MEXT Program for Promoting Researches on the Supercomputer Fugaku, Leading research on innovative aircraft design technologies to replace flight test

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Abstract

Realization of high-precision aerodynamic prediction by high-fedelity LES analysis around whole aircraft configulation for actual flight conditions.

Ref. URL: http://www.klab.mech.tohoku.ac.jp/fugaku/index.html

Reasons and benefits of using JAXA Supercomputer System

It is possible to develop programs efficiently because JSS has the same architecture as the final target "Supercomputer Fugaku",

Achievements of the Year

Flow analysis, which requires high B/F, has become difficult to perform on recent low B/F computers. In particular, continuous access and long loop lengths are required to fully utilize the memory performance. However, stencil calculations, which are commonly used in fluid dynamics, have several problems that prevent them from fully utilizing the memory access performance. Therefore, in order to cope with the ever worsening B/F environment, we evaluated the performance of base function-based methods, aiming to break away from stencil calculations. Here, we employed the FR method and compared the conventional stencil calculation with the FR method for a hierarchical equally spaced orthogonal structured grid.

Figure 1 shows the results for the A64FX CPU as an example of the comparison results, where "cl" indicates application to the cell loop and "sl" indicates application to the solution point (SP) loop, for loops applying thread parallelism using OpenMP. "FD" is the result of the conventional finite difference method (stencil calculation), and "3D, 1D, and 4D" are the results of the FR method. Here, "3D, 1D, and 4D" are the differences in the data/loop structure of the program. SP is generally 3-dimensional in space, and the cells that contain SP together form a 4-

dimensional, 4-layered loop. Based on "3D," which implements this with a single loop of cells plus a triple loop of SPs, "1D" is a triple loop of SPs fused into a single loop and "4D" is a fusion of the triple loop of the SP and the single loop of the cell to make a single loop. From the figure, it can be seen that the FR method, especially 4D, is faster than the finite difference method (FD) in regions where SP is small (regions used by the FR method). On the other hand, the conventional finite difference method (FD) is faster in regions where SP is large (meaning ultra-high-order accuracy in the FR method). Thus, differences in performance characteristics were obtained depending on the value of SP and the data loop structure. Note that the FR method calculates with higher-order precision when the SP is increased, but the precision remains the same for the finite difference method. We plan to conduct a more detailed comparison including these differences.

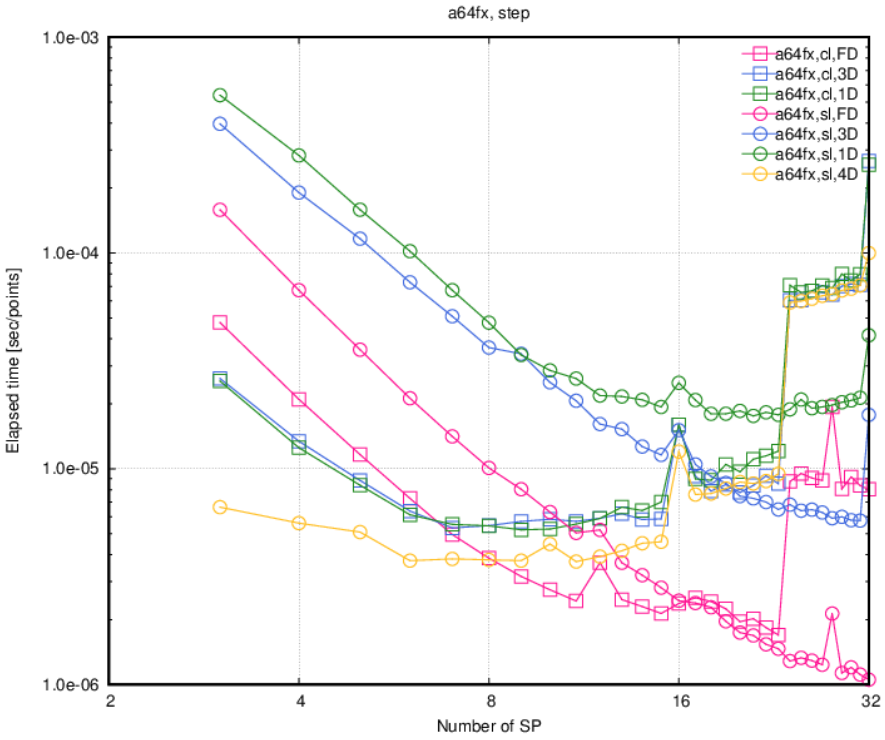

Fig. 1: Performance comparison between finite difference method(FD) and FR method(3D, 1D, and 4D).

Publications

- Oral Presentations

Ryoji Takaki, "Study on conservation of immersed boundary method", 55th Fluid Dynamics Conference/41th Aerospace Numerical Simulation Symposium, 3C04, 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 40
Elapsed Time per Case	50 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.14

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	3,880,322.30	0.18
TOKI-ST	14,102.96	0.02
TOKI-GP	62.55	0.00
TOKI-XM	0.00	0.00
TOKI-LM	247.67	0.02
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	495.58	0.41
/data and /data2	23,605.46	0.15
/ssd	1,636.15	0.15

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	2.99	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2 (%)
ISV Software Licenses (Total)	46.19	0.02

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.