

Boyana Norris

Mathematics and Computer Science Division
Argonne National Laboratory
Building 240, Room 2152
9700 South Cass Avenue
Argonne, IL 60439

Office: (630) 252-7908

Fax: (630) 252-5986

norris@mcs.anl.gov

<http://www.mcs.anl.gov/~norris>

RESEARCH INTERESTS

Norris conducts research on enabling technologies for high-performance simulations in computational science and engineering, with emphasis on *automation* of the development, deployment, testing, and performance tuning of parallel applications. Specific research areas include (1) compiler techniques for source code analysis and transformation for automatic differentiation and performance analysis (2) embeddable domain-specific languages for code generation and autotuning of scientific computations; and (3) quality of service infrastructure for scientific software (including numerical software taxonomy and automated configuration), for optimizing performance, energy use, and resilience of complex applications.

EDUCATION

Ph.D. in Computer Science, University of Illinois at Urbana-Champaign, Urbana, IL, Jan. 2000.

Thesis Title: “An Environment For Interactive Parallel Numerical Computing”

Thesis Advisor: Professor Michael T. Heath

B.S. in Computer Science, Wake Forest University, Winston-Salem, NC, May 1995.

EMPLOYMENT

Computer Scientist, Argonne National Laboratory, March 2006–present. Design and development of numerical components and related infrastructure; compiler-based tools for automatic differentiation; performance modeling and prediction; power-aware high-performance computing; methods and software for nanophotonics simulation.

Assistant Computer Scientist, Argonne National Laboratory, October 2001–March 2006. High performance scientific component software; automatic differentiation; performance modeling and prediction; computational nanophotonics.

Postdoctoral Research Staff, Argonne National Laboratory, November 1999–October 2001. Development of tools for automatic differentiation and AD integration into numerical software.

Teaching Assistant, University of Illinois at Urbana-Champaign, January–May, 1999. Teaching discussion sections in an introductory computer science course, exam and homework preparation and grading.

Wallace Givens Research Associate, Argonne National Laboratory, Summer 1998. Development of a differentiated version of PETSc using automatic differentiation tools and high-level algorithmic templates.

Graduate Research Assistant to Professor Michael Heath, National Center for Supercomputing Applications, University of Illinois, June 1996–January 1999, August–November 1999. Design and implementation of a Matlab-based high-performance parallel computing environment.

Consultant/Senior Programmer, Liberty Data Systems, Kernersville, NC, summer 1995. Network application development and consulting.

Consultant/Programmer, self-employed, Apr. 1994–May 1995. Business application development and general software and hardware consulting.

Computer Center Consultant, Wake Forest University, Aug. 1994–May 1995. Applications support for university software (Windows, MacOS, Unix).

Software Developer, AMP, Inc., Winston-Salem, NC, summer 1994. MS Windows business application development, mainly relational databases for plant operation and administration.

Consultant/Programmer, Information Technology Professionals, Winston-Salem, NC, Aug. 1993–May 1994. Business application development, including relational databases management applications and custom accounting software.

Undergraduate research assistant to Dr. Michael Heath (REU Program), National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, Jan. 1993–May 1993. Developed and implemented a generalized parallel matrix multiplication algorithm using 2D data partitioning.

HONORS AND AWARDS

- Fellowship recipient at the Second MIT CFD Conference, June 2003.
- Led the design and implementation of the parallel components for partial differential equations and optimization, which were recognized as one of the top 10 DOE Office of Science achievements in 2002 (http://www.sc.doe.gov/sub/accomplishments/top_10.htm).
- Other: Excellent Teaching Assistant Award, University of Illinois at Urbana-Champaign, Spring 1999; SURGE Graduate Fellowship, University of Illinois at Urbana-Champaign, Sep. 1995–1999; Carswell Distinguished Scholarship, Wake Forest University, Sep. 1994–May 1995; Presidential Scholarship, Southwest State University, Sep. 1991–Dec. 1993.
- Member of the National Honor Society since Jan., 1991; Phi Beta Kappa since Apr., 1994.

EXTERNAL FUNDING

- Co-PI, National Science Foundation, *SHF: Small: Collaborative Research: Lighthouse: Resource-Aware Advisor for High-Performance Linear Algebra*, PIs: E. Jessup (University of Colorado at Boulder), B. Norris (ANL), \$500K total, 2012 – 2015.
- Co-PI, Department of Energy, *Institute for Sustained Performance, Energy, and Resilience (SUPER)*, Scientific Discovery through Advanced Computing (SciDAC-3), collaborative project led by Robert F. Lucas (USC), \$375K/year (Argonne), 2011 – 2016.
- Co-PI, Department of Energy, *Community Project for Accelerator Science and Simulation (COMPASS)*, Scientific Discovery through Advanced Computing (SciDAC-3), lead PI: Panagiotis Spentzouris (Fermilab), Argonne PI: Boyana Norris, \$140K/year (Argonne), 2012 – 2015.
- Co-PI, Department of Energy, Phase II SBIR lead by Gerald Sabin of RNET Technologies, Inc. on performance tuning of PETSc kernels and data structures, \$240K (Argonne), 2010 – 2013.
- Co-PI, Department of Energy, *Algorithms and Software for Communication Avoidance and Communication Hiding at the Extreme Scale*, collaborative project led by Erich Strohmeier (LBNL), \$349K/year (Argonne), 2009 – 2012.
- Co-PI, Department of Energy, *Performance Engineering Research Institute*, Scientific Discovery through Advanced Computing (SciDAC-2) Institute, collaborative project led by Robert F. Lucas (USC), \$3M/year, 2006 – 2011.
- Co-PI, National Science Foundation, *Taxonomy for the Automated Tuning of Matrix Algebra Software*, collaborative project led by E. Jessup (University of Colorado at Boulder), B. Norris (ANL), \$500K total, 2009 – 2012.
- Co-PI, National Science Foundation, *Multicore Optimization of an Astrophysical Simulation Code using Performance Annotations*, P. Ricker (UIUC), B. Norris (ANL), \$75K, 2007 – 2008.
- Co-PI, Department of Energy, *Combinatorial Scientific Computing and Petascale Simulations*, SciDAC-2 Institute headed by Alex Pothen (Old Dominion University), \$1.3M/year, 2006 – 2011.
- Co-PI, National Science Foundation, *Adaptive Software for Extreme-Scale Scientific Computing: Co-Managing Quality-Performance-Power Tradeoffs*, P. Raghavan (Penn. State), M. J. Irwin (Penn. State), L. C. McInnes (ANL), and B. Norris (ANL), \$750K total, October 2004 – October 2007.
- Co-PI, National Science Foundation, *Collaborative Research: CMG: Uncertainty Quantification in Geophysical State Estimation*, P. Hovland (University of Chicago), B. Norris (ANL), C. Wunsch (MIT), approximately \$723K total, 2005 – 2008.
- Co-PI, Department of Energy, *Computational Nanophotonics: Modeling Optical Interactions and Transport in Tailored Nanosystem Architectures*, SciDAC-2 Application Project led by Stephen Gray (ANL), approximately \$1.3M/year, August 2003 – August 2008.

PROFESSIONAL ACTIVITIES

- Member (since): ACM (1998), SIAM (1998), SIAG/SC (2005).

- Member of the Community Surface Dynamics Modeling System (CSDMS) Steering Committee, 2009–present.
- Secretary of SIAM Activity Group on Supercomputing: 2006-08, Vice-chair: 2010-12.
- Argonne Committees: Member of the MCS Library Committee, 2003–2005, 2011–present; Human Resources Policy Advisory Board (2008–present); Computational Science Postdoctoral Search Committee (2009), LDRD Director’s Competitive Grants Committee (2009–2011); Women in Science and Technology Steering Committee (2008–2010).
- Program Committees: SC (multiple years), ICS (multiple years), IPDPS (multiple years), QOSA (multiple years), Grace Hopper’11, SMART’10, PACT’09, Cluster’06, AD’2004, AD Workshop at ICCSA’03, SAC’03, HICSS (2003, 2004), IPDPS’2001.
- Reviewer: SISC, IJHPCA, CPE, Computers & Geosciences, ParCo, TPDS.
- Minisymposia organized: *The Role of Performance Models in Providing Efficient Programming Solutions on Modern Multicore Architectures* at SIAM CSE’11; *Performance Evaluation Challenges and Adaptive Numerical Approaches in Scientific Software* at the SIAM CSE’05; *High Performance Components* at the Eleventh SIAM Conference on Parallel Processing for Scientific Computing (PP04).
- Organizing committees: PACT (multiple years); ICS (multiple years); SIAM Parallel Processing (multiple years); Science Careers in Search of Women Conference (multiple years); Fourth International Conference on Automatic Differentiation (2004); Workshop on Domain-Specific Languages for Optimization, Argonne (2004); High Performance Computing Workshop at the Computer Science Department, University of Illinois at Urbana-Champaign, 1999.

PUBLICATIONS (h-index: 16, i10-index: 23)

Books Edited

- [1] H. M. Bücker, G. F. Corliss, P. D. Hovland, U. Naumann, and B. Norris, editors. *Automatic Differentiation: Applications, Theory, and Implementations*, vol. 50. Lecture Notes in Computational Science and Engineering. Springer, New York, NY, 2006, <http://dx.doi.org/10.1007/3-540-28438-9>.

Refereed Journal Articles and Book Chapters

- [2] C. Choudary, J. Godwin, J. Holewinski, D. Karthik, D. Lowell, A. Mametjanov, B. Norris, G. Sabin, and P. Sadayappan. Stencil-aware GPU optimization of iterative solvers. *SIAM Journal on Scientific Computing*, July 2013, <http://www.mcs.anl.gov/uploads/cels/papers/P3008-0712.pdf>. To appear. Also available as Argonne Preprint ANL/MCS-P3008-0712.
- [3] S. Peckham, E. Hutton, and B. Norris. A component-based approach to integrated modeling in the geosciences: The design of CSDMS. *Computers and Geoscience: Modeling for Environmental Change*, April 2012, <http://www.mcs.anl.gov/uploads/cels/papers/P1969.pdf>. Also available as Argonne Preprint ANL/MCS-P1969-1011.

- [4] C. H. Bischof, P. D. Hovland, and B. Norris. On the implementation of automatic differentiation tools. *Higher-Order and Symbolic Computation* 21:311–331, Sept. 2008, <http://www.springerlink.com/content/165g637737055372>.
- [5] B. A. Allan, B. Norris, W. R. Elwasif, and R. C. Armstrong. Managing scientific software complexity with Bocca and CCA. *Scientific Programming* 16(4):315–327, Dec. 2008.
- [6] E. T. Ong, J. Walter Larson, B. Norris, R. L. Jacob, M. Tobis, and M. Steder. A multilingual programming model for coupled systems. *International Journal for Multiscale Computational Engineering* 6:39–51, 2008, <http://www.begellhouse.com/journals/61fd1b191cf7e96f,0c7854ff2b43051a,12a7011e66e8e4cf.html>.
- [7] B. Norris, L. C. McInnes, S. Bhowmick, and L. Li. Adaptive numerical components for PDE-based simulations. *PAMM: Special Issue: Sixth International Congress on Industrial Applied Mathematics (ICIAM07) and GAMM Annual Meeting, Zurich 2007* 7:1140509–1140510, Dec. 2007, <http://dx.doi.org/10.1002/pamm.200700687>.
- [8] D. H. Bailey, R. Lucas, P. Hovland, B. Norris, K. Yelick, D. Gunter, B. de Supinski, D. Quinlan, P. Worley, J. Vetter, P. Roth, J. Mellor-Crummey, A. Snively, J. Hollingsworth, D. Reed, R. Fowler, Y. Zhang, M. Hall, J. Chame, J. Dongarra, and S. Moore. Performance engineering: Understanding and improving the performance of large-scale codes. *CTWatch Quarterly* 3(4), Nov 2007.
- [9] B. Norris, S. Bhowmick, D. Kaushik, and L. C. McInnes. Middleware for dynamic adaptation of component applications. *Grid-Based Problem Solving Environments*, pp. 127–153. Springer, IFIP International Federation for Information Processing, 2007.
- [10] B. Norris, A. Hartono, and W. Gropp. Annotations for productivity and performance portability. *Petascale Computing: Algorithms and Applications*, pp. 443–462. Chapman & Hall / CRC Press, Taylor and Francis Group, Computational Science, 2007, <http://www.mcs.anl.gov/uploads/cels/papers/P1392.pdf>. Preprint ANL/MCS-P1392-0107.
- [11] P. D. Hovland, B. Norris, M. M. Strout, and J. Utke. Term graphs for computing derivatives in imperative languages. *Electronic Notes on Theoretical Computer Science*, 2007, <http://www.mcs.anl.gov/uploads/cels/papers/P1311.pdf>. Preprint ANL/MCS-P1311-0106.
- [12] Z. Meglicki, S. K. Gray, and B. Norris. Mutligrid FDTD with Chombo. *Computer Physics Communications*, 10 2006, <http://dx.doi.org/10.1016/j.cpc.2006.08.008>.
- [13] L. C. McInnes, B. A. Allan, R. Armstrong, S. J. Benson, D. E. Bernholdt, T. L. Dahlgren, L. F. Diachin, M. Krishnan, J. A. Kohl, J. W. Larson, S. Lefantzi, J. Nieplocha, B. Norris, S. G. Parker, J. Ray, and S. Zhou. Parallel PDE-based simulations using the Common Component Architecture. *Numerical Solution of Partial Differential Equations on Parallel Computers*, pp. 327–381. Springer, Lecture Notes in Computational Science and Engineering 51, 2006, [http://dx.doi.org/10.1016/S0167-8191\(02\)00191-6](http://dx.doi.org/10.1016/S0167-8191(02)00191-6). Preprint ANL/MCS-P1179-0704.
- [14] D. E. Bernholdt, B. A. Allan, R. Armstrong, F. Bertrand, K. Chiu, T. L. Dahlgren, K. Damevski, W. R. Elwasif, T. G. W. Epperly, M. Govindaraju, D. S. Katz, J. A. Kohl, M. Krishnan, G. Kumfert, J. W. Larson, S. Lefantzi, M. J. Lewis, A. D. Malony, L. C. McInnes, J. Nieplocha, B. Norris, S. G. Parker, J. Ray, S. Shende, T. L. Windus, and S. Zhou. A component architecture for high-performance scientific computing. *International Journal of High Performance Computing Applications* 20(2):163–202, 2006, <http://dx.doi.org/10.1177/1094342006064488>.
- [15] P. Hovland, B. Norris, and B. Smith. Making automatic differentiation truly automatic: Coupling PETSc with ADIC. *Future Generation Computer Systems* 21(8):1426–1438, 2005, <http://dx.doi.org/10.1016/j.future.2004.11.008>.
- [16] B. Norris and P. Hovland. A distributed application server for automatic differentiation. *INFORMATION* 6(3):305–314, July 2003, <http://www.mcs.anl.gov/uploads/cels/papers/>

P856.ps.z. Preprint ANL/MCS-P856-1100.

- [17] C. Bischof, P. Hovland, and B. Norris. Implementation of automatic differentiation tools. *Proceedings of the 2002 ACM SIGPLAN Workshop on Partial Evaluation and Semantics-Based Program Manipulation (PEPM-02)*, vol. 37, pp. 98–107. ACM Press, ACM SIGPLAN Notices 3, Jan. 14–15 2002. Substantially revised version to appear in a special issue of Higher-Order and Symbolic Computation, Springer.
- [18] S. Bhowmick, P. Raghavan, L. C. McInnes, and B. Norris. Faster PDE-based simulations using robust composite linear solvers. *Future Generation Computer Systems* 20(3):373–387, 2004, <http://dx.doi.org/10.1016/j.future.2003.07.012>.
- [19] B. Norris, S. Balay, S. Benson, L. Freitag, P. Hovland, L. McInnes, and B. Smith. Parallel components for PDEs and optimization: Some issues and experiences. *Parallel Computing* 28(12):1811–1831, 2002, [http://dx.doi.org/10.1016/S0167-8191\(02\)00191-6](http://dx.doi.org/10.1016/S0167-8191(02)00191-6).
- [20] J. Abate, S. Benson, L. Grignon, P. Hovland, L. McInnes, and B. Norris. Integrating automatic differentiation with object-oriented toolkits for high-performance scientific computing. *Automatic Differentiation of Algorithms: From Simulation to Optimization*, chapter 20, pp. 173–178. Springer, 2002. Proceedings of AD2000.
- [21] A. Radenski, A. Vann, and B. Norris. Parallel probabilistic computations on a cluster of workstations. *Parallel Computing: Fundamentals, Applications, and New Directions*. Elsevier, 1998.

Refereed Conference Proceedings

- [22] A. Radenski and B. Norris. Distributed large-scale laplace relaxation on the cloud with mapreduce. *Proceedings of ParCo2013*, Sept. 2013, <http://www.mcs.anl.gov/uploads/cels/papers/P4047-0313.pdf>. To appear, also available as Preprint ANL/MCS-P4047-0313.
- [23] P. Balaprakash, D. Buntinas, A. Chan, A. Guha, S. H. K. Narayanan, A. A. Chien, P. Hovland, and B. Norris. Exascale workload characterization and architecture implications. *Proceedings of the 21st High Performance Computing Symposium (HPC)*, San Diego, April 2013, <http://www.mcs.anl.gov/uploads/cels/papers/P4034-0213.pdf>. Best paper award. Also available as Preprint ANL/MCS-P4034-0213.
- [24] A. Mametjanov, D. Lowell, C.-C. Ma, and B. Norris. Autotuning stencil-based computations on GPUs. *Proceedings of IEEE Cluster 2012*, 2012, <http://www.mcs.anl.gov/uploads/cels/papers/P2094-0512.pdf>. Also available as Preprint ANL/MCS-P2094-0512.
- [25] P. Balaprakash, S. Wild, and B. Norris. SPAPT: Search problems in automatic performance tuning. *Proceeding of the ICCS Workshop on Tools for Program Development and Analysis in Computational Science*, no. Also available as Preprint ANL/MCS-P1872-0411, 2012, <http://www.mcs.anl.gov/uploads/cels/papers/P1872.pdf>.
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- [29] S. H. K. Narayanan, B. Norris, and P. D. Hovland. Generating performance bounds from source code. *Proceedings of the First International Workshop on Parallel Software Tools and Tool Infrastructures (PSTI 2010)*, 9 2010, <http://www.mcs.anl.gov/uploads/cels/papers/P1685.pdf>. Also available as Preprint ANL/MCS-P1685-1009.
- [30] S. H. K. Narayanan, B. Norris, and B. Winnicka. ADIC2: Development of a component source transformation system for differentiating C and C++. *Workshop on Automated Program Generation for Computational Science, May 31, Amsterdam, The Netherlands*, 5 2010, <http://www.mcs.anl.gov/uploads/cels/papers/P1714.pdf>. Also available as Preprint ANL/MCS-P1714-0110.
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- [32] L. Li, T. Dahlgren, L. C. McInnes, and B. Norris. Interface contract enforcement for improvement of computational quality of service (CQoS) for scientific components (extended abstract). *Proceedings of the 2009 Workshop on Component-Based High Performance Computing (CBHPC 2009)*, Nov. 2009.
- [33] S. Muszala, J. Amundson, L. C. McInnes, and B. Norris. Two-tiered component design and performance analysis of Synergia2 accelerator simulations. *Proceedings of the 2009 Workshop on Component-Based High Performance Computing (CBHPC 2009)*, Nov. 2009.
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- [35] A. Hartono, M. M. Baskaran, C. Bastoul, A. Cohen, S. Krishnamoorth, B. Norris, J. Ramanujam, and P. Sadayappan. PrimeTile: A parametric multi-level tiler for imperfect loop nests. *Proceedings of the 23rd International Conference on Supercomputing, June 8-12, 2009, IBM T. J. Watson Research Center, Yorktown Heights, NY, USA*, 2009, <http://www.cse.ohio-state.edu/~hartonoa/papers/ics09-ext.pdf>. Also available as Tech. Report OSU-CISRC-2/09-TR04.
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- B. Norris. Capturing performance knowledge for automated analysis. *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC'08)*, 2008.
- [40] V. Bui, B. Norris, K. Huck, L. C. McInnes, L. Li, O. Hernandez, and B. Chapman. A component infrastructure for performance and power modeling of parallel scientific applications. *Proceedings of Component-Based High Performance Computing Workshop, October 14-17, 2008, Karlsruhe, Germany*. ACM, 2008, <http://www.mcs.anl.gov/uploads/cels/papers/P1538.pdf>. Also available as Preprint ANL/MCS-P1538-0908.
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- [45] D. R. Dechow, B. Norris, and J. Amundson. The Common Component Architecture for particle accelerator simulations. *Proceedings of HPC-GECO/CompFrame'07, October 21-22, 2007, Montreal, Québec, Canada*. ACM, 2007.
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- [51] S. Bhowmick, D. Kaushik, L. McInnes, B. Norris, and P. Raghavan. Parallel adaptive solvers in compressible PETSc-FUN3D simulations. *Proceedings of the 17th International Conference on Parallel Computational Fluid Dynamics, University of Maryland, College Park, MD, May 24–27, 2005*, ftp://info.mcs.anl.gov/pub/tech_reports/reports/P1279.pdf. Preprint ANL/MCS-P1279-0805.

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- [53] P. Hovland, B. Norris, M. Strout, S. Bhowmick, and J. Utke. Sensitivity analysis and design optimization through automatic differentiation. *SciDAC 2005*, vol. 16, pp. 466–470. Institute of Physics Publishing, Journal of Physics: Conference Series, 2005, http://www.iop.org/EJ/article/1742-6596/16/1/063/jpconf5_16_063.pdf.
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Other Publications

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INVITED PRESENTATIONS

- Keynote speaker, Science Careers in Search of Women, April 14, 2011.
- Keynote speaker, “Component-Based Scientific Software Development: Usability Challenges and Tools,” Community Surface Dynamics Modeling System (CSDMS) Annual Meeting, Oct. 15, 2010.
- “Approaches and Tools for Understanding and Improving the Performance of Scientific Applications,” University of Nebraska at Omaha, Oct. 2010.
- “Annotation-Based Empirical Performance Tuning of Scientific Applications,” Math/CS Seminar at Chapman University, Orange, CA, May 3rd, 2010.
- “Making High-Performance Multilingual Component Development Easy,” Computational Science and Engineering Colloquium, The Pennsylvania State University, Jan. 11, 2008.
- “Enabling Adaptive Numerical Algorithms through Component-Based Software Engineering,” Aachen University, Germany, July 11, 2007.
- “Computational Quality of Service for Scientific Component Applications,” WoCo9: Grid-based Problem Solving Environments: Implications for Development and Deployment of Numerical Software, July 18, 2006.
- “Performance Annotations on the BlueGene/L,” SIAM PP’06 minisymposium on Application Performance Analysis and Optimization on BlueGene/L, Feb. 22, 2006.
- “Enabling Technologies for Computational Science: Automatic Differentiation, Component Software, and Performance,” EECE Colloquium, Marquette University, March 15, 2005.
- “Software Architecture Approaches for Adaptive Scientific Computing,” PARA’04 minisymposium on Advanced Algorithms and Software for Scientific Computing, June 21, 2004.
- “Issues and Approaches in Scientific Component Software Development,” Colloquium, Penn State University Computer Science and Engineering, March 18, 2004.

- “High-Performance Scientific Components,” First Friday Forum, Argonne National Laboratory, June 2003.
- Panel member at the Women in Science Careers Conference, Argonne National Laboratory, March 2003.
- “CCA Components for Linear System Solution,” SIAM Annual Meeting, minisymposium on New Approaches for Scalable Sparse Linear System Solution, July 10, 2002, Philadelphia.

TUTORIALS

- Common Component Architecture (CCA) Tutorials: SC’05, HPC2005, SC’04, SIAM PP’04, SC’03, and at some quarterly CCA meetings. Developed hands-on code and reusable build system.
- “Tools and Methods for Performance Modeling and Prediction,” SIGMETRICS’04 Tutorial, New York, June 13, 2004.

STUDENTS

Every year I involve students in my research through several DOE and Argonne internship programs and student employment options. Many of these students continue working with me after their initial internship appointment.

- Supervised 9 undergraduate students in research projects ranging in duration from 2 months to 5 years.
- Supervised 15 graduate students in research projects ranging in duration from 2 months to 4 years.
- Member of 3 Ph.D. thesis committees and one M.S. thesis committee.

OUTREACH ACTIVITIES

- Member of the Women in Science and Technology (WIST) program, which was created at Argonne in 1990 to recruit, retain, and promote women in an effort to diversify and strengthen the Laboratory’s scientific workforce (2008-2010).
- Co-organizer of the Science Careers in Search of Women (SCSW) annual conference for high-school girls (multiple years), and Introduce a Girl to Engineering Day (multiple years).

SELECTED SOFTWARE

- Orio (<http://tinyurl.com/OrioTool>), a lightweight, extensible framework that supports the definition of embeddable domain languages and empirical performance tuning of C and Fortran applications. Orio employs a source code annotation approach that enables key computations to be expressed at a high level and embedded in existing code as comments, from which Orio then generates many optimized versions, which are then evaluated empirically to select the best versions to use for production runs. Correctness testing is also performed as part of the tuning process.

- Static performance modeling tools: estimate the number of floating-point operations and memory accesses through source code analysis (C and C++), and provide upper bounds on the performance of an application; high-level user performance annotations for generating highly optimized code with the goal of increasing developer productivity, application performance, and performance portability on high-end architectures (<http://www.mcs.anl.gov/performance>).
- Lighthouse (<http://code.google.com/p/lighthouse-taxonomy/>), a framework for creating, maintaining, and using a taxonomy of available software that can be used to build highly-optimized matrix algebra computations. The initial implementation provides novice and expert search interfaces to LAPACK, and generate code templates using the search results. Work is ongoing on incorporated sparse matrix computations, as well as automated code tuning based on high-level Matlab-like specification of the computation.
- ADIC, source transformation automatic differentiation of ANSI C and C++ programs (<http://www.mcs.anl.gov/adic>). ADIC implements a technique for automatically transforming a computer code implementing an arbitrary mathematical function into another code that computes the function and its derivatives without incurring truncation error and often resulting in better performance than numerical approximation approaches, such as finite differences. Over the past five years, ADIC has been downloaded over 500 times and has been used in numerical optimization, sensitivity analysis, climate modeling, computational fluid dynamics, and other application areas.
- XAIF, an XML-based abstract intermediate representation for mathematical computations (<http://www.mcs.anl.gov/xaiif>). The XAIF format enables clear separation between language-specific parser and analysis engines, which are typically very difficult to develop, and differentiation algorithms, which are intrinsically language-independent and can be implemented as graph transformations. XAIF is used in ADIC and the language-independent differentiation modules and Fortran AD tool being developed as part of the multi-institution OpenAD project.
- CCA scientific components; CCA middleware infrastructure and automated build system support (see tutorial source code at <http://www.cca-forum.org/tutorials>); Eclipse-based IDE support for scientific component development (see Usability at <http://cca-forum.org/wiki>); CCA-compliant linear algebra and optimization components. Numerical components have been used in scientific applications, such as molecular geometry optimization and computational fluid dynamics.
- Bocca, a tool for automating the management and build of SIDL-based multilanguage projects, including CCA components (<http://trac.mcs.anl.gov/projects/cca/wiki/bocca>).
- Multimethod parallel linear solvers: combining or adaptively applying existing iterative algorithms to produce multimethod heuristics that result in improved robustness and performance. The prototype implementations are designed to feed into linear solver components and numerical toolkits, such as PETSc.
- Structured block adaptive mesh refinement in finite-difference time-domain methods for nanophotonics simulations, whose goal is to learn how to control light on the nanoscale, for example, to replace electrons as information carriers in optical or opto-electronic devices, or to create novel chemical and biological sensors (<http://www.mcs.anl.gov/Nanophotonics>).