



The Computer Science Research Institute (CSRI) at Sandia National Laboratories brings together researchers from universities and the national laboratories to solve problems in computer science, computational science and mathematics and to provide new capabilities in modeling and simulation. Participants are also encouraged to develop long-term relationships with laboratory scientists and researchers.

The CSRI complements existing laboratory research programs and ASCI university alliances. It provides both a physical and technical focal point for identifying problems, for conducting research and for developing and strengthening interactions between the university and laboratory researchers.

University and industry researchers participate in the CSRI through collaborative research projects, short-term visits, extended visits, summer positions, sabbaticals, and workshops. The CSRI also supports both graduate and undergraduate student programs. These include post-doctoral positions, summer jobs and graduate fellowships. The CSRI encourages students to choose careers in computer science, computational science and mathematics that support directly the challenges of national security.

The CSRI has physical locations in Albuquerque, New Mexico and Livermore, California. These facilities include office space for over 75 staff and collaborators, conference rooms, collaborative work areas and extensive computing facilities. These facilities include the Intel Teraflops computer, Cplant™, (a scalable cluster-based computer) an SGI Origin 2000, a Compaq Sierra cluster, and other computers available for research.

During 2002, the third year of operation, the CSRI hosted over 200 short-term visitors from almost 100 institutions. The CSRI also hosted over 50 summer students and faculty, organized six workshops, and

sponsored six graduate fellows through the HPCS and NPSC programs.

Technical Focus of the CSRI

The CSRI sponsors studies in computer science, computational science and mathematics that impact large-scale modeling and simulation. One of the key technical issues is that of scaling; the CSRI is interested in developing algorithms and software that scale both as the size and complexity of the problems increase and as the number of processors increase to the thousands or tens of thousands. The CSRI is also interested in computer platforms, including hardware and system software that scale to thousands of processors.

Some of the technical areas of interest include

- **Scalable solvers:** Linear and nonlinear solvers form the computational kernel of most finite element simulations. Algorithms that scale to very large problems and thousands of processors are of interest, as is the coupling between linear and nonlinear solvers and solvers for coupled physics problems. Scalable eigensolvers are also of interest.
- **Optimization:** Research problems of interest include optimization for large-scale PDE constrained optimization, integer and mixed-integer optimization, global optimization and optimization in the presence of uncertainty.
- **Adaptivity and mesh refinement:** Simulation codes increasingly require the ability to handle multiple finite element meshes or to automatically refine meshes. Research areas include error estimators and indicators, and the integration with other research, particularly multilevel solvers and dynamic load balancing.
- **Algorithms for solution of differential and integral equations:** Finite-element discretizations,



time integration and the coupling to linear and nonlinear solvers are of particular interest.

- **Graph-based, discrete and combinatorial algorithms:** These algorithms are important in applications such as scheduling and resource management.
- **Uncertainty estimation** and verification and validation for complex simulations.
- **Mesh generation:** Many research problems remain in the generation of high-quality hex and tet meshes for complex geometries. Geometry verification is also of interest.
- **Dynamic load balancing:** This is required for efficient use of MPP computers for adaptive and time-dependent simulations and on heterogeneous platforms.
- **Visualization** and mining of large scientific datasets. These datasets can be terabytes in size.
- **Scalable cluster computers and heterogeneous computers:** The goal of this research is to develop the technology for scalable cluster computer and heterogeneous systems, including operating systems, low-level interprocessor communications, and resource and system management.
- **Data-intensive computing** and research into efficient processing of large datasets on massively parallel computers.
- **Environments for scalable computing**, including large-scale debugging.
- **Parallel I/O:** MPP hardware and software must be able to sustain tens of gigabytes per second.
- **Advanced architectures** for massively parallel computing. This includes the study of performance of modeling and simulation codes on these architectures.

Opportunities for Participation

The CSRI presents many opportunities for collaborations between university researchers and laboratory scientists in the areas of computer science, computational science and mathematics. These include

- Faculty sabbaticals lasting between a semester and a year,
- Summer faculty positions,
- Graduate fellowships through the NPSC and HPCS (Krell Institute) programs,
- Summer student positions,
- Technical visits of lengths between one week and three months,
- Post-doctoral positions lasting up to two years,

- Conference sponsorships,
- A CSRI colloquium series,
- Visits by laboratory staff to universities.

The Computer Science Research Institute is currently soliciting applications and proposals for all types of participation. More information on participation and applications can be found on the CSRI web site at <http://www.cs.sandia.gov/CSRI>.



Top row: Curt Ober, SNL; Simon Tavener, Colorado State University; Donald Estep, Colorado State University; Jim Teresco, Williams College; Max Gunzburger, Florida State University; Joe Flaherty, Rensselaer Polytechnic Institute; Martin Berggren, SNL; Bill Hart, SNL; John Shadid, SNL; Roscoe Bartlett, SNL

Bottom row: Karen Devine, Pavel Bochev, Rich Lehoucq, and David Ropp, all SNL

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The CSRI maintains a web site at
<http://www.cs.sandia.gov/CSRI>.