Performance of a parallel technique for solving stiff odes using an implicit Runge-Kutta method

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Differential equations arise in many fields of application, such as in the simulation of phenomena in chemistry, physics, mathematics, engineering, biology and medicine. The models are generally in the form of initial value problems (IVPs) ODEs, which can be extermely costly to solve when they are stiff due to the requirement of working with implicit methods. It is widely believed that computationally intensive problems are only feasible to be solved using parallel computers.

In this article we propose a parallel implementation of an ODE solver based on implicit Runge-Kutta framework. The parallelization was performed in two levels, across the method in solving the arising nonlinear systems, and across the system in solving the associated linear systems. We used two kinds of test problems, Brusselator and Dense problems. The experiment was performed on a cluster of PCs under PVM message passing environment.

The result shows that for the Brusselator problem either with finite-difference or analytical Jacobian, an ideal speedup can be achieved by using two or four processors. For dense problem the maximum speedup can reach up to 2.0 and 3.2 by using two and four processors respectively.