New method for domain decomposition of complex geometries in flow simulation

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Abstract

A new method of domain decomposition has been developed for arbitrary complex geometries. The method is not based on equal subvolumes but on equal numbers of active cells. Thus the variables of the simulation are stored in ordered one-dimensional arrays to replace the conventional three-dimensional arrays, and domain decompositions of complex three-dimensional problems become one-dimensional. Finally, three-dimensional results can be recovered using a coordinate matrix. To illustrate the new method, flow simulation in rectangular ducts was performed using the Lattice Boltzmann Method (LBM). The results of parallelization show that domains of complicated geometries can automatically be decomposed and there are no load imbalances induced by the present domain decomposition. Furthermore, it keeps the advantage of the slice and box decomposition so that the dependencies between processors are simple due to the nearest connectivity of the lattices on the interfaces to communicate. The amount of data to be transmitted has been reduced to a minimum. In addition, the memory use is almost optimal since only the active cells of the computational domain are stored in memory. Although this approach is illustrated with LBM, it is also suitable for other numerical methods in fluid dynamics.

Key words: Domain decomposition; Parallel computation; Lattice Boltzmann method; High Performance Computing (HPC); complex flow.

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