§2. Study of Parallel Distributed Processing

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In the current NIFS network system, there are many powerful workstations and personal computers which are not always busy. We propose to utilize some of these computing resources to perform fluid simulation with PVM (Parallel Virtual Machine)[1], a widely used message passing software library. Domain decomposition strategies have already been adopted to accommodate a simple and robust parallel local numerical scheme. Because cluster computing is rather complicated task, simple approach is most practical. We have developed a simple explicit finite volume scheme Simplified Flux Splitting or SFS[2], for use as the local numerical scheme in each domain. This scheme in fact turns out to be a modified AUSM scheme.

1) Development of explicit finite volume scheme SFS2

The usual flux vector splitting scheme(FVS) in Euler solvers is simple and robust and seemed suitable for parallel computing. However, FVS is known to be more diffusive than flux difference splitting scheme. We started to improve FVS scheme less diffusive. In the usual FVS scheme, the subsonic flux is estimated by out-going and in-coming 2-particles, which transfer mass, momentum, and energy, and also cause numerical viscosity. We use a modified approach in which 1-particles transfer momentum and energy whereas mass flux is evaluated as in ordinary FVS.

This scheme is simple and robust for hypersonic calculations in which numerical instability often occurs. It is also less diffusive, thus allowing better high Reynolds number boundary layer resolution[2]. The SFS flux exhibits a discontinuity at the sonic point, which causes slow convergence. This difficulty is improved by changing the definition in which the local sound velocity is represented, resulting in a mass flux calculation similar to that in the original Van-leer FVS[3,4]. We call this scheme SFS2. Another uni-particle up-wind scheme called SHUS, different from SFS2 in regards to the estimation of the mass flux was found by Shima[3]. In SHUS, the mass flux estimation is the same as Roe's scheme, a flux difference splitting scheme with desirable less diffusive properties. All these different schemes turned out to belong AUSM scheme family. And this fact is explained by considering a moving control volume. The momentum and energy fluxes are transferred by upwind uniparticle motion evaluated by a first order approximate Riemann solver[5].

2) Validation of cluster computing with PVM

We examined network-based concurrent workstation cluster computing using Himeno's Poisson benchmark kernel for the performance check. Our virtual machine includes SUN4/IX, SUN4/10 HP model 712/60 and HP E35 workstations, and all these machines are connected to the same Ethernet LAN. We modified the Poisson benchmark kernel, which is an essential part of incompressible fluid simulation solvers, to be a PVM parallel kernel using domain decomposition as a parallelization technique. The benchmark kernel simulates an essential part of Poisson solver, which characterize less calculation compared to memory access of referring computational domain. Unfortunately the benchmark performs more poorly as a parallel kernel divided among 4 networked workstations than as a non-parallel problem running on one workstation. We take this to indicate that only embarrassingly parallel problems, based on a trivial partitioning of the problem which requires little or no communication between processors are suitable to today's network computing. But recently our network environment grows rapidly. Next generation ATM LANs may resolve the problem of long latency for interprocessor communication.

References

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