

Parallel Iterative Solves for Solid Earth Simulation on the Earth Simulator

Kengo Nakajima

Department of Computational Earth Sciences, Research Organization for Information Science and Technology (RIST), Tokyo, Japan, e-mail: nakajima@tokyo.rist.or.jp

An efficient parallel iterative method for unstructured grids developed by the authors for shared memory symmetric multiprocessor (SMP) cluster architectures on the GeoFEM platform is presented. The method is based on a three-level hybrid parallel programming model, including message passing for inter-SMP node communication, OpenMP directives for intra-SMP node parallelization and vectorization for each processing element (PE). Simple 3D elastic linear problems with more than 2.2×10^9 DOF have been solved by localized 3×3 block ICCG(0) with additive Schwarz domain decomposition and PDJDS/CM-RCM (Parallel Descending-order Jagged Diagonal Storage/Cyclic Multicolor-Reverse Cuthil McKee) reordering on 176 SMP nodes of the Earth Simulator, achieving performance of 3.8 TFLOPS (33.7% of peak performance). The PDJDS/CM-RCM reordering method provides excellent vector and parallel performance in SMP nodes, and is essential for parallelization of forward/backward substitution in IC/ILU factorization with global data dependency.

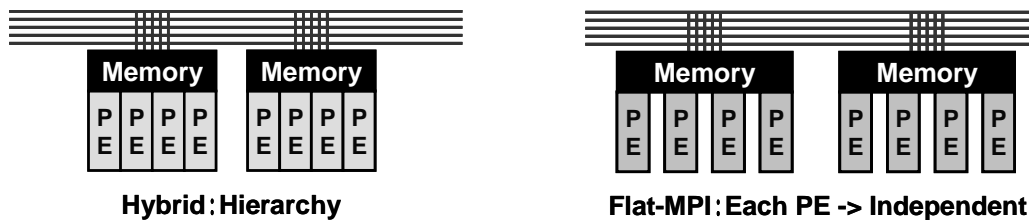


Fig. 1 Parallel programming models for SMP cluster architectures

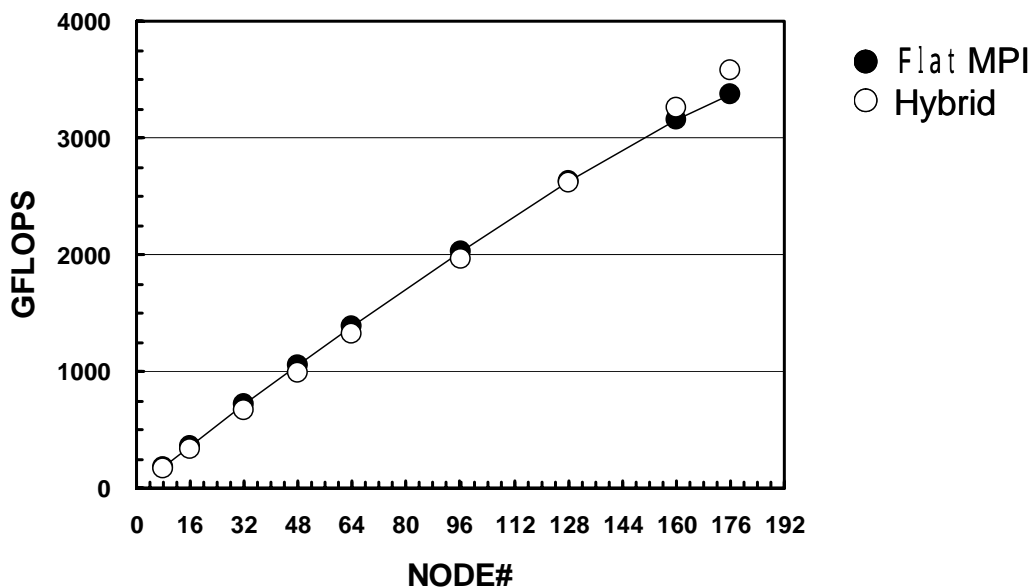


Fig. 2 Problem size and parallel performance (GFLOPS rate) on the Earth Simulator for the 3D linear elastic problem using between 8 and 176 SMP nodes. Problem size/SMP node is fixed as 12,582,912 DOF ($3 \times 256 \times 128 \times 128$). Largest case is 2,214,592,512 DOF on 176 SMP nodes (1408 PEs). Maximum performance is 3.78 (Flat MPI) and 3.80 (Hybrid) TFLOPS (Peak performance= 11.26 TFLOPS). (BLACK Circles: Flat MPI, WHITE Circles: Hybrid).