UPACS project in NAL

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Introduction

The progress of computational fluid dynamics (CFD) and parallel computers in 1990s enables massive computation of flow around realistic complicated aircraft configuration, direct optimization of aerodynamic design including structure analysis or heat transfer, complicated unsteady flow in jet engines, and so on. This means, however, the computer program increases its complexity as well for the adaptation to the complex configuration, the parallel computation and the multi-physics coupling. Although the programming has been accomplished by great efforts of a few researchers and engineers for each specific application areas, we know it is actually inefficient not only for writing programs but also for the code validation and the accumulation of know-how.

In order to overcome the difficulty in such complicated programming and to accelerate the code development, NAL has started a pilot project UPACS (Unified Platform for Aerospace Computer Simulation) in 1998. The project aims development of common CFD codes that can be shared among researchers and code developers. The basic concept of the code design, the parallel computational method, the multi-block method and its programming are shown in the presentation.

Concept of the UPACS code

After several conceptual studies we determined the following design concept and approaches.

(1) Multi-block methods: Concerning the adaptation to complex configuration, we chose multi-block structured grid methods as the first step. Extension to unstructured grid methods is also under consideration.

(2) Separation of multi-block multi-processor procedures: The parallel computation and multi-block data control processes are clearly separated from the CFD solver modules so that one can modify the solver modules without concerning the parallel techniques and multi-block data handling.

(3) Portability: The parallelization based on domain-decomposition using the communication library, MPI, is used to minimize the dependency on the hardware architecture.

(4) Structure and capsulation: Clear data and program structure and capsulation of modules are used to make the code sharing easier among CFD researchers and developers.

There are several key features in the UPACS code design to realize these concepts. For example, one of them is shown in Fig. 1, the hierarchical structure of the UPACS code. The lower layer consists of the CFD solver modules for a single block, which can be easily prepared for several numerical models. The middle layer has to handle the complicated multi-block data controls for the multi-processor hardware and the data transfer between the blocks. This layer is generalized and prepared as a library so that one can achieve complicated calculations without getting into the detail of data handling algorithms. The upper layer, which is also prepared for code extensions, determines the framework of iteration algorithm that would be dependent on the solution methods or numerical models.

Current status

The UPACS code is now under development through discussion on the detail design and validation of the CFD solver and the multi-block multi-processor procedures. The target in 2000 is practical applications in the several projects and extension to the interdisciplinary (multi-physics) problems.
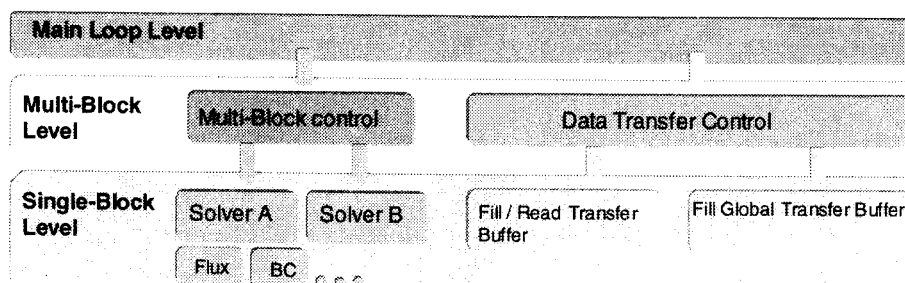

Fig.1   Hierarchical code structure of UPACS