Lawrence Livermore
National Laboratory
University of California

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Sisal Language Project

Paring Parallel Production Prices

Mission:

The objectives of the Sisal Language Project are to develop high-performance functional compilers and runtime systems to simplify the process of writing scientific programs on parallel supercomputers and help programs develop functional scientific applications.

Impact:

Functional languages such as Sisal provide a low-cost approach to developing parallel computing applications that still offer high performance and portability. This is of major significance in an area where costs are projected to top $1 trillion.

Despite the commercial availability of multiprocessor computer systems, the number of parallel scientific and commercial applications in production use today remains small. It is estimated that the worldwide cost of developing software for sequential machines will reach $450 billion in 1995. Even if only a quarter of the software is parallelized, it would cost at least an additional $550 billion. Functional programming can reduce this increased cost while still providing high performance and portability.

Parallel Programming

Parallel programming in imperative languages, such as Fortran and C, has proven difficult. These languages developed for sequential computer systems do not naturally support parallelism. In addition to expressing the algorithm, the programmer must encode the program's synchronization and communication operations, ensure data integrity, and safeguard against race conditions. The extra programming complexity increases costs, and the time-dependent errors exposed by these languages can frustrate even the most experienced programmers.

Parallel Language Technology

Functional languages, such as Sisal, promote the construction of correct parallel programs by isolating the programmer from the complexities of parallel processing. Based on the principles of mathematics, Sisal exposes implicit parallelism through data independence and guarantees determinate results.

A functional program consists of a set of mathematical expressions that map inputs to outputs. Sisal programs are referentially transparent and free of side effects, deadlock, and nondeterminacy. The determination of data dependencies, scheduling of operations, communication of data values, and synchronization of concurrent operations are realized automatically by the compiler and runtime system. The programmer does not and cannot manage these operations.

Sisal programs that run correctly on a single processor are guaranteed to run correctly on any multiprocessor, regardless of architecture. Relieved of the most onerous chores of parallel programming, the software developer is free to concentrate on algorithm design and application development.

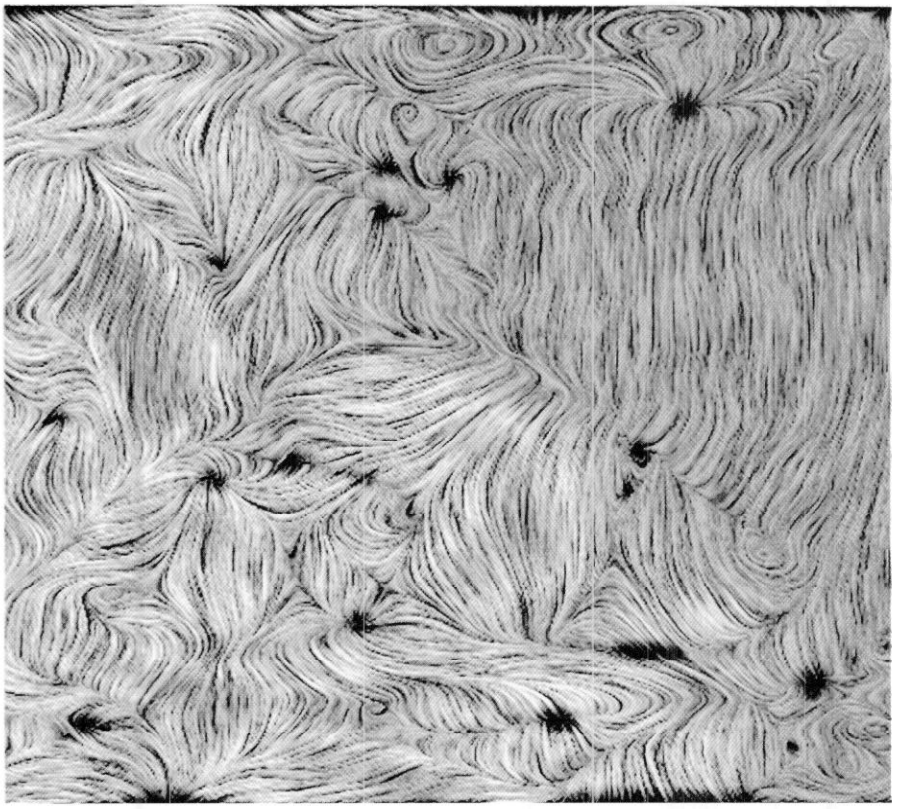
Performance

Today, most Sisal programs outperform equivalent Fortran programs compiled using automatic vectorizing and parallelizing software, and run comparable to hand-written parallel Fortran codes. Due to the simplicity of the functional programming model, the development cost of the Sisal programs is five to seven times less than the Fortran programs.

Mature Sisal systems exist for the family of CRAY computers, SGI 340 Iris, Convex C2, Sequent Symmetry, Encore Multimax, Sparc and RS6000 workstations, and Macintosh. Prototype systems exist for the Intel Paragon and Ncube 2000. Sisal systems include a high-performance compiler, a high-performance microtasking runtime system, a debugger, and tools to collect compile-time and runtime statistics. We have implemented a mixed-language interface that allows Sisal programs to call C and Fortran and vice versa. Presently, we are extending the language to include Fortran 90 array syntax and array operations. Copies of the new language definition and copies of the proceedings of the most recent Sisal conference are available.

Technology Transfer

Lawrence Livermore National Laboratory (LLNL), IBM Corporation, and BioNumerik Pharmaceuticals have signed a Cooperative Research and Development Agreement to develop a high-performance Sisal–Fortran 90 programming environment for the IBM Power/4 and Power/4 follow-on systems, if any, and to write in Sisal *ab initio* quantum mechanical and statistical mechanical molecular dynamics codes to facilitate the rational design of cancer drugs. The project is a three-year, $6 million effort funded by the Department of Energy (DOE) Technology Transfer Initiative and in-kind contributions from IBM Corporation and BioNumerik Pharmaceuticals.



Computational fluid dynamics field imaged by a line integral convolution algorithm written in Sisal.

Sisal Scientific Computing Initiative

The Computing Research Group at LLNL is accepting proposals for the Sisal Scientific Computing Initiative. This Initiative, sponsored by LLNL and the DOE, is intended to promote the use of Sisal and educate the scientific community in the art of functional programming. Members of the Computing Research Group will provide free CRAY computer time, educational material, training, consulting, and user services to scientific applications programmers interested in writing Sisal applications.

The group concentrates on the development and efficient implementation of the programming language Sisal and the development of scientific applications. The group welcomes the opportunity to work with scientific application groups to explore this emerging programming technology.

The Computing Research Group is one of the four largely independent research groups in the Computing and Mathematics Research Division at LLNL. These four groups pursue different problem areas in scientific computation. The general focus of their efforts is on developing algorithms and software for basic computational problems, but on occasion a method will be implemented to address a specific application, often in collaboration with other projects either within or outside LLNL.

For more information about the Sisal Language Project, contact John Feo, 510-422-6389, feo@diego.llnl.gov.

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