Sandia National Laboratories

Scalability Assessment for Parallel Algorithms of Numerical Simulation: Gas Dynamics and Heat Conduction (Diffusion)

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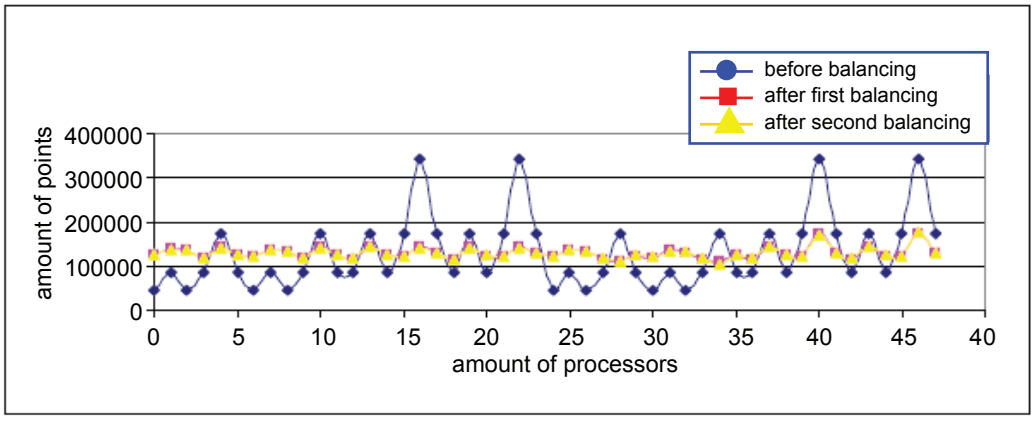
Project Description

The scalability of 3-D solutions to gas dynamics and diffusion equations on parallel computers will be researched. The work is conducted within several software requirements, such as minimization of redundant computations, minimization of interprocessor communications, and optimization of transfer lengths. Furthermore, there are three sources of load imbalance to be considered: the physical terms of the governing equations, mathematical sources of imbalance, such as local iterations and software optimizations, and the hardware itself and associated system software.

Using an analytical approach, validated by 3-D simulations, VNIIEF will obtain formulas for the runtime of algorithms based on problem and parallel computer parameters. This will permit prediction of the scalability of applications on future high-performance computers (e.g., those created by ASC or VNIIEF).

Twelve tasks will be performed at the discretion of the Sandia principal investigator, and as of December 2006, the first six tasks have been completed:

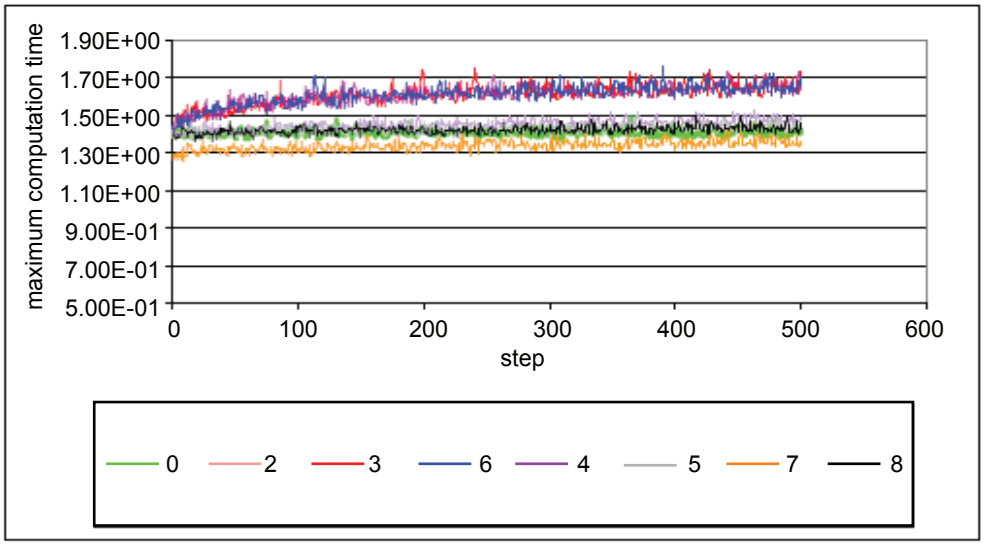
- Provide a description of Trek+++.
- Develop a set of dynamic problem examples as test cases for Trek+++.
- Develop and implement the analytical runtime formula for the Eulerian approach for gas dynamics problems.
- Develop analytical runtime formula for diffusion problems and validate gas dynamics and diffusion runtime formulas for Eulerian approach.
- Improve scalability of algorithms for gas dynamics.
- Improve scalability of algorithms for gas dynamics as well as coupled gas dynamics and diffusion problems.
- Enhance analytical runtime formula and calculator.
- Improve model of computational scheme for adaptive grid refinement of gas dynamic problems to enhance scalability.
- Improve model of computational scheme for adaptive grid refinement of gas diffusion problems to enhance scalability; develop diffusion and dynamic models.
- Enhance analytical runtime formula and analytical formula calculator incorporating adaptive grid refinement algorithms.
- Present at an international conference in St. Petersburg, Russia.



Distribution of points over the processors, 48 processors.

Technical Purpose and Benefits

Both Sandia and VNIEFF are major supercomputer users on behalf of their governments. It is of mutual interest to both organizations for their use of supercomputers to be efficient and predictable. By modeling hypothetical supercomputer operations, it can be determined whether particular algorithms will be successful and whether changes need to be made in the supercomputer design. Software styles with good performance over many hypothetical computer designs can be recommended for use.



Maximum computation time on one processor versus computational step on 48 processors.

Collaboration between Sandia National Laboratories (SNL), Livermore, CA, USA, and the Russian Federal Nuclear Center – All Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov, Russia

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