【Grant-in-Aid for Scientific Research (S)】

Integrated Disciplines (Informatics)

Title of Project: Advancement of CFD Applications for Manufacturing Technology to Exascale

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Research Area: Informatics
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【Purpose and Background of the Research】

Innovative developments in CAE are necessary for Japan to become a leading manufacturing technology country in the world. To this end, it is essential to make use of large-scale simulations using ultra-high resolution computation with a leading-edge supercomputer. Due to the low memory access and node interconnection performance compared to the high performance of floating-point arithmetic computation, it is hard to achieve a high performance on current supercomputers, and this imbalance is predicted to become worse. We need to develop new numerical schemes, algorithms, and parallelization techniques suitable for next-generation exascale supercomputers to enable more efficient use of computer resources. The purpose of this project is to develop and demonstrate the efficient run of applications for exascale super computers to contribute to manufacturing. We do not focus on FLOPS performance or the computational efficiency of benchmark tests but rather attach importance to **time-to-solution**, which refers to the actual time it takes to acquire the simulation results.

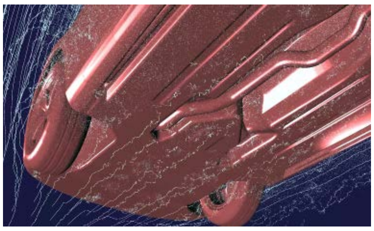

Fig.1 Aerodynamics around an automobile.

【Research Methods】

In order to improve the **time-to-solution** performance on exascale supercomputers, we are developing a novel performance model considering local memories, caches, and internode communication specifications and are exploring efficient numerical schemes and algorithms. We are also experimenting with combining various optimization techniques, such as overlapping of calculation and communication, minimizing the data transfer and have evaluated resulting application performances on a peta-scale supercomputer TSUBAME2.5/3.0

Essentially, we show the path to exascale simulation for manufacturing technology by developing prototype applications and evaluating their **time-to-solution** performances. The target applications include incompressible turbulent flow (Large-Eddy Simulation), multi-phase flow, fluid-structure interaction, phase-field simulation of material dendritic solidification in flow field, and particle-based simulation.

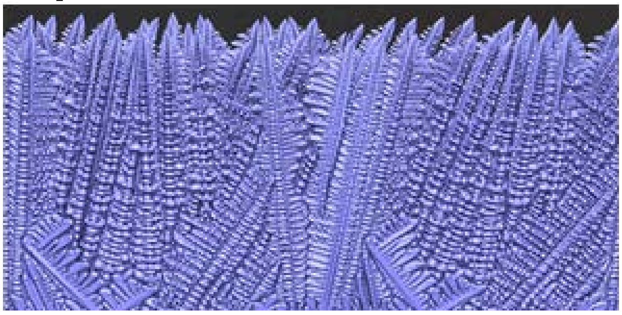

Fig.2 Phase field simulation for dendritic solidification of binary alloy on TSUBAME 2.0 (4,096 × 6,400 × 12,800 mesh, 2.0 PFLOPS in single precision).

【Expected Research Achievements and Scientific Significance】

We predict a more than 30 times reduction of the **time-to-solution** on exascale supercomputers. Another expected advantage is a reduced electronic power consumption due to shortening the **time-to-solution**. The project outcomes can be applied to other mesh/particle-based HPC applications for manufacturing technology.

【Publications Relevant to the Project】

T. Shimokawabe, T. Aoki, T. Takaki, A. Yamanaka, A. Nukada, T. Endo, N. Maruyama, S. Matsuoka: "Peta-scale Phase-Field Simulation for Dendritic Solidification on the TSUBAME2.0 Supercomputer", in Proceedings of the 2011 ACM/IEEE and Analysis, SC'11, IEEE Computer Society, Seattle, WA, USA, Nov. 15, 2011, SC'11 Technical Papers.

【Term of Project】 FY 2014-2018

【Budget Allocation】 144,900 Thousand Yen

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