The evolution equations involve many local operations which can be performed simultaneously. And this method is explicit in nature.

The objective of this work is that develop LBM algorithm suits parallel computing. The performance of LBM is quantitatively evaluated for massively parallel computing architectures.

2 Scheme

At the state of the particle in the Lattice Boltzmann Method, I decided to be handled cavity flow by 9 kinds of particles on 2D square lattice. I assumed as a equilibrium distribution function The expression of the low speed Taylor expansion (up to two order) of Maxwell-Boltzmann distribution which was the equilibrium solution of the Boltzmann equation.

LBM source codes to simulate 2D Cavity flow are developed on SGI Cray-T3E. This Machene consists of 128 nodes, which has 64MB memory each other. In Parallel computation, optimization of communication that avoid decrease calculation speed is very important. Using Massage Passing Interface(MPI), only equilibrium distribution function are transfer. And, computation by 1D and 2D decomposion of domain were conpared. To discuss about parallel efficiency, performance model was constructed.

3 Result

- Many programs occer in parallelize LBM code were discussed. Parallelized LBm codes leads to accurate results.
- Lattice Boltzmann codes to simulate 2D cavity flow are developed on parallel computer SGI Cary T3E. Computaion by 1D decomposion of domain leads 75.0% parallel efiiciency at Grid=384x384,64PEs, 85.9% at Grid=768x768, 64PEs. By using 2D decomposion of domain, Parallel efficiency was 88.0%, 93.5% .