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# Motherboard heat dissipation design using the Parareal method in PETSc

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**Abstract**

This work presents a parallel implementation of the Parareal method using PETSc (Portable, Extensible Toolkit for Scientific Computation) to solve a typical motherboard heat dissipation design problem that can be viewed as a parabolic partial differential equation with known boundary conditions and initial state, where the minimized cost function relates the controller energy usage and the approximation of the solution to an optimal known function. The equations that model the process are discretized with Finite Elements in space and Finite Differences in time. After discretization in space and time, the problem is transformed to a huge linear system of algebraic equations that is solved by the Conjugate Gradient method. The Parareal preconditioner is implemented to speed up the convergence of the Conjugate Gradient. The main advantage in using the Parareal method in this parallel implementation in PETSc is to speed up the resolution time, when comparing to implementations that only use the Conjugate Gradient or GMRES methods. The implementation developed in this work offers a parallelization relative efficiency for the strong scaling that is approximately 70% each time the process count doubles, while for the weak scaling it is 75% each time the process count doubles for a constant solution size per process and up to 96% each time the process count doubles for a constant data size per process.

**Key words**: motherboard design, parallel implementation in PETSc, Pararreal preconditioner, Finite Elements in space and Finite Difference in time, parallelization efficiency.

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