A Parallel Calculation of A Flow field Using The Dynamic Load Balancing Method

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Abstract

In this thesis, the technique to mount the AMR (Adaptive Mesh Refinement) method on a parallel computer was considered.

In the case of analyzing the compressible fluid using a numerical method, it is necessary to use the technique to give the sharp capturing the numerical discontinuous. The TVD method gives us sharp solutions at the numerical discontinuous region. And that method keeps a highly accurate solution at the continuity region. This method was proposed in beginning 1980 by Harten and it is generally used as a technique of compressed fluid analysis. To obtain the solution of higher accuracy from obtaining the solution on the grid point (discreet point), a general numerical analysis method including the TVD method should increase the number of grids. However, the calculation cost grows by increasing the number of grids. To obtain the solution of high accuracy without enlarging the calculation cost as much as possible, the method by which the grid is increased only to the area where we want to obtain high accuracy is devised. In a flow scene analysis in the object surroundings, the method which gives a fine grid at the downstream is generally used. When an appearance of the flow scene can be forecast so steady to some degree, we only has to put the fine grid on a necessary place. However, it is necessary to often think about the generation of an efficient fine grid so that the area where necessary to keep high accuracy is may change at time when a physical phenomenon is unsteady. The technique by which a local fine grid method is applied to unsteady problem is advocated by Berger et al. It is called AMR (Adaptive Mesh Refinement), and as the fine technique of the grid, this technique is looking for, and a technique by which the grid in the area satisfied this condition is fined as for the area where the inclination of a physical amount is large. Because only necessary amount of fine grid is given in the place where high accuracy is necessary, this technique is very dominant in the point of the calculation cost.

The Domain Decomposition Method (DDM) is given as a technique generally used when calculating in parallel. This is a technique by which those small areas are allocated in each PE by decomposing the calculation area into two or more small areas. The calculation is advanced independently, data is exchanged according to necessary timing, and then the calculation is

advanced. Especially, it is a very general technique of the distributed memory computer environment. When the AMR method is mounted on a parallel computer by using this technique, it is necessary to consider following.
1:Problem of amount of load
2:Problem of amount of communication
About the first problem, amount of the load is especially an important element in AMR method. Generally, the area where the fine grid is generated changes as the calculation step advances because the AMR method is applied to unsteady problem. Therefore, how the calculation area is allotted to each PE to distribute the amount of the load of each PE when the domain decomposition method is used as a technique of the parallel calculation. The second problem is an additional process caused when calculating in parallel. It is necessary to keep the cost to achieve the performance improvement by a parallel calculation.

In such background, as for the technique which uses the domain decomposition on a parallel computer of the distributed memory type, the research of Kinoshita is given. It is a technique of dynamically take charge by each PE and calculate this area by dividing the calculation area into a small area more than the number of PE in this technique. To increases the number of division, the more on average the load is distributed. However, the problem of the amount of the communication became a problem.

In this thesis, a dynamic domain decomposition method to which the area of which each PE took charge changed as the time step advanced was used to distribute the load concretely. As for each PE, if only the calculation area given beforehand calculates, the thing to often reduce the amount of the communication becomes possible because we use this technique. Moreover, some limitation is added to the method of the domain decomposition and deals with this though the problem of the complexity of the message communication is brought up advance by the time step. This limitation fixes the direction where a dynamic area is divided to the one direction, and suppresses this complexity. Moreover, the communication cost decreased as much as possible because it was very high cost. So the best timing by which the area was decomposed was examined in this research for that. Such an examination was done with parallel computer CrayT3E of the distributed memory type in number 8 of PE. We succeeded in making the problem of the flow in jurisdiction with the difference that the subdivision grid concentrates on a comparatively local area a speed improvement ratio and obtaining six times or more the performance.

Key Words: **Parallel Calculation, Dynamic Load Balancing, DDM, AMR, Compressible Flow**