

Formura: a domain-specific programming language for code-generation and autotuning of stencil computation

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High-performance computing (HPC), is the art of making efficient use of the supercomputers such as the K computer. HPC enables high-resolution numerical simulation. Thus it is one of the fundamental tools of science and engineering. Stencil computations, or explicit lattice schemes are one of the important categories of numerical simulation schemes, where the state of the simulated system is represented as multidimensional array and the computation proceeds by repeatedly updating the elements of the array as the function of elements of their neighbors. Stencil computations have lots of applications such as meteorology, seismology, material science and astrophysics.

Stencil computation programs for supercomputers are very long. They sometimes span hundreds of thousands of lines, as is common in HPC, and takes lots of effort to write.

We have been developing programming language Formura to tackle this problem. In Formura, you can specify your application in simple notations much similar to partial differential equations. From that specification Formura generates fully-parallelized and optimized codes for you. Formura have been developed and tested on the K-computer. Our work has been selected as one of the finalists for the ACM Gordon Bell prize in 2016, that recognizes outstanding achievement in high-performance computing.

Formura, for the first time, have demonstrated that it is possible to generate HPC programs from the essential specifications of the application. We hope that such code-generation technology get developed and used, starting from in stencil computations and then in many other branches of numerical simulation.