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RESEARCH INTERESTS

Novel approaches to addressing the challenge of developing and maintaining complex high-performance applications for rapidly evolving parallel architectures, with emphasis on of methods and tools for *automation* of the development, deployment, testing, and performance tuning of parallel scientific 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.

PROFESSIONAL EXPERIENCE

- Associate Professor, University of Oregon, Sept. 2015–present. Research in domain-specific language approaches to high-performance computing, performance engineering, and software engineering for scientific applications.
- Assistant Professor, University of Oregon, Sept. 2013–Sept. 2015. Research in domain-specific language approaches to high-performance computing, performance engineering, and software engineering for scientific applications.
- Computer Scientist, Argonne National Laboratory, and Senior Fellow, Computation Institute, University of Chicago, March 2006–Aug. 2013. Group leader of the performance group in the Mathematics and Computer Science Division (5-9 members).
- Assistant Computer Scientist, Argonne National Laboratory, October 2001–March 2006. Conducted research in several research areas, including methodologies for high performance scientific component software; automatic differentiation for C and C++ through source transformation; performance modeling and prediction; and computational nanophotonics.
- Postdoctoral Research Staff, Argonne National Laboratory, November 1999–October 2001. Development of tools for automatic differentiation and AD integration into numerical software. Postdoctoral Advisor: Dr. William Gropp.

HONORS AND AWARDS

- Best paper finalist: K. Sood, B. Norris, and E. Jessup. Comparative performance modeling of parallel preconditioned Krylov methods. *Proceedings the 18th IEEE International Conference on High*

Performance Computing and Communications (HPCC), 2017.

- Best paper award: 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.
- 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`).
- Member of the National Honor Society since Jan., 1991; Phi Beta Kappa since Apr., 1994.
- Excellent Teaching Assistant Award, University of Illinois at Urbana-Champaign, Spring 1999.

PUBLICATIONS (Google Scholar: h-index: 22, i10-index: 41)

Peer-Reviewed Journal Articles

[1] S. Srinivasan, S. D. Pollard, B. Norris, S. K. Das, and S. Bhowmick. A shared memory algorithm for updating tree-based properties of large dynamic networks. To appear in *IEEE Transactions on Big Data*, 2018.

[2] P. Balaprakash, J. Dongarra, T. Gamblin, M. Hall, J. K. Hollingsworth, B. Norris, and R. Vuduc. Autotuning in high-performance computing applications. *Proceedings of the IEEE*, 2018.

[3] E. Jessup, P. Motter, B. Norris, and K. Sood. Performance-based numerical solver selection in the Lighthouse framework. *SIAM Journal on Scientific Computing* 38:S750–S771, 11 2016, `http://epubs.siam.org/toc/sjoce3/38/5`.

[4] T. Nelson, G. Belter, J. Siek, E. Jessup, and B. Norris. Reliable generation of high-performance matrix algebra. *ACM Transactions on Mathematical Software* 41, June 2015.

[5] A. Callejo, S. H. K. Narayanan, J. G. de Jalon, and B. Norris. Performance of automatic differentiation tools in the dynamic simulation of multibody systems. *Advances in Engineering Software* 73:35–44, 2014.

[6] 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* 35(5):S209–S228, October 2013, `http://www.mcs.anl.gov/uploads/cels/papers/P3008-0712.pdf`.

[7] 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* 53:3–12, Apr 2013, `http://www.mcs.anl.gov/uploads/cels/papers/P1969.pdf`. Also available as Argonne Preprint ANL/MCS-P1969-1011.

[8] 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`.

[9] 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.

[10] 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`.

[11] 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, Zürich 2007 7:1140509–1140510, Dec. 2007, http://dx.doi.org/10.1002/pamm.200700687.

[12] 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.

[13] 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.

[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, ftp://info.mcs.anl.gov/pub/tech_reports/reports/P856.pdf. Also available as Preprint ANL/MCS-P856-1100.

[17] 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.

[18] 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.

Peer-Reviewed Book Chapters

[19] 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.

[20] 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. Also available as Preprint ANL/MCS-P1392-0107.

[21] 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. Preprint ANL/MCS-P1179-0704.

Peer-Reviewed Conference Proceedings

[22] S. D. Pollard, S. Srinivasan, and B. Norris. A performance and recommendation system for parallel graph processing implementations: Work-in-progress. To appear in *The 10th ACM/SPEC International Conference on Performance Engineering Companion*. ACM, Apr. 2019.

[23] S. Srinivasan, S. Riazi, B. Norris, S. K. Das, and S. Bhowmick. A shared-memory parallel algorithm for updating single-source shortest paths in large dynamic networks. To appear in *Proceedings of the 25th IEEE International Conference on. High Performance Computing, Data, and Analytics*, 2018.

[24] K. Sood, B. Norris, and E. Jessup. Comparative performance modeling of parallel preconditioned Krylov methods. *Proceedings the 18th IEEE International Conference on High Performance Computing and Communications (HPCC)*, 2017. Acceptance rate 36%.

[25] K. Meng and B. Norris. Mira: A framework for static performance analysis. *2017 IEEE International Conference on Cluster Computing (CLUSTER)*, pp. 103–113, Sept 2017. Acceptance rate 21% (216).

[26] R. Lim, B. Norris, and A. Malony. Autotuning GPU kernels via static and predictive analysis. *2017 46th International Conference on Parallel Processing (ICPP)*, pp. 523–532, Aug 2017. Acceptance rate 28.4%.

[27] B. Norris, W. Spear, and A. Malony. Performance analysis of applications in the context of architectural rooflines. *Proceedings of the 8th ACM/SPEC on International Conference on Performance Engineering*, pp. 345–348. ACM, ICPE '17, 2017, `http://doi.acm.org/10.1145/3030207.3030232`. Acceptance rate 33%.

[28] S. Riazi and B. Norris. Graphflow: Workflow-based big graph processing. *2016 IEEE International Conference on Big Data (Big Data)*, pp. 3336–3343, Dec 2016.

[29] M. Rashti, G. Sabin, and B. Norris. Power and energy analysis and modeling of high performance computing systems using WattProf. *Proceedings of the 2015 IEEE National Aerospace and Electronics Conference (NAECON)*, July 2015.

[30] T. Nelson, A. Rivera, M. Hall, P. Hovland, E. Jessup, B. Norris, and P. Balaprakash. Generating efficient tensor contractions for GPUs. *Proceedings of The 44th International Conference on Parallel Processing (ICPP)*, 2015. (Acceptance rate: 99/305 or 32.5% for main track).

[31] N. Chaimov, B. Norris, and A. Malony. Toward multi-target autotuning for accelerators. *Proceedings of the 20th IEEE International Conference on Parallel and Distributed Systems, December 16-19, 2014, Hsinchu, Taiwan*, 2014, `http://ix.cs.uoregon.edu/~norris/icpads14.pdf`. (Acceptance rate: 96/322 or 29.8% for main track).

[32] R. Nair, S.-L. Bernstein, E. Jessup, and B. Norris. Generating customized sparse eigenvalue solutions with Lighthouse. *Proceedings of the Ninth International Multi-Conference on Computing in the Global Information Technology June 22 - 17, 2014, Seville, Spain*, 2014.

[33] A. Radenski and B. Norris. MapReduce streaming algorithms for Laplace relaxation on the cloud. *Parallel Computing: Accelerating Computational Science and Engineering (CSE). Advances in Parallel Computing*, vol. 25, pp. 215–224. IOS Press, 2014.

[34] 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**).

[35] 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`. (Acceptance rate: 58/201=29%) Also available as Preprint ANL/MCS-P2094-0512.

[36] S. H. K. Narayanan, B. Norris, P. Hovland, and A. Gebremedhin. Implementation of partial separability in a source to source transformation AD tool. *Proceedings of the 6th International Conference on Automatic Differentiation, Fort Collins, CO, July 23-27, 2012*, July 2012, `http://www.mcs.anl.gov/uploads/cels/papers/P1997-0112.pdf`. Also available as Preprint ANL/MCS-1997-0112.

[37] A. Mametjanov, B. Norris, X. Zeng, B. Drewniak, J. Utke, M. Anitescu, and P. Hovland. Applying automatic differentiation to the community land model. *Proceedings of the 6th International Conference on Automatic Differentiation, Fort Collins, CO, July 23-27, 2012*, July 2012, http://www.mcs.anl.gov/uploads/cels/papers/P1993-0112.pdf. Also available as Preprint ANL/MCS-1993-0112.

[38] S. H. K. Narayanan, B. Norris, P. Hovland, D. C. Nguyen, and A. H. Gebremedhin. Sparse Jacobian computation using ADIC2 and ColPack. *Procedia Computer Science* 4:2115 – 2123, 2011, http://www.sciencedirect.com/science/article/pii/S1877050911002894. Proceedings of the International Conference on Computational Science, ICCS 2011.

[39] 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. Also available as Tech. Report OSU-CISRC-2/09–TR04.

[40] L. Li, J. P. Kenny, M.-S. Wu, K. Huck, A. Gaenko, M. S. Gordon, C. L. Janssen, L. C. McInnes, H. Mori, H. M. Netzloff, B. Norris, and T. L. Windus. Adaptive application composition in quantum chemistry. *Proceedings of The 5th International Conference on the Quality of Software Architectures (QoSA 2009)*, February 2009, http://www.mcs.anl.gov/uploads/cels/papers/P1575.pdf. Also available as Preprint ANL/MCS-P1575-0209.

[41] B. Norris, A. Hartono, E. Jessup, and J. Siek. Generating empirically optimized composed matrix kernels from MATLAB prototypes. *Proceedings of the 9th International Conference on Computational Science*, 2009, http://www.mcs.anl.gov/uploads/cels/papers/P1581.pdf. Also available as Preprint ANL/MCS-P1581-0209.

[42] A. Hartono, B. Norris, and P. Sadayappan. Annotation-based empirical performance tuning using Orio. *Proceedings of the 23rd IEEE International Parallel & Distributed Processing Symposium*, 2009, http://www.mcs.anl.gov/uploads/cels/papers/P1556.pdf. Also available as Preprint ANL/MCS-P1556-1008.

[43] K. A. Huck, O. Hernandez, V. Bui, S. Chandrasekaran, B. Chapman, A. D. Malony, L. C. McInnes, and B. Norris. Capturing performance knowledge for automated analysis. *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC'08)*, 2008. (Acceptance rate: 59/277=21.3%).

[44] J. W. Larson and B. Norris. Component specification for parallel coupling infrastructure. *Proceedings of the International Conference on Computational Science and its Applications (ICCSA 2007)*, vol. 4707, pp. 56–68. Springer-Verlag, Lecture Notes in Computer Science, Aug 2007.

[45] E. T. Ong, J. W. Larson, B. Norris, R. L. Jacob, M. Tobis, and M. S. der. Multilingual interfaces for coupling in multiphysics and multiscale systems. *Proceedings of the International Conference on Computational Science, May 27–30, 2007*, vol. 4488, Lecture Notes in Computer Science, 2007. (Acceptance rate: 80/360=22%).

[46] S. Akioka, K. Malkowski, P. Raghavan, M. J. Erwin, L. C. McInnes, and B. Norris. Characterizing the performance and energy attributes of scientific simulations. *Computational Science ICCS 2006: 6th International Conference, Reading, UK, May 28-31, 2006, Proceedings, Part I*, vol. 3991, pp. 242–249. Springer Berlin / Heidelberg, Lecture Notes in Computer Science, 2006, http://dx.doi.org/10.1007/11758501_36.

[47] B. Norris. Software architecture issues in scientific component development. *Applied Parallel Computing: 7th International Conference, PARA 2004, Lyngby, Denmark, June 20-23, 2004. Revised Selected Papers*, vol. 3732, pp. 629–636. Springer Berlin / Heidelberg, Lecture Notes in Computer Science, 2006, http://dx.doi.org/10.1007/11558958_75.

[48] 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.

[49] B. Norris, L. McInnes, and I. Veljkovic. Computational quality of service in parallel CFD. *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/P1283.pdf`. Preprint ANL/MCS-P1283-0805.

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

[51] P. Raghavan, M. J. Irwin, L. C. McInnes, and B. Norris. Adaptive software for scientific computing: Co-managing quality-performance-power tradeoffs. *Proceedings of the IEEE International Parallel & Distributed Processing Symposium 2005 (CDROM)*. IEEE Computer Society Press, 2005, `http://dx.doi.org/10.1109/IPDPS.2005.83`.

[52] S. Bhowmick, L. McInnes, B. Norris, and P. Raghavan. Robust algorithms and software for parallel PDE-based simulations. *Proceedings of the Advanced Simulation Technologies Conference, ASTC'04, April 18 - 22, 2004*. Society for Modeling and Simulation International (SCS), 2004, `http://scs.proceedingscentral.com`.

[53] B. Norris, J. Ray, R. C. Armstrong, L. C. McInnes, D. E. Bernholdt, W. R. Elwasif, A. D. Malony, and S. Shende. Computational quality of service for scientific components. *Proceedings of the International Symposium on Component-Based Software Engineering (CBSE7), Edinburgh, Scotland, May 24–25, 2004*, vol. 3054, pp. 264–271. Springer, Lecture Notes in Computer Science, 2004, `http://www.springerlink.com/content/bklr81vrwaxuy2bl`.

[54] J. W. Larson, B. Norris, E. T. Ong, D. E. Bernholdt, J. B. Drake, W. R. Elwasif, M. W. Ham, C. E. Rasmussen, G. Kumfert, D. S. Katz, S. Zhou, C. DeLuca, and N. S. Collins. Components, the common component architecture, and the climate/weather/ocean community. *84th Annual Meeting of the American Meteorological Society*. AMS, 2004, `http://www.mcs.anl.gov/~norris/pubs/larson-et-al-CCA-CWO-AMS-2004.pdf`.

[55] S. Bhowmick, L. C. McInnes, B. Norris, and P. Raghavan. The role of multi-method linear solvers in PDE-based simulations. *Computational Science and Its Applications - ICCSA 2003, Part I*, vol. 2667, pp. 828–839. Springer, 2003.

[56] P. Hovland, K. Keahey, L. C. McInnes, B. Norris, L. F. Diachin, and P. Raghavan. A quality of service approach for high-performance numerical components. *Proceedings of Workshop on QoS in Component-Based Software Engineering, Software Technologies Conference*, 20 June 2003.

[57] L. McInnes, B. Norris, S. Bhowmick, and P. Raghavan. Adaptive sparse linear solvers for implicit CFD using Newton-Krylov algorithms. *Proceedings of the Second MIT Conference on Computational Fluid and Solid Mechanics, Massachusetts Institute of Technology, Boston, USA, June 17-20, 2003*, pp. 1024–1028. Elsevier, 2003.

[58] P. D. Hovland, U. Naumann, and B. Norris. An XML-based platform for semantic transformation of numerical programs. *Proceedings of Software Engineering and Applications, November 4-6, 2002 Cambridge, MA*, pp. 530–538. ACTA Press, Nov. 02 2002, `ftp://info.mcs.anl.gov/pub/tech_reports/reports/P950.pdf`. Argonne National Laboratory prerprint ANL/MCS-P950-0402.

[59] P. D. Hovland, B. Norris, and B. F. Smith. Making automatic differentiation truly automatic: Coupling PETSc with ADIC. *International Conference on Computational Science (2)*, vol. 2330, pp. 1087–1096, Lecture Notes in Computer Science, Jan. 2002.

[60] 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.

[61] E. Dolan, P. Hovland, J. More, B. Norris, and B. Smith. Remote access to mathematical software. *Proceedings of Internet Accessible Mathematical Computation, a Workshop at ISSAC'2001*, Dec. 27 2001, `http://icm.mcs.kent.edu/research/iamc2001.papers/norris.pdf`.

[62] P. Hovland, S. Lee, L. McInnes, B. Norris, and B. Smith. Challenges and opportunities in using automatic differentiation with object-oriented toolkits for scientific computing. *1st Sandia Workshop on Large-Scale PDE-Constrained Optimization, Santa Fe, NM, April 4 – 6, 2001*, Apr. 2001, `http://www.llnl.gov/tid/lof/documents/pdf/244369.pdf`.

[63] A. Radenski and B. Norris. Generic cluster-computing algorithms and applications. *Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications, PDPTA 2000, June 24-29, 2000, Las Vegas, Nevada, USA*. CSREA Press, 2000. (Acceptance rate: 24%).

[64] A. Radenski, B. Norris, and W. Chenn. A generic all-pairs cluster computing pipeline and its applications. *Parallel Computing: Fundamentals & Applications: Proceedings of the International Conference ParCo99, TU Delft, The Netherlands*, pp. 367–374. Imperial College Press, 2000.

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[66] A. Radenski, A. Vann, and B. Norris. Parallel probabilistic computations on a cluster of workstations. *Parallel Computing: Fundamentals, Applications and New Directions, Proceedings of the Conference ParCo'97, 19-22 September 1997, Bonn, Germany*, vol. 12, pp. 105–112. Elsevier, North-Holland, Advances in Parallel Computing, Feb. 1998.

Books Edited

[67] 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.

Invited Papers (full papers that accompany an invited talk)

[68] B. de Supinski, S. Alam, D. Bailey, L. Carrington, C. Daley, A. Dubey, T. Gamblin, D. Gunter, P. Hovland, H. Jagode, K. Karavanic, G. Marin, J. Mellor-Crummey, S. Moore, B. Norris, L. Oliker, C. Olschanowsky, P. Roth, M. Schulz, S. Shende, A. Snavely, W. Spear, M. Tikir, J. Vetter, P. Worley, and N. Wright. Modeling the office of science ten year facilities plan: The PERI architecture tiger team. *Journal of Physics: Conference Series (Proceedings of SciDAC 2009)* 180(012039), July 2009.

[69] J. F. Amundson, D. Dechow, L. McInnes, B. Norris, P. Spentzouris, and P. Stoltz. Multiscale, multiphysics beam dynamics framework design and applications. *Proceedings of SciDAC 2008*. IOP Publishing, 2008. Journal of Physics: Conference Series 125 (2008) 012001.

[70] A. Pothen, A. H. Gebremendhin, F. Dobrian, E. G. Boman, K. D. Devine, B. A. Hendrickson, P. Hovland, B. Norris, J. Utke, U. V. Catalyurek, and M. M. Strout. Combinatorial algorithms for petascale science. *SciDAC Review* (5):26–35, Fall 2007.

Peer-Reviewed Workshop Proceedings

[71] R. Lim, B. Norris, and A. Malony. A similarity measure for GPU kernel subgraph matching. To appear in *31st International Workshop on Languages and Compilers for Parallel Computing (LCPC)*, 2018.

[72] A. Farzad, B. Norris, and M. Rashti. Portable power/performance benchmarking and analysis with WattProf. *Proceedings of the 6th International Workshop in Performance Modeling, Benchmarking and Simulation of High Performance Computer Systems (PMBS15)*, Nov 2015.

[73] P. Motter, K. Sood, E. Jessup, and B. Norris. Lighthouse: An automated solver selection tool. *Proceedings of the Third International Workshop on Software Engineering for High Performance Computing in Computational Science and Engineering (SEHPCCSE)*, Nov 2015.

[74] K. Sood, B. Norris, and E. Jessup. Lighthouse: A taxonomy-based solver selection tool. *Proceedings of the Second Workshop on Software Engineering for Parallel Systems (SEPS)*, Oct 2015.

[75] M. Rashti, G. Sabin, D. Vansickle, and B. Norris. WattProf: A flexible platform for fine-grained HPC power profiling. *Proceedings of Workshop on Monitoring and Analysis of HPC Systems Plus Applications*, Sept 2015.

[76] R. Lim, A. Malony, B. Norris, and N. Chaimov. Identifying optimization opportunities within kernel execution in GPU codes. *Proceedings of the Thirteenth International Workshop on Algorithms, Models and Tools for Parallel Computing on Heterogeneous Platforms (HeteroPar'2015)*, 2015.

[77] X. Dai, B. Norris, and A. D. Malony. Autoperf: Workflow support for performance experiments. *Proceedings of the Workshop on Challenges in Performance Methods for Software Development (WOSPC'15), January 31, 2015, Austin, Texas*, 1 2015.

[78] 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*, 2012, `http://www.mcs.anl.gov/uploads/cels/papers/P1872.pdf`. Also available as Preprint ANL/MCS-P1872-0411.

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Other Publications

[93] S. Pollard and B. Norris. A comparison of parallel graph processing implementations, May 2017. arXiv:arXiv:1704.02003.

[94] B. Norris, S.-L. Bernstein, R. Nair, and E. Jessup. Lighthouse: A user-centered Web system for linear algebra software. Tech. rep., 2015. arXiv:1408.1363.

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[105] B. Norris. *An Environment For Interactive Parallel Numerical Computing*. Ph.D. thesis, University of Illinois at Urbana-Champaign, Jan. 2000, http://citeseer.ist.psu.edu/408665.html.

MINISYMPOSIA ORGANIZED

- *Algorithm Comparison, Selection, and Tuning for Large Scale Network and Graph Problems* at SIAM PP'16 (co-organizer Sanjukta Bhowmick);
- *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).

KEYNOTE PRESENTATIONS

- The Ninth International Workshop on Automatic Performance Tuning, Eugene, OR, July 1, 2014.
- 2014 ky-triwic: Lexington, Louisville, and the Greater-Cincinnati Area's Celebration of Women in Computing Conference, Feb. 8, 2014.
- Science Careers in Search of Women, April 14, 2011.
- "Component-Based Scientific Software Development: Usability Challenges and Tools," Community Surface Dynamics Modeling System (CSDMS) Annual Meeting, Oct. 15, 2010.

OTHER INVITED PRESENTATIONS

- "Understanding and Optimizing the Performance of Applications and their Developers," Oregon

Health & Science University Biomedical Engineering Seminar, Oct. 2018.
- "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.

CURRENT FUNDING (PI)

- NSF SHF: Small: Collaborative Research: Automated Numerical Solver EnviRonment (ANSER), $225K
- NSF SPX: Collaborative Research: SANDY: Sparsification-based Approach for Analyzing Network Dynamics, $225K
- DOE ECP: Advancing Software Productivity for Exascale Applications: IDEAS2, $ 450K, 1/1/17-12/31/20
- DOE SciDAC4: HEP Event Reconstruction with Cutting Edge Computing Architectures, $353K, 09/01/17-8/31/20
- DOE SciDAC4: Nuclear Low Energy Initiative (NUCLEI), $270K, 10/1/17-8/31/22
- RNET Corporation (DOE STTR), Automated Solver Selection for Nuclear Engineering Simulations, $300K, 8/15/16-7/31/18
- NSF, EAGER: Collaborative Research: Lighthouse: A User-Centered Web System for High-Performance Software Development, $300,000, 10/1/2015 – 7/31/18. Taxonomy-based numerical solver expert system that supports performance model-based search.

PREVIOUS FUNDING (UNIVERSITY OF OREGON PI)

- DOE, Community Project for Accelerator Science and Simulation 3 (ComPASS3), $137,000, 9/1/15–8/31/2017. Performance modeling of high energy physics algorithms and software.

- RNET Corporation (DOE STTR), A Machine Learning Toolkit for Predicting Optimal Numerical Methods in NEAMS Tools, $47,000, 7/15 – 4/16.
- Argonne National Laboratory, Performance Analysis, Modeling, and Optimization of DOE Scientific Applications, $654K total, 2/2014 – 1/2017. A subcontract from Argonne to continue research and leadership as part of the DOE SciDAC SUPER and ComPASS projects (for which I was the Argonne PI prior to joining UO).
- University of Oregon Underrepresented Minority Recruitment Program Grant, $90K total, 9/2013-8/2016. Activities that target the recruitment and retention of women and minorities at all levels, undergraduate, graduate, and faculty, including conference travel for women and minorities, distinguished speaker visits, and workshops organized by the Women in Computer Science organization.
- RNET Technologies, HPC Application Energy Measurement and Optimization (funding source DOE), $90K total, 8/2014 – 4/2015. Use new fine-grained power measurement hardware developed by RNET to validate performance models based on performance hardware counters for DOE applications and explore model-based optimization of energy consumption.

PREVIOUS FUNDING (ARGONNE/U.CHICAGO PI)

- National Science Foundation, *SHF: Small: Collaborative Research: Lighthouse: Resource-Aware Advisor for High-Performance Linear Algebra*, Other PIs: E. Jessup (University of Colorado at Boulder), $500K total, 2012 – 2015.
- Department of Energy, *Institute for Sustained Performance, Energy, and Resilience (SUPER)*, Scientific Discovery through Advanced Computing (SciDAC-3), Collaborative project involving 13 institutions led by Robert F. Lucas (USC), $375K/year (Argonne), 2011 – 2016.
- Department of Energy, *SciDAC3: Community Project for Accelerator Science and Simulation (COMPASS)*, $420K (Argonne), 2012–2015.
- National Science Foundation, *SI-2: Collaborative Research: Software Institute for Abstractions and Methodologies for HPC Simulation Codes on Future Architectures*, institute conceptualization project, $181,642, 2012 – 2013.
- 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.
- National Science Foundation, *Multicore Optimization of an Astrophysical Simulation Code using Performance Annotations*, Other PIs: P. Ricker (UIUC), $75K, 2007 – 2008.

PREVIOUS FUNDING (CO-I)

- National Science Foundation, *SHF: Small: Collaborative Research: Taxonomy for the Automated Tuning of Matrix Algebra Software*, PIs: B. Norris (University of Chicago), E. Jessup (University of Colorado), $500K total, 2009 – 2012. My roles were to co-design the searchable database representation of numerical software (LAPACK) functionality, design a flexible dynamic web-based user interface to the taxonomy, and train and supervise a programmer in its implementation.
- 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. My role: Lead performance analysis and modeling efforts.
- 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. My role: Design and implement domain language support for performance-portable code generation and autotuning in parallel sparse linear solvers.

- Department of Energy, *Performance Engineering Research Institute*, Scientific Discovery through Advanced Computing (SciDAC-2) Institute, multi-institutional collaborative project led by Robert F. Lucas (USC), $3M/year, 2006 – 2011. My role: Performance model generation through source analysis (PBound tool), performance modeling of parallel scientific applications.
- Department of Energy, *Combinatorial Scientific Computing and Petascale Simulations*, SciDAC-2 Institute headed by Alex Pothen (Old Dominion University), $1.3M/year, 2006 – 2011. My role: Advancing C/C++ automatic differentiation capabilities, including research on heuristics for more efficient computation of derivatives and support for new language features in ADIC.
- 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. My role: Devise strategies for automated offline performance modeling of PETSc parallel sparse linear solvers and runtime heuristics for selecting and configuring different solution methods to optimize a given performance objective (e.g., resilience, performance, or power).
- 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. My role: Extend automatic differentiation capabilities for climate applications.
- 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. My role: lead Computer Science activities in designing and implementing a new multigrid 20D 3-dimensional FDTD solvers for parallel nanophotonic simulations. Designed and supervised the implementation of a graphical interface to configuring the geometry and particle configurations for 2-D simulations (student project).

COURSES TAUGHT

- CIS 624 Structure of Programming Languages (Fall 2017, Fall 2016, Fall 2015, Fall 2014, Fall 2013)
- CIS 330 C/C++ & Unix (Winter 2017, Winter 2016, Winter 2015, Winter 2014)
- CIS 431/531 Introduction to Parallel Computing (Spring 2017)
- CIS 410 Data Science (Winter 2016)
- CIS 410/510 System and Network Administration Lab (Spring 2015)
- CIS 410/510 Program Analysis and Transformation (Spring 2014)

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 (RESEARCH ADVISOR)

- Graduate students
  - Kanika Sood, Ph.D., 2014–
  - Sara Riazi, Ph.D., 2015–
  - Kewen Meng, Ph.D., 2015–
  - Brian Gravelle, Ph.D., 2016–
  - Samuel Pollard, Ph.D., 2016–

  - Roscoe Casita, Ph.D., 2017–
  - Nashid Shaila, M.S., 2014–2016
  - Roscoe Casita, M.S., 2014–2017
- Undergraduate students
  - Anu Deodhar (1/16-6/17), Honors College Thesis Advisor
  - Theodore J. LaGrow (1/16-6/17), REU, Honors College Thesis Advisor
  - Jacob Bieker (6/16-12/16), REU
  - Jeremy Lipps (10/14–6/15), Honors College Thesis Advisor
  - Jack Dempsey (6/14–6/15), Research Supervisor
  - Colin Gabrielson (1/14–6/14), Research Supervisor

PH.D. AND M.S. THESES

- Ph.D. Theses (Co-advisor, committee member)
  - Albert Hartono, The Ohio State University, Ph.D., "Tools for Performance Optimizations and Tuning of Affine Loop Nests", 2009. OSU Advisor: Prof. P. Sadayappan.
  - Thomas Nelson, University of Colorado Boulder, 2011–2015. UC Advisor: Prof. E. Jessup.
- Ph.D. Theses (Committee member)
  - Sri Hari Krishna Narayanan, The Pennsylvania State University, "Software Based Techniques for Robust Computing on Chip Multiprocessors," Dec. 2008. Penn State Advisor: Prof. M. Kandemir.
- Masters Theses (Co-advisor, committee member)
  - Li-Yin Young, University of Colorado, May 2015. UC Advisor: Prof. E. Jessup.
  - Ramya Nair, University of Colorado, May 2014. UC Advisor: Prof. E. Jessup.
  - Javed Hossain, University of Colorado, May 2014. UC Advisor: Prof. E. Jessup.
- Masters Theses (Committee member)
  - Kanika Sood, University of Oregon, June 2014. Advisor: Prof. C. Wilson.
  - Geoffrey Belter, University of Colorado, Nov, 2012. UC Advisor: Prof. J. Siek.

POSTDOCTORAL RESEARCHERS SUPERVISED

- Sri Hari Krishna Narayanan (2008-2012); currently Assistant Scientist at Argonne National Laboratory
- Azamat Mametjanov (2011-2013); currently postdoctoral researcher at Argonne National Laboratory
- Qian Zhu (2010-2011); currently at Accenture
- Li Li (2008-2010); currently searching for faculty position in China

PREDOCTORAL RESEARCHERS SUPERVISED

Predoctoral researchers at Argonne National Laboratory are students who have earned an M.S. within the past 3 years and plan to pursue a Ph.D. in the future.

- Daniel Lowell (2010-2012), currently at AMD
- Van Bui (2008-2013), currently pursuing Ph.D. at Columbia University

OTHER STUDENTS (RESEARCH SUPERVISOR AT ARGONNE NATIONAL LABORATORY)

Every year at Argonne I included students in my research through several DOE and Argonne internship programs and student employment options. Many of these students continued work-

ing with me after their initial internship appointment. For a complete list, refer to `http://ix.cs.uoregon.edu/~norris/anlstudents.html`.

- 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.

PROFESSIONAL SERVICE

- Professional society memberships (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.
- Current University of Oregon committees:
  - University of Oregon HPC Faculty Advisory Committee: 1/17–present
  - Computing Resources Committee, Department of Computer and Information Science, University of Oregon: 9/17–present
  - Faculty sponsor for computer science student organizations (ACM and Women in Computer Science): 9/13–present.
- Past University of Oregon committees:
  - Computational genomics search committee: 10/16-5/17.
  - Computer and Information Science Personnel Committee: 9/16-6/17.
  - Computer and Information Science Undergraduate Education Committee: 9/15-6/16.
  - University of Oregon Committee on Courses: 9/14–6/17.
  - Recruiting Committee, Department of Computer and Information Science, University of Oregon: 9/13–9/14.
  - Computing Resources Committee, Department of Computer and Information Science, University of Oregon: 9/13–9/14.
- Argonne National Laboratory committees:
  - Mathematics and Computer Science Library Committee, 2003–2005; responsible for making journal subscription decisions and other library matters.
  - Human Resources Policy Advisory Board (2008–2013): lab-wide committee responsible for regular evaluation and revision of HR policies and procedures.
  - Computational Science Postdoctoral Search Committee (2009): lab-wide committee responsible for reviewing nominations computational science fellowships and making hiring recommendations.
  - LDRD Director's Competitive Grants Committee (2009–2011): lab-wide committee responsible for reviewing and making funding decisions for all internal funding proposals each year (selecting 20 out of 130 proposals from all scientific areas in the lab, each for 2 or 3 year projects totaling $200K-$400K total).
  - Women in Science and Technology Steering Committee (2008–2010): lab-wide committee responsible for generating and implementing strategies for recruiting and retaining women at all levels in STEM, including through interaction with local K-12 schools.
- Organizing committees:
  - The International Conference for High Performance Computing, Networking, Storage and Analysis (SC), since 2015
  - IEEE Cluster, 2018
  - Workshop on Monitoring and Analysis for High Performance Computing Systems Plus Applications (HPCMASPA), since 2014

  - Workshop on Modeling & Simulation of Exascale Systems (ModSim) 2013
  - Software Institute for Methodologies and Abstractions for Codes (SIMAC) Workshop 2012
  - International Conference on Parallel Architectures and Compilation Techniques (PACT): 2008, 2009
  - The ACM International Conference on Supercomputing (ICS): 2011, 2013, 2017
  - 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.
- Program committees:
  - ACM Student Research Competition: since 2015
  - The International Conference for High-Performance Computing, Networking, Storage, and Analysis (SC): since 2009
  - The ACM International Conference on Supercomputing (ICS): 2009, 2011, 2013, 2017
  - IEEE Cluster, 2006, 2017
  - International Conference on Supercomputing, 2017
  - IEEE International Parallel & Distributed Processing Symposium (IPDPS): since 2011
  - The International Workshop on Automatic Performance Tuning (iWAPT): since 2011
  - Quality of Software Architectures (QoSA): 2009-2011
  - Grace Hopper'11
  - Workshop on Statistical and Machine learning approaches to ARchitecture and compilaTion (SMART'10)
  - International Conference on Parallel Architectures and Compilation Techniques (PACT): 2009, 2010
  - Component-Based High Performance Computing Workshop (CBHPC'08)
  - HPC-GECO/CompFrame 2007
  - International Conference on Automatic Differentiation (AD) 2004, 2008
  - AD Workshop at ICCSA'03
  - ACM Symposium on Applied Computing (SAC'03)
  - Hawaii International Conference on System Sciences (HICSS): 2003, 2004
- Reviewer (journals):
  - Transactions on Mathematical Software
  - Computing in Science and Engineering
  - IEEE Computer
  - Transactions on Parallel and Distributed Systems
  - SIAM Journal on Scientific Computing (SISC)
  - International Journal of High Performance Computing Applications (IJHPCA)
  - Concurrency and Computation: Practice and Experience
  - Computers & Geosciences
  - Parallel Computing
  - Transactions on Parallel and Distributed Systems.
- Funding proposals (reviewer/panelist)
  - NSF (HECURA, SI2-SSE, CAREER): 2008–present
  - DOE SBIR/STTR Phase I and Phase II proposals: 2006–present (1-2 proposals annually)

- Argonne Laboratory Directed Research and Development (LDRD) Proposals: 2009–2011 (~30 proposals annually)
- DOE Early Career Principle Investigator (1 proposal): 2004

OUTREACH ACTIVITIES

- Faculty sponsor for the ACM Student Chapter and the Women In Computer Science organization at University of Oregon (2013–present).
- 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://brnorris03.github.io/Orio/`) is 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. Orio has been cited over 50 times (excluding self-citations) [Google Scholar, 11/14] and has served as the basis of one Ph.D. thesis and several M.S. theses.
- 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.
- 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`).
- 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.
- 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 com-

puter 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/xaif`). 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.