Keith D. Cooper

Department of Computer Science
Rice University
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Houston, Texas, USA 77005

Education

B.S., Rice University, 1978 (Electrical Engineering)

M.S., Rice University, 1982 (Mathematical Sciences)

Ph.D., Rice University, 1983 (Mathematical Sciences)

Positions

Research Associate, Rice University: May 1983 – June 1990

Associate Professor, Rice University, July 1990 – present

Professional Activities

1. Vice President, Sun Microsystems Users Group, Incorporated; 1984-1985.
2. Member, Program Committee, Sigplan '88 Conference on Programming Language Design and Implementation.
3. Member, Cray Research Fortran Advisory Board, 1988 – 1993.
4. Member, Facilities Committee, Center for Research on Parallel Computation, 1990 – 1994.
5. Member, Policy Board, Concurrent Supercomputing Consortium, 1991 – 1997.
6. Member, Technical Steering Committee, Center for Research on Parallel Computation; 1991 – present.
7. Tutorials Chair, Sigplan '93 Conference on Programming Language Design and Implementation
8. Member, Tutorials Committee, Supercomputing '93
9. Program Chair, Sigplan '98 Conference on Programming Language Design and Implementation
10. Member, Program Committee, 1998 Conference on Parallel Architectures and Compilation Techniques (Pact 98)
11. Member, Academic Planning and Coordination Committee, Los Alamos Computer Science Institute, June 1999 – present
12. Referee, *ACM Transactions on Programming Languages and Systems*, *Software–Practice and Experience*, *Science of Computer Programming*, *IEEE Computer*, *IEEE Software*, *Information Processing Letters*, *ACM Letters on Programming Languages and Systems*, *Journal of Programming Languages*, *Microprocessors and Microsystems*

University Activities

1. Associate: Brown College, August 1983 – present

   Brown College Award for Excellence in the Sciences, 1985, 1994, 1995
   Outstanding Faculty Associate, August 1984 – present
   Resident Associate, August 1984 – June 1989

2. Engineering Computer Planning Committee, George R. Brown School of Engineering, June 1984 – May 1987
3. University Committee on Computing, *ex officio,* August 1985 – May 1988
4. OwlNet Facilities Committee, August 1987 – April 1989
5. Undergraduate Divisional Advisor, School of Engineering, August 1988 – present
6. University Task Force on Aids, August 1988 – May 1989
7. Chairman, Computer Science Department Facilities Committee, July 1988 – June 1993
8. OwlNet Steering Committee, July 1990 – July 1991
9. University Research Council, August 1990 – June 1993
10. Program Development Committee for a Building for Computation and Information Science and Engineering, July 1991 – December 1992
11. University Graduation Marshall – May 1993, May 1994, May 1996
12. User Liaison, Computational Engineering Building, May 1993 – Fall 1996
13. University *Ad Hoc* Security Review Committee, July 1994 – April 1995
14. University *Ad Hoc* Committee on Access, July 1995 – Fall 1996
15. Duncan Hall Operations Committee, consultant to the committee, Fall 1996 – present
16. Committee on Public Lectures, July 1997 – June 1998.
17. University Committee of Marshalls, July 1997 – present.
18. Dean's Search Committee, George R. Brown School of Engineering, September 1997 – February 1998.
19. *Ad-Hoc* Committee on Classrooms, Fall 1998 – June 1999
20. Faculty Search Committee, Department of Electrical and Computer Engineering, Fall 1998 – present
21. Parking Study Advisory Committee, June 1999 – present

Journal and Conference Papers

1. "Efficient Computation of Flow Insensitive Interprocedural Summary Information" (with K. Kennedy), *Proceedings of the SIGPLAN 84 Symposium on Compiler Construction,* SIGPLAN Notices 19(6), June, 1984, pages 247–258.
2. "Analyzing Aliases of Reference Formal Parameters", *Conference Record of the Twelfth Annual ACM SIGACT/SIGPLAN Symposium on Principles of Programming Languages*, January 1985, pages 281–290.

3. "The Impact of Interprocedural Analysis and Optimization on the Design of a Software Development Environment" (with K. Kennedy and L. Torczon), *Proceedings of the SIGPLAN 85 Symposium on Language Issues in Programming Environments,* SIGPLAN Notices 20(7), July, 1985, pages 107–116.
4. "Optimization of Compiled Code in the $\mathcal{R}^n$ Programming Environment" (with K. Kennedy and L. Torczon), *Proceedings of the 19th Annual Hawaii International Conference on Systems Sciences*, January, 1986, pages 492–502.
5. "Interprocedural Constant Propagation" (with D. Callahan, K. Kennedy and L. Torczon), *Proceedings of the SIGPLAN 86 Symposium on Compiler Construction,* SIGPLAN Notices 21(7), July, 1986, pages 152–161.
6. "Interprocedural Optimization: Eliminating Unnecessary Recompilation" (with K. Kennedy and L. Torczon), *Proceedings of the SIGPLAN 86 Symposium on Compiler Construction*, SIGPLAN Notices 21(7), July, 1986, pages 58–67.
7. "The Impact of Interprocedural Analysis and Optimization in the $\mathcal{R}^n$ Programming Environment" (with K. Kennedy and L. Torczon), *ACM Transactions on Programming Languages and Systems (TOPLAS)*, October, 1986, pages 491-523.
8. "Editing and Compiling Whole Programs" (with K. Kennedy, L. Torczon, A. Weingarten, and M. Wolcott), *Proceedings of the Second ACM SIGPLAN/SIGSOFT Symposium on Practical Software Development Environments*, December, 1986, pages 92–101.
9. "Parallel Programming Support in ParaScope" (with D. Callahan, R.T. Hood, K. Kennedy, L. Torczon, and S.K. Warren), *Proceedings of the 1987 DFVLR-Conference on Parallel Processing in Science and Engineering*, Koln, Germany, June, 1987. Also as *Parallel Computing in Science and Engineering* (R. Dierstein, D. Muller-Wichards, and H. Wacker, editors), Lecture Notes in Computer Science 295, Springer-Verlag, Berlin, June 1987, pages 91–106.
10. "A Practical Environment for Scientific Programming" (with A. Carle, R.T. Hood, K. Kennedy, L. Torczon, and S.K. Warren), *IEEE Computer*, 20(11), November, 1987, pages 75-89.
11. "Efficient Computation of Flow-Insensitive Interprocedural Summary Information – A Correction" (with K. Kennedy), SIGPLAN Notices 23(4), April, 1988, pages 35-42.
12. "Interprocedural Side-Effect Analysis in Linear Time" (with K. Kennedy), *Proceedings of the SIGPLAN 88 Conference on Programming Language Design and Implementation,* SIGPLAN Notices 23(7), July, 1988, pages 57-66.
13. "ParaScope: a Parallel Programming Environment" (with D. Callahan, K. Kennedy, R.T. Hood, and L. Torczon), *The International Journal of Supercomputer Applications*, 2(4), December, 1988, pages 84-99.
14. "Fast Interprocedural Alias Analysis" (with K. Kennedy), *Conference Record of the Sixteenth Annual ACM SIGACT/SIGPLAN Symposium on Principles of Programming Languages*, January, 1989, pages 49–59.
15. "Coloring Heuristics for Register Allocation" (with P. Briggs, K. Kennedy, and L. Torczon), *Proceedings of the SIGPLAN 89 Conference on Programming Language Design and Implementation,* SIGPLAN Notices 24(7), July, 1989, pages 275-284.
16. "An Experiment with Inline Substitution" (with M.W. Hall and L. Torczon), *Software–Practice and Experience* 21(6), June, 1991, pages 581-601.

17. "Procedure Cloning" (with M. Hall and K. Kennedy), *Proceedings of the IEEE Computer Society 1992 International Conference on Computer Languages*, April, 1992, pages 96-105.
18. "Using Compiler Technology to Drive Advanced Microprocessors" *Proceedings of the DARPA Software Technology Conference*, Los Angeles, CA, April 28-30, 1992, pages 42-49.
19. "Coloring Register Pairs" (with P. Briggs and L. Torczon), *ACM Letters on Programming Languages and Systems*, (LOPLAS) 1(1), March 1992, pages 3-13.
20. "Unexpected Side Effects of Inline Substitution: A Case Study" (with M.W. Hall and L. Torczon), *ACM Letters on Programming Languages and Systems* (LOPLAS) 1(1), March 1992, pages 22-32.
21. "Rematerialization" (with P. Briggs and L. Torczon), *Proceedings of the SIGPLAN 92 Conference on Programming Language Design and Implementation*, SIGPLAN Notices 27(7), July, 1992, pages 311-321.
22. "The ParaScope Parallel Programming Environment" (with M.W. Hall, R.T. Hood, K. Kennedy, K. McKinley, J. Mellor-Crummey, L. Torczon, and S.K. Warren) *Proceedings of the IEEE*, 81(2), February 1993, pages 244–263.
23. "A Methodology for Procedure Cloning" (with M.W. Hall and K. Kennedy) *Computer Languages*, 19(2), April 1993, pages 105–118.
24. "Improvements to Graph Coloring Register Allocation", (with P. Briggs and L. Torczon), *ACM Transactions on Programming Languages and Systems* (TOPLAS) 16(3), May 1994, pages 428–456.
25. "Effective Partial Redundancy Elimination" (with P. Briggs), *Proceedings of the* Sigplan 94 Conference on Programming Language Design and Implementation, SIGPLAN Notices 29(6) June 1994, pages 159–170.
26. "Combining Analyses, Combining Optimizations" (with C. Click), *ACM Transactions on Programming Languages and Systems* (TOPLAS), 17(2), March 1995, pages 181-196.
27. "Interprocedural Analysis and Optimization" (with M. Hall, K. Kennedy, and L. Torczon) *Communications on Pure and Applied Mathematics,* Volume 48, 1995, pages 947–1003.
28. "Cross-loop Reuse Analysis and its Application to Cache Optimizations" (with K. Kennedy and N. McIntosh), *Proceedings of Languages and Compilers for Parallel Computers*, August 1996.
29. "Value Numbering", (with P. Briggs and L. Taylor Simpson), *Software—Practice and Experience* 27(6), June 1997, pages 710-724.
30. "Register promotion in C programs", (with J. Lu) *Proceedings of the SIGPLAN 97 Conference on Programming Language Design and Implementation,* SIGPLAN Notices 32(6), June 1997, pages 308–319.
31. "How to build an interference graph" (with T.J. Harvey and L. Torczon). *Software–Practice and Experience*, 28(4), April, 1998, pages 425–444.
32. "Live-range splitting in a graph coloring register allocator", (with L.T. Simpson), *Proceedings of the 1998 International Conference on Compiler Construction*, (*Lecture Notes in Computer Science, 1383*, Springer), March/April 1998 (Lisbon, Portugal), pages 174–187.
33. "Practical Improvements to the Construction and Destruction of Static Single Assignment Form" (with P. Briggs, T.J. Harvey, and L. Taylor Simpson). *Software–Practice and Experience* 28(8), July, 1998, pages 859–881.

34. "Compiler-controlled memory" (with T.J. Harvey). *Proceedings of the Eighth International Conference on Architectural Support for Programming Languages and Operating Systems* (ASPLOS), San Jose, CA, October 1998, pages 2–11 (Also: ACM SIGPLAN Notices, 33(11), November 1998; ACM SIGOPS Operating Systems Review, 32(5), December 1998; and ACM SIGARCH Computer Architecture News, 26(Special Issue), October 1998.)
35. "Enhanced Code Compression for Embedded RISC Processors," (with N. McIntosh), *Proceedings of the SIGPLAN 99 Conference on Programming Language Design and Implementation,* SIGPLAN Notices 34(5), May 1999, pages 139–149.
36. "Operator Strength Reduction" (with L.T. Simpson and C. Vick). ACM TOPLAS, (*to appear*).

Workshop papers

1. "Aggressive Live Range Splitting" (with P. Briggs and L. Torczon), *Code 91 – Concepts, Tools, and Techniques,* Schloss Dagstuhl, Germany, May, 1991.
2. "Compilers, Microprocessors, and Memory Systems" (with P. Briggs), *NSF Workshop on High Performance Memory Systems*, Charlottesville, Virginia, April, 1993.
3. "Non-local instruction scheduling with limited code growth" (with P.J. Schielke). *1998 ACM SIGPLAN Workshop on Languages, Compilers, and Tools for Embedded Systems* (*LCTES*), Montreal, CA, June 1998. (*Lecture Notes in Computer Science, 1474*, F. Mueller and A. Bestavros, (*editors*), Springer), June 1988, pages 193–207.
4. "Optimizing for Reduced Code Space using Genetic Algorithms," (with P. Schielke and D. Subramanian), *1999 ACM SIGPLAN Workshop on Languages, Compilers, and Tools for Embedded Systems* (*LCTES*), Atlanta, GA, May 1999. (Proceedings will appear as an issue of SIGPLAN Notices)

Technical Reports

1. "Recompilation Algorithms for an Optimizing Compiler Based in the $\mathcal{R}^n$ Programming Environment" (with K. Kennedy and L. Torczon), Computer Science Technical Report 84-7, Rice University, November 1984.
2. "The $\mathcal{R}^n$ Environment: A Capsule Description" (with R.T. Hood, K. Kennedy, and L. Torczon), Computer Science Technical Report 87-46, Rice University, June 1987.
3. "Advanced Techniques in Interprocedural Analysis" (with D. Callahan, K. Kennedy, and L. Torczon), Computer Science Technical Report 87-48, Rice University, June 1987.
4. "Goal-directed Interprocedural Optimization", (with P. Briggs, M.W. Hall, and L. Torczon), Computer Science Technical Report 90-147, November 1990.
5. "Value Numbering" (with P. Briggs and L.T. Simpson), Center for Research on Parallel Computation Technical Report TR94527, November 1994.
6. "An Empirical Study of Inter-loop Reuse in the NAS Benchmarks" (with K. Kennedy and N. McIntosh) Center for Research on Parallel Computation Technical Report TR95519 (available online), March 1995.
7. "Using Conditional Branches to Improve Constant Propagation" (with P. Briggs and L. Torczon), Center for Research on Parallel Computation Technical Report TR95533 (available online), April 1995.

8. "Operator Strength Reduction" (with L.T. Simpson and C. Vick), Center for Research on Parallel Computation Technical Report TR95635 (available online), October 1995.
9. "SCC-Based Value Numbering" (with L.T. Simpson), Center for Research on Parallel Computation Technical Report TR95636 (available online), October 1995.
10. "Value-Driven Code Motion" (with L.T. Simpson), Center for Research on Parallel Computation Technical Report TR95637 (available online), October 1995.
11. "Compiler Techniques for Software Prefetching of Cache-Coherent Shared-Memory Multiprocessors" (with N. McIntosh, K. Fletcher, and K. Kennedy), Center for Research on Parallel Computation Technical Report TR96675, October 1996.
12. "An Experimental Evaluation of List Scheduling" (with P. Schielke and D. Subramanian), Rice University Department of Computer Science Technical Report 98-326, September 1998.

Papers In Preparation

1. "An Experimental Evaluation of List Scheduling" (with P. Schielke and D. Subramanian)
2. "Compiler-based Code Improvement Techniques" (with P. Briggs and L. Torczon).

Patents

Digital Computer Register Allocation and Code Spilling Using Interference Graph Coloring (with P. Briggs, K. Kennedy, and L. Torczon), Patent number 5,249,295.

Research Funding

1. *Code Optimization for Embedded Systems*, $1,107,398 from the Defense Advanced Research Projects Agency (with D. Subramanian and L. Torczon) project director and principal investigator, 7/97–10/00.
2. *Optimizing VHDL Intermediate Forms*, $751,246 from the Defense Advanced Research Projects Agency (with J.K. Bennett and L. Torczon) project director and principal investigator, 7/97–10/00.
3. *Compiling for IA-64*, $180,000 as part of the Los Alamos Computer Science Institute (with L. Torczon), 10/99–9/00.
4. *Compilation Problems for Scalable Node Machines*, $1,100,594 from the Advanced Research Projects Agency (with K. Kennedy and L. Torczon) project director and principal investigator, 8/95–10/98.
5. *Compiling for Partitioned Register Set Machines*, $32,182, Texas Instruments, 8/95–8/96.
6. *A Software Platform for Parallel Scientific Programming*, $2,821,028 from the Defense Advanced Research Projects Agency (with A. Carle, M.W. Hall, R.T. Hood, K. Kennedy, J. Mellor-Crummey, L. Torczon, and S.K. Warren), principal investigator, *three years*, 7/92 – 7/95 (extended to 12/95). $1,118,644 from the Advanced Research Projects Agency (with K. Kennedy and L. Torczon) project director and principal investigator, 7/95–9/98.
7. *Compiling for Advanced Microprocessors*, $1,949,884 from the Defense Advanced Research Projects Agency (with K. Kennedy and L. Torczon), project director and principal investigator, 6/91 – 9/94 (no cost extension to 12/95).
8. *Compiling for Large Scale SIMD Architectures*, $676,269 (*equipment matching funds*) from the Digital Equipment Corporation, 1990.

9. *Advanced Fortran Programming Environment*, $675,000 from IBM Corporation (with R.T. Hood, K. Kennedy, and L. Torczon), principal investigator, 9/1/89 – 8/31/91.
10. *Advanced Techniques in Interprocedural Analysis*, $203,985 from the National Science Foundation (with K. Kennedy and L. Torczon), principal investigator, 2/15/88 – 7/31/91.
11. *An Advanced Programming Environment for Workstations*, $1,912,000 from IBM Corporation (with R. Hood, K. Kennedy, and L. Torczon), principal investigator starting in 5/85, 8/1/83 – 8/31/89.
12. *Parallel Programming Support in the $\mathcal{R}^n$ Programming Environment*, $638,000 from IBM Corporation (with D. Callahan, R. T. Hood, K. Kennedy, and L. Torczon), principal investigator, 9/87 – 8/89

Buildings

Duncan Hall, Rice University, Spring 1993 – Fall 1996. User Liaison to the design team; attended nearly all design meetings, construction progress meetings; active participant in fund raising for the project (over $40,000,000).

– *Invited speaker*, Annual meeting of the Marek Brothers Family of Companies, August 1996.

– *Invited speaker*, Symposium on Computational Engineering, February 1997.

– *Monograph* "Outram's Building at Rice: Icons, Images, and Themes", published by Rice University, October 1996; 20 pages.

Student Advising

Ph.D. Students

1. Preston Briggs, May 1992.
2. Cliff Click, May 1995.
3. Taylor Simpson, May 1996.
4. Nathaniel McIntosh, May 1997 (joint with K. Kennedy)
5. John Lu, August 1997
6. Edmar Wienskoski, May 1998
7. Philip Schielke
8. Jingsong He
9. Li Xu
10. Timothy J. Harvey
11. Todd Waterman

Thesis Masters Students

1. Karim Esseghir, May 1993
2. Chris Vick, May 1994
3. Timothy J. Harvey, May 1998.

$\mathcal{R}^n$ Newsletters

1. "The $\mathcal{R}^n$ Programming Environment Database Facilities" (with L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 2, Department of Mathematical Sciences, Rice University, December 1983.

2. "The Secret Database CP Handshake" (with L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 8, Department of Mathematical Sciences, Rice University, February 1984.
3. "The $\mathcal{R}^n$ Programming Environment Database Command Processor" (with K. McKinley and L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 9, Department of Computer Science, Rice University, August 1984.
4. "The Impact of Interprocedural Analysis and Optimization on the $\mathcal{R}^n$ Programming Environment" (with L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 13, Department of Computer Science, Rice University, November 1984.
5. "The Multi-user Database: A Reworking of the Interface". $\mathcal{R}^n$ Programming Environment Newsletter 15, Department of Computer Science, Rice University, February, 1985.
6. "The Code Generator: A Preliminary Design Discussion". $\mathcal{R}^n$ Programming Environment Newsletter 16, Department of Computer Science, Rice University, February, 1985.
7. "A Revised ILOC Definition" (with K. McKinley, and L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 35, Department of Computer Science, Rice University, September, 1986.
8. "Porting the Environment to the RT/PC" (with D. Baker, B. Chase, D. Chase, R. Hood, L. Torczon, A. Weingarten), $\mathcal{R}^n$ Programming Environment Newsletter 38, October, 1986.
9. "The Program Compiler Design" (with A. Carle, K. Kennedy, L. Torczon, and M. Wolcott). $\mathcal{R}^n$ Programming Environment Newsletter 41, Department of Computer Science, Rice University, October, 1987.
10. "ILOC '87" (with P. Briggs and L. Torczon). $\mathcal{R}^n$ Programming Environment Newsletter 44, Department of Computer Science, Rice University, October, 1987.