A Domain-Specific Programming Language for Particle Simulations on Distributed-Memory Parallel Computers

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ABSTRACT

Particle methods provide a fully adaptive numerical simulation scheme that efficiently parallelizes on distributed-memory computers. The necessary parallel data structures and operators have been implemented in the PPM Library [3], effectively reducing code development times to just a few hours.

The PPM Library implements a generic set of abstractions for particle methods and hybrid particle-mesh methods. These abstractions naturally define a language in which the workflow of a particle simulation can be concisely expressed. We present the domain-specific programming language PPML, the parallel particle-mesh language, for hybrid particle-mesh simulations. PPML provides a compact notation for particle methods. The PPML compiler translates PPML code to object-oriented Fortran 2003 code that can then be compiled and run on the target machine. The PPM Library is used as a runtime system, providing transparent parallelization on distributed-memory computers.

We aim at reducing the knowledge gap for mid-sized adaptive-resolution simulations running on a few hundred to a few thousand processors. We present several examples of PPML and its use, highlighting the computational efficiency and parallel scalability of the automatically generated simulation codes. We further present WebCG, a graphical front-end for PPML that runs in a web browser and allows remotely generating, running, and controlling parallel particle simulations.

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