Performance Tuning of Parallel Structural Analysis Code Based on Iterative Substructuring with BDD Pre-conditioner for Peta-scale Supercomputers

Hiroshi Kawai[1]*, Masao Ogino[2]**, Ryuji Shioya[3]***, Tomonori Yamada[4]**** and Shinobu Yoshimura[4]****

* Department of Mechanical Systems Engineering, Tokyo University of Science-Suwa
5000-1 Toyohira, Chino-city, Nagano, Japan
E-mail: kawai@rs.tus.ac.jp

** Nagoya University

*** Toyo University

**** The University of Tokyo

Abstract

Recently, rapid adoption of multi-core scalar CPU in the HPC industry is forcing the application developers to optimize the performance of their simulation codes for a massively parallel multicore supercomputer. The total number of processor core in a system is already reaching the order of millions. Also, to obtain high intra-node performance, efficient utilization of processor cache memory and SIMD instruction set should be considered. Drastically new design and implementation approaches will be required in the peta-scale as well as the post peta-scale eras.

In this work, performance tuning approaches of a structural analysis code based on the hierarchical domain decomposition method (HDDM) as a form of iterative substructuring-type DDM for peta-scale massively parallel supercomputers are presented. First, a new subdomain local FE solver, DS-LSC, using explicit evaluation of local Schur complement, is introduced. Next, the coarse grid correction step in BDD pre-conditioner is accelerated by the explicit evaluation of the inverse of the coarse matrix. These approaches are effective for a linear dynamic analysis, where a linear equation with the constant coefficient matrix has to be solved repeatedly. As a preliminary benchmark result, about 10 % of peak FP performance is obtained on RIKEN K Computer using 32768 nodes. The implementation will be introduced to the future version of open-source CAE system, ADVENTURE.