

## Randal E. Bryant

### Education

- 1974–1981 Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, S.M. (1977), E.E. (1978), PhD (1981). Thesis Supervisor: Prof. Jack B. Dennis. PhD Thesis Title: “A Switch-Level Simulation Model of Integrated Logic Circuits.”
- 1970–1973 University of Michigan, College of Engineering (Applied Math), B.S. (1973).

### Employment

- 2004–Present Dean, School of Computer Science, Carnegie Mellon University.
- 2004–Present University Professor of Computer Science, Carnegie Mellon University.
- 1999–2004 Head, Computer Science Department, Carnegie Mellon University.
- 1997–2004 Robert Mehrabian Professor of Computer Science, Carnegie Mellon University.
- 1992–1997 Professor of Computer Science, Carnegie Mellon University. Research areas: VLSI circuit verification, symbolic manipulation, and parallel computation. Teaching subjects: computer architecture
- 1987–1992 Associate Professor of Computer Science, Carnegie Mellon University. (Tenure granted Sept., 1990.) Research areas: VLSI simulation, VLSI circuit verification, symbolic manipulation, and parallel computation. Teaching subjects: introductory computer science, computer architecture, advanced VLSI design.
- 1990–1991 Visiting Research Fellow, Fujitsu Laboratories, Ltd., Kawasaki, Japan.
- 1984–1987 Assistant Professor of Computer Science, Carnegie Mellon University.
- 1984–present Courtesy appointment in Electrical and Computer Engineering, Carnegie Mellon University.
- 1981–1984 Assistant Professor of Computer Science, California Institute of Technology. Research areas: VLSI circuit models, logic simulation, and circuit testing. Teaching subjects: computer architecture, digital systems theory, and computer algorithms.

### Professional Activities

#### Affiliations

- 1977–present IEEE. Elected Fellow, 1990, citation: “for contributions to switch-level simulation of very large scale integrated circuits”.
- 1978–present ACM. Elected Fellow, 1999.
- 2003–present National Academy of Engineering. Elected 2003. Section 5 (computer science and engineering) Peer Committee 2008–2009, Nominating Committee, 2010.
- 2006–present Academic Research Council, Singapore Ministry of Education.

2005–2009	Office of the Chief Information Officer Advisory Board, Federal Bureau of Investigation.
2006–2009	Computer and Information Science and Engineering (CISE) Advisory Board, National Science Foundation.
2000–2006	Board of Directors, Computing Research Association.
1999–2003	Technical Advisory Board, Innologic Systems (acquired by Synopsys in 2003).
1998–2000	Technical Advisory Board, Simplex Solutions (acquired by Cadence in 2002).
1993–2005	Technical Advisory Boards Fujitsu Labs of America, San Jose, CA.
1981–present	Consultant: Hewlett Packard, Litton Data Systems, Digital Equipment Corporation, IBM, and other companies. America

## Awards

2009	Phil Kaufman Award, Electronic Design Automation Consortium (EDAC) and IEEE Council for Electronic Design Automation. Citation: “for his seminal breakthroughs in the area of formal verification.”
2008	University of Michigan Distinguished Engineering Alumni Award.
2007	IEEE Emanuel R. Piore Award. Citation: “For seminal contributions to the field of computer-aided circuit design and verification, including the development and promulgation of ordered binary decision diagrams.”
2003	IEEE CAD Transactions Best Paper Award. For paper coauthored with Ph.D. student Yirng-An Chen.
2003	Elected to National Academy of Engineering. Citation: “For contributions to symbolic simulation and logic verification.”
2003	Paper selected for inclusion in <i>The Best of ICCAD, 20 Years of Excellence in Computer-Aided Design</i> , a collection of 42 out of over 2,200 papers that have been presented at the International Conference on Computer-Aided Design between 1983 and 2002.
2000	Golden Jubilee Medal. Awarded to 118 members of the IEEE Circuits and Systems Society for professional contributions.
1998	Allen Newell Research Excellence Medal, Computer Science Department, Carnegie Mellon University.
1998	ACM Kanellakis Theory and Practice Award. Shared with Ken McMillan, Edmund M. Clarke, and Allen Emerson for the development of symbolic model checking
1996	Technical Excellence Award, Semiconductor Research Corporation. Shared with Ken McMillan and Edmund M. Clarke for the development of symbolic model checking.
1995	Litton Fellow, Carnegie Mellon Computer Science Department.
1995	Best Paper Award, Simulation, Verification, and Test Category, 32nd Design Automation Conference, for paper coauthored with Ph.D. student Yirng-An Chen.
1990	Inventor Recognition Award, Semiconductor Research Corporation, for the BDD symbolic Boolean manipulation software library.
1989	Inventor Recognition Award, Semiconductor Research Corporation. for the COSMOS switch-level simulator.
1989	IEEE W. R. G. Baker Award for “The most outstanding paper reporting original work in any of the IEEE <i>Transactions</i> , <i>Proceedings of the IEEE</i> , journals, or magazines issued

- during the previous year.”
- 1988 Best Paper Award, Design, Simulation and Test Category, 25th Design Automation Conference. For paper coauthored with Ph.D. student Derek Beatty.
  - 1988 Two papers selected for inclusion in *Twenty Five Years of Electronic Design Automation*, a collection of 77 of the over 1600 papers presented at the Design Automation Conferences for the years 1964–1987.
  - 1987 IEEE CAD Transactions Best Paper Award.
  - 1983, 1984 IBM Faculty Development Award (One of 100 recipients of special grant for junior faculty.)
  - 1974–1978 National Science Foundation Graduate Fellow.

### Academic Review Committees

- 2009 University of Utah, School of Computing.
- 2009 Princeton University, Computer Science Department.
- 2009 University of Virginia, Computer Science Department.
- 2009 Massachusetts Institute of Technology, Department of EECS.
- 2009 University of Washington Computer Science Department.
- 2007 Georgia Institute of Technology, College of Computing.
- 2007 Stanford University, Department of Computer Science.
- 2005 University of Virginia, Computer Science Department.
- 2004 Kuwait University, Graduate program in computer science.
- 2004 Information Technology University of Copenhagen, Denmark.
- 2003 University of Pittsburgh Computer Science Department.
- 2003 University of Utah School of Computing.
- 2002 University of Texas, Computer Science Department.
- 2001 Stanford University Electrical Engineering Department.
- 2000 Faculty of Computer Science, Technion, Haifa, Israel.

### Conference Committees

- 2008 Co-organizer, Hadoop Summit and Symposium on Data-Intensive Computing, Sunnyvale, CA.
- 2002–2004 Program Committee, Design and Test in Europe.
- 1996, 1998, 2000, 2002, 2004 Program Committee, International Conference on Formal Methods in Computer-Aided Design.
- 1990, 1994, 2000–2001, 2004, 2006 Program Committee, International Conference on Computer-Aided Verification.
- 1994–2000 Executive Committee, Design Automation Conference (tutorial chair 1994–1995, program co-chair 1998–1999).
- 1990, 1992 Program Committee, TAU International Workshop on Timing Issues in the Specification and Synthesis of Digital Systems.
- 1991, 1993 Program Committee, International Workshop on Logic Synthesis.
- 1989 Program Committee, IFIP Workshop on Applied Formal Methods for Correct VLSI

- Design.
- 1986–1992 Program Committee, Design Automation Conference.
  - 1989–1990 Program Committee, Microelectronic System Education Conference.
  - 1989 Program Committee, International Conference on Computer-Aided Design.
  - 1988 Program Committee, IFIP Conference on Design Methodologies for VLSI and Computer Architecture.
  - 1987 Program Committee, IEEE VLSI Workshop, Clearwater Beach, Florida.
  - 1985–1991, 1997 Program Committee, Conference on Advanced Research in VLSI (held at MIT, Caltech, UNC, Brown, and Michigan).
  - 1983 Chairman, Third Caltech Conference on Very Large Scale Integration.
  - 1979 Organizer, MIT Workshop on Self-Timed Systems.

### Proposal Review Committees

- 2001 Texas Advanced Research/Advanced Technology Programs Reviewer.
- 2001 National Science Foundation CAREER Program Proposal Panel.
- 2001 National Science Foundation ITR Program Preproposal Panel.
- 1990 National Science Foundation Graduate Fellowship evaluation panel.

### Editorships and Reviewing

- 1995–1997 Editor-in-Chief, *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*.
- 1991–present Editorial Board, *Formal Methods in System Design*
- 1989–1995 Associate Editor, *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*.
- 1976–present Reviewer for papers submitted to *IEEE Transactions on Computers*, *IEEE Computer*, *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, *IEEE Transactions on Software Engineering*, *IEEE Transactions on Circuits and Systems*, *ACM Transactions on Computing Systems*, *Journal of the ACM*, *International Journal of Parallel Programming*, *Communications of the ACM*, *Theoretical Computer Science*, *Information Processing Letters*, and numerous conferences.
- 1983–1988 Reviewer for ACM Distinguished Dissertation Award

### University Service

- 2007 Member of Search Committee for Dean of Mellon College of Science
- 2004 Member of Search Committee for Director of Robotics Institute.
- 2000 Member of Provost Search Committee
- 1998–1999 Co-Chair of School of Computer Science Dean Search Committee
- 1993–1999 In charge of faculty reappointments and promotions, Computer Science Department.
- 1991–1993 School of Computer of Computer Science Graduate Council. Chairman-Elect 1991–1992, Chairman 1992–1993.
- 1991–1993 Member, CMU Faculty Development Awards Committee

- 1992 School of Computer Science Dean Search Committee
- 1988–1989 Presidential appointee to CMU Faculty Senate.
- 1988–1990 Graduate Admissions Committee, CMU Computer Science (Chairman, 1989).
- 1985–1987 Qualifier Review Committee, CMU Computer Science Dept. (Chairman, 1986–1987).
- 1986–1987 University Research Council, CMU.
- 1986–1988 Facilities Advisory Committee, CMU Computer Science Dept.
- 1981–1984 Organized Computer Science Seminar series, Caltech.
- 1982–1984 In charge of Computer Science Library, Caltech.
- 1982 Computer Science Graduate Admissions Committee, Caltech.

## Publications

### Books and Book Chapters

R. E. Bryant, and J. H. Kukula, “Formal Methods for Functional Verification,” in *The Best of ICCAD: 20 Years of Excellence in Computer-Aided Design*, A. Kuehlmann, ed. Kluwer Academic Publishers, 2003, pp. 3–16. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/iccad-best02.{ps,pdf}>.

R. E. Bryant, and D. R. O’Hallaron, *Computer Systems: A Programmer’s Perspective*, Prentice-Hall, 2003. More information available at <http://csapp.cs.cmu.edu/>.

R. E. Bryant, and C. Meinel, “Ordered Binary Decision Diagrams,” in *Logic Synthesis and Verification*, S. Hassoun and T. Sasao, eds., Kluwer Academic Publishers, 2001.

R. E. Bryant, ed., *Proceedings of the Third Caltech Conference on Very Large Scale Integration*, Computer Science Press, March, 1983.

R. E. Bryant and J. B. Dennis, “Concurrent Programming,” in *Research Directions in Software Technology*, P. Wegner, ed., MIT Press, June, 1979, pp. 584–610. Revised version in *Operating Systems Engineering, Lecture Notes in Computer Science 143*, M. Maekawa and L. A. Belady, eds., Springer-Verlag, 1982, pp. 426–451.

### Refereed Journal and Book Articles

R. E. Bryant, D. Kroening, J. Ouaknine, S. A. Seshia, O. Strichman, and B. Brady, “An Abstraction-Based Decision Procedure for Bit-Vector Arithmetic,” *International Journal of Software Tools for Technology*, Springer-Verlag Vol. 11, No. 2 (April, 2009), pp. 95–104.

R. M. Jensen, M. M. Veloso, and R. E. Bryant, “State-Set Branching: Leveraging BDDs for Heuristic Search,” *Artificial Intelligence*, Vol. 172, Issues 2–3 (February, 2008), pp. 103–139. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/aij07.{ps,pdf}>.

S. K. Lahiri, and R. E. Bryant, “Predicate Abstraction with Indexed Predicates,” *ACM Transactions on Computational Logic*, Vol. 9, No. 1 (Dec., 2007). Available as

<http://www.cs.cmu.edu/~bryant/pubdir/tocl06.{ps,pdf}>.

S. A. Seshia, K. Subramani, and R. E. Bryant, “On Solving Boolean Combinations of UTVPI Constraints,” *Journal of Satisfiability, Boolean Modeling and Computation*, Vol. 3 (2007), pp. 67–90. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/jsat07.{ps,pdf}>.

M. N. Velev, and R. E. Bryant, “TLSim and EVC: A Term-Level Symbolic Simulator and an Efficient Decision Procedure for the Logic of Equality with Uninterpreted Functions and Memories,” *International Journal of Embedded Systems*, Vol. 1, No. 1/2 (2005), pp. 134–149. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/ijes05.{ps,pdf}>.

S. A. Seshia, and R. E. Bryant, “Deciding Quantifier-Free Presburger Formulas Using Parameterized Solution Bounds,” *Logical Methods in Computer Science*, Vol. 1, Issue 2, Paper 7 (December, 2005). Available as

<http://www.cs.cmu.edu/~bryant/pubdir/lmcs05.{ps,pdf}>.

M. N. Velev, and R. E. Bryant, “Effective Use of Boolean Satisfiability Procedures in the Formal Verification of Superscalar and VLIW Microprocessors,” *Journal of Symbolic Computation*. Vol. 35, No. 2 (February, 2003), pp. 73–106. Submitted version available as

<http://www.cs.cmu.edu/~bryant/pubdir/jsc03.{ps,pdf}>.

R. E. Bryant and M. N. Velev, “Boolean Satisfiability with Transitivity Constraints,” *ACM Transactions on Computational Logic*, Vol. 3, No. 4 (October, 2002). Available as

<http://www.cs.cmu.edu/~bryant/pubdir/tocl-trans01.{ps,pdf}>.

Y.-A. Chen, and R. E. Bryant, “An Efficient Graph Representation for Arithmetic Circuit Verification,” *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 20, No. 12 (December, 2001), pp. 1442–1454. Winner of 2003 IEEE CAD Transactions Best Paper Award. Preprint version available as

<http://www.cs.cmu.edu/~bryant/pubdir/tcad01-chen.{ps,pdf}>.

R. E. Bryant, and Y.-A. Chen, “Verification of Arithmetic Circuits Using Binary Moment Diagrams,” *Software Tools for Technology Transfer*, Springer-Verlag, Vol. 3, No. 2 (May, 2001), pp. 137–155. Submitted version available as

<http://www.cs.cmu.edu/~bryant/pubdir/sttt-submit.{ps,pdf}>.

C. B. McDonald and R. E. Bryant, “CMOS Circuit Verification with Symbolic Switch-Level Timing Simulation,” *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 20, No. 3 (March, 2001), pp. 458–474. Preprint version available as

<http://www.cs.cmu.edu/~bryant/pubdir/tcad01.{ps,pdf}>.

R. E. Bryant, S. German, M. N. Velev, “Processor Verification Using Efficient Reductions of the Logic of Uninterpreted Functions to Propositional Logic,” *ACM Transactions on Computational Logic*, Vol. 2, No. 1 (January, 2001). Available as

<http://www.cs.cmu.edu/~bryant/pubdir/tocl01.{ps,pdf}>.

M. Pandey, and R. E. Bryant, “Exploiting symmetry when verifying transistor-level circuits by symbolic trajectory evaluation,” *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 18, No. 7 (July, 1999), pp. 918–935. Winner of 2001 IEEE Circuits and Systems Society Outstanding Young Author Award. Preprint version available as

<http://www.cs.cmu.edu/~bryant/pubdir/tcad99.{ps,pdf}>.

C.-J. H. Seger, and R. E. Bryant, “Formal Verification by Symbolic Evaluation of Partially-Ordered Trajectories,” *Formal Methods in System Design*, Vol. 6, No. 2 (March, 1995), pp. 147–190. Preprint version available as

<http://www.cs.cmu.edu/~bryant/pubdir/fmsd95.{ps,pdf}>.

- R. E. Bryant, J. D. Tygar, and L. P. Huang, "Geometric Characterization of Series-Parallel Variable Resistor Networks," *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, Vol. 41, No. 11 (November, 1994), pp. 686–698. Manuscript version available as  
<http://www.cs.cmu.edu/~bryant/pubdir/tcas94.{ps,pdf}>.
- L. P. Huang, and R. E. Bryant, "Intractability in Linear Switch-Level Simulation," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 12, No. 6 (June, 1993), pp. 829–836.
- R. E. Bryant, "Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams," *ACM Computing Surveys*, Vol. 24, No. 3 (September, 1992), pp. 293–318. Preprint version published as CMU Technical Report CMU-CS-92-160,  
<http://www.cs.cmu.edu/~bryant/pubdir/CMU-CS-92-160.{ps,pdf}>. Also available as  
<http://www.cs.cmu.edu/~bryant/pubdir/acmcs92.{ps,pdf}>
- S. A. Kravitz, R. E. Bryant, and R. A. Rutenbar, "Massively Parallel Switch-Level Simulation: A Feasibility Study," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 10, No. 7 (July, 1991) pp. 871–894.
- R. E. Bryant, "A Methodology for Hardware Verification Based on Logic Simulation," *J.ACM*, Vol. 38, No. 2 (April, 1991), pp. 299–328. Preprint available as  
<http://www.cs.cmu.edu/~bryant/pubdir/jacm91.{ps,pdf}>.
- R. E. Bryant, "On the Complexity of VLSI Implementations and Graph Representations of Boolean Functions with Application to Integer Multiplication," *IEEE Transactions on Computers*, Vol. 40, No. 2 (February, 1991), pp. 205–213. Preprint available as  
<http://www.cs.cmu.edu/~bryant/pubdir/ieeetc91.{ps,pdf}>.
- R. E. Bryant, "Formal Verification of Memory Circuits by Switch-Level Simulation," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. 10, No. 1 (January, 1991), pp. 94–102. Preprint available as  
<http://www.cs.cmu.edu/~bryant/pubdir/tcad91.{ps,pdf}>.
- D. L. Beatty, and R. E. Bryant, "Incremental Switch-Level Analysis," *IEEE Design and Test of Computers*, Vol. 5, No. 6 (December, 1988), pp. 33–42.
- R. E. Bryant, "A Survey of Switch-Level Algorithms," *IEEE Design and Test of Computers*, Vol. 4, No. 4 (August, 1987), pp. 26–40.
- R. E. Bryant, "Algorithmic Aspects of Symbolic Switch Network Analysis," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. CAD-6, No. 4 (July, 1987), pp. 618–633. Winner of 1987 IEEE CAD Transactions Best Paper Award, and the 1989 IEEE W. R. G. Baker Award. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/tcad87a.{ps,pdf}>.
- R. E. Bryant, "Boolean Analysis of MOS Circuits," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. CAD-6, No. 4 (July, 1987), pp. 634–649. Winner of the IEEE W. R. G. Baker Award. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/tcad87b.{ps,pdf}>.
- R. E. Bryant, "Graph-Based Algorithms for Boolean Function Manipulation," *IEEE Transactions on Computers*, Vol. C-35, No. 8 (August, 1986), pp. 677–691. Reprinted in M. Yoeli, *Formal Verification of Hardware Design*, IEEE Computer Society Press, 1990, pp. 253–267. Electronic version with annotations available as

<http://www.cs.cmu.edu/~bryant/pubdir/ieeetc86.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/ieeetc86.pdf).

W. J. Dally and R. E. Bryant, "A Hardware Architecture for Switch-Level Simulation," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, Vol. CAD-4, No. 3 (July, 1985), pp. 239–249.

R. E. Bryant, "A Switch-Level Model and Simulator for MOS Digital Systems," *IEEE Transactions on Computers*, Vol. C-33, No. 2 (February, 1984), pp. 160–177.

## Refereed Conference Articles

R. E. Bryant, D. Kroening, J. Ouaknine, S. A. Seshia, O. Strichman, and B. Brady, "Deciding Bit-Vector Arithmetic with Abstraction," *Tools and Algorithms for the Construction and Analysis of Systems TACAS 2007*, April, 2007. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/tacas07.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/tacas07.pdf).

M. Christodorescu, S. Jha, S. A. Seshia, D. Song, and R. E. Bryant, "Semantics Aware Malware Detection," *IEEE Symposium on Security and Privacy*, May, 2005, pp. 32–46. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/oakland05.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/oakland05.pdf).

V. Ganapathy, S. A. Seshia, S. Jha, T. W. Reps, and R. E. Bryant, "Automatic Discovery of API-Level Exploits," *International Conference on Software Engineering ICSE 05*, May, 2005, pp. 312–321. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/icse05.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/icse05.pdf).

S. A. Seshia, R. E. Bryant, and K. S. Stevens, "Modeling and Verifying Circuits Using Generalized Relative Timing," *IEEE International Symposium on Asynchronous Circuits and Systems, ASYNC 05*, March, 2005, pp. 98–108 Available as

<http://www.cs.cmu.edu/~bryant/pubdir/async05.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/async05.pdf).

S. K. Lahiri and R. E. Bryant, "Indexed Predicate Discovery for Unbounded System Verification," *Computer-Aided Verification CAV 2004*, R. Alur, and D. A. Peled, eds., LNCS 3114, Springer-Verlag, July, 2004, pp. 135–147. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/cav04b.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/cav04b.pdf).

A. Goel and R. E. Bryant, "Symbolic Simulation, Model Checking and Abstraction with Partially Ordered Boolean Function Vectors," *Computer-Aided Verification CAV 2004*, R. Alur, and D. A. Peled, eds., LNCS 3114, Springer-Verlag, July, 2004, pp. 255–267. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/cav04a.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/cav04a.pdf).

S. A. Seshia and R. E. Bryant, "Deciding Quantifier-Free Presburger Formulas Using Parameterized Solution Bounds," *Logic in Computer Science LICS 2004*, IEEE, July, 2004, pp. 100–109. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/lics04.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/lics04.pdf).

R. M. Jensen, M. M. Veloso, and R. E. Bryant, "Fault Tolerant Planning: Toward Probabilistic Uncertainty Models in Symbolic Non-Deterministic Planning," *International Conference on Automated Planning and Scheduling ICAPS 04*, June, 2004. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/icaps04.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/icaps04.pdf).

S. K. Lahiri, R. E. Bryant, A. Goel, and M. Talupur "Revisiting Positive Equality," *Tools and Algorithms for the Construction and Analysis of Systems TACAS 2004*, K. Jensen, and A. Podelski, eds., LNCS 2988, Springer-Verlag, March, 2004, pp. 1–15 Available as

- <http://www.cs.cmu.edu/~bryant/pubdir/tacas04.{ps,pdf}>.
- S. K. Lahiri, and R. E. Bryant, “Constructing Quantified Invariants via Predicate Abstraction,” *Verification, Model Checking, and Abstract Interpretation (VMCAI '04)*, B. Steffen, and G. Levi, eds., LNCS 2937, Springer-Verlag, February, 2004, pp. 267–281. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/vmcai04.{ps,pdf}>. Slightly longer version available (as gzipped postscript) as  
<http://www.cs.cmu.edu/~bryant/pubdir/vmcai04-long.ps.gz.{ps,pdf}>
- R. E. Bryant, S. K. Lahiri, and S. A. Seshia, “Convergence Testing in Term-Level Bounded Model Checking,” *Correct Hardware Design and Verification Methods CHARME '03*. D. Geist, and E. Tronci, eds., LNCS 2860, Springer-Verlag, October, 2003, pp. 348–362. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/charme03.{ps,pdf}>.
- R. M. Jensen, M. M. Veloso, and R. E. Bryant, “Guided Symbolic Universal Planning,” *International Conference on Automated Planning and Scheduling ICAPS 03*, pp. 123–132, 2003. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/icaps03.{ps,pdf}>
- S. K. Lahiri, and R. E. Bryant, “Deductive Verification of Advanced Out-of-Order Microprocessors,” *Computer-Aided Verification CAV '2003*, W. A. Hunt, Jr., and F. Somenzi, eds., LNCS 2725, Springer-Verlag, July, 2003, pp. 341–354. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/cav03a.{ps,pdf}>
- S. K. Lahiri, R. E. Bryant, and B. Cook, “A Symbolic Approach to Predicate Abstraction,” *Computer-Aided Verification CAV '2003*, W. A. Hunt, Jr., and F. Somenzi, eds., LNCS 2725, Springer-Verlag, July, 2003, pp. 141–153. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/cav03b.{ps,pdf}>
- S. A. Seshia, and R. E. Bryant, “Unbounded, Fully Symbolic Model Checking of Timed Automata using Boolean Methods,” *Computer-Aided Verification CAV 2003*, W. A. Hunt, Jr., and F. Somenzi, eds., LNCS 2725, Springer-Verlag, July, 2003, pp. 154–166. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/cav03c.{ps,pdf}>
- S. A. Seshia, S. K. Lahiri, and R. E. Bryant, “A Hybrid SAT-Based Decision Procedure for Separation Logic with Uninterpreted Functions,” *40th Design Automation Conference*, 2003, pp. 425–430. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/dac03a.{ps,pdf}>
- A. Goel, G. Hasteer, and R. E. Bryant, “Symbolic Representation with Ordered Function Templates,” *40th Design Automation Conference*, 2003, pp. 431–435. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/dac03b.{ps,pdf}>
- A. Goel, and R. E. Bryant “Set Manipulation with Boolean Functional Vectors for Symbolic Reachability Analysis,” *Design and Test Europe DATE 2003*, March, 2003. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/date03.{ps,pdf}>.
- S. K. Lahiri, S. A. Seshia, and R. E. Bryant, “Modeling and Verification of Out-of-Order Processors in UCLID,” *Formal Methods in Computer-Aided Design FMCAD '2002*, M. D. Aagaard and J. W. O’Leary, eds., LNCS 2517, November, 2002, pp. 142–159. Available as  
<http://www.cs.cmu.edu/~bryant/pubdir/fmcad02.{ps,pdf}>.
- R. E. Bryant, S. K. Lahiri, and S. A. Seshia, “Modeling and Verifying Systems using a Logic of Counter Arithmetic with Lambda Expressions and Uninterpreted Functions,” *Computer-Aided Verification CAV '2002*, E. Brinksma, and K. G. Larsen, eds., LNCS 2404, Springer-Verlag, July, 2002, pp. 78–92. Available as

- <http://www.cs.cmu.edu/~bryant/pubdir/cav02a.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/cav02a.pdf)
- O. Strichtman, S. A. Seshia, and R. E. Bryant, “Deciding Separation Formulas with SAT,” *Computer-Aided Verification CAV ’2002*, E. Brinksma, and K. G. Larsen, eds., LNCS 2404, Springer-Verlag, July, 2002, pp. 209–222. Available as
- <http://www.cs.cmu.edu/~bryant/pubdir/cav02b.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/cav02b.pdf)
- R. M. Jensen, R. E. Bryant, and M. M. Veloso, “An Efficient BDD-Based A\* Algorithm,” *Proceedings of AIPS-02 Workshop on Planning via Model Checking*, 2002. Available as
- <http://www.cs.cmu.edu/~bryant/pubdir/aips02.ps>, [pdf](http://www.cs.cmu.edu/~bryant/pubdir/aips02.pdf)
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Y.-A. Chen, B. Yang, and R. E. Bryant, “Breadth-First with Depth-First BDD Construction: A Hybrid Approach,” Technical Report CMU-CS-97-120, March, 1997. Available as

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M. Starkey, and R. E. Bryant, “Using Ordered Binary-Decision Diagrams for Compressing Images and Image Sequences,” Technical Report CMU-CS-95-105, January, 1995. Available as

<http://reports-archive.adm.cs.cmu.edu/anon/1995/CMU-CS-95-105.ps>.

R. E. Bryant, “An Analysis of U.S. Patent 5,243,538 ‘Comparison and Verification System for Logic Circuits and Method Thereof’,” unpublished manuscript, 1994. Available as

<http://www.cs.cmu.edu/~bryant/pubdir/patent94.{ps,pdf}>.

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<http://reports-archive.adm.cs.cmu.edu/anon/1994/CMU-CS-94-160.ps>, and also as

<http://www.cs.cmu.edu/~bryant/pubdir/CMU-CS-94-160.{ps,pdf}>.

D. Beatty, K. Brace, R. E. Bryant, K. Cho, and L. Huang, *User’s Guide to COSMOS*, 1987.

M. Schuster, and R. E. Bryant, *FMOSSIM: A Switch-Level Logic and Fault Simulator*, unpublished user’s manual, 1985.

R. E. Bryant, M. Schuster, and D. Whiting, *MOSSIM II: A Switch-Level Simulator for MOS LSI, User’s Manual*, Technical Report 5033, Caltech Computer Science, 1982.

R. E. Bryant, *A Switch-Level Simulation Model for Integrated Logic Circuits*, (PhD thesis), Technical Report

TR-259, MIT Laboratory for Computer Science, March, 1981.

R. E. Bryant, *Simulation of Packet Communication Architecture Computer Systems*, (Master's thesis), Technical Report TR-188, MIT Laboratory for Computer Science, November, 1977.

## Technical Presentations

### Professional Meetings and Conferences

Invited talks indicated with asterisk.

- 11/04/09 “BDDs and SAT Solvers: Applying Boolean Reasoning to Formal Hardware Verification,” Cadence Design Systems, Sunnyvale, CA.
- \*10/13/09 “Data-Intensive Scalable Computing,” Los Alamos Computer Science Symposium, Santa Fe, NM.
- 07/30/09 “Data-Intensive Computing: The Prospects and the Challenges,” Workshop on Enabling Data-Intensive Computing: from Systems to Applications, University of Pittsburgh, Pittsburgh, PA.
- 6/25/08 “Data-Intensive Cloud Computing,” as part of panel session on Cloud Computing at the High-Performance Distributed Computing Conference, Boston, MA.
- \*4/23/08 “Reasoning about Data: Bits, Bit Vectors, or Words,” Keynote Speech, International Symposium on VLSI Design Automation, and Test, Hsinchu, Taiwan.
- \*3/26/08 “Data-Intensive Super Computing,” Symposium on Data-Intensive Computing, Sunnyvale, CA.
- \*3/17/08 “Data-Intensive Super Computing,” Technology@Sun 2008 (an internal meeting of the engineering leadership of Sun Microsystems, Santa Cruz, CA).
- \*11/11/07 “Modeling Data in Formal Verification: Bits, Bit Vectors, or Words,” Tutorial at Formal Methods in Computer-Aided Design, Austin, TX.
- \*6/13/07 “Data-Intensive Super Computing: Taking Google-Style Computing Beyond Web Search,” Special session at Federated Computing Research Conference, San Diego, CA.
- \*8/16/06 “A View from the Engine Room: Computational Support for Symbolic Model Checking,” Workshop on 25 Years of Model Checking, Seattle, WA.
- \*8/12/06 “Formal Verification of Infinite State Systems using Boolean Methods,” Plenary talk, Federated Logic Conference, Seattle, WA.
- \*7/26/05 “Decision Procedures Customized for Formal Verification,” Conference on Automated Deduction (CADE), Tallinn, Estonia
- 11/9/04 “Symbolic, Word-Level Hardware Verification,” Embedded tutorial, ICCAD '04, San Jose, CA.
- \*6/23/04 “System Modeling and Verification with UCLID,” Keynote talk, Formal Methods and Models for Co-Design, San Diego, CA.
- \*12/15/03 “Reasoning about Infinite-State Systems Using Boolean Methods,” Keynote talk, Foundations of Software Technology and Theoretical Computer Science, Mumbai, India.
- 12/14/03 “SAT-Based Decision Procedures for Subsets of First-Order Logic,” Workshop on Model Checking, Mumbai, India.

- \*11/2/02 “Symbolic Simulation and its Connection to Formal Verification,” Formal Methods in Computer-Aided Design, Portland, Oregon
- \*6/3/02 “Introducing Computer Systems from a Programmer’s Perspective,” David C. Evans Conference on Computer Engineering, Utah
- \*5/00 “Binary Decision Diagrams and Symbolic Model Checking,” Symposium on Algorithms in the Real World, Pittsburgh, PA
- 7/10/99 “Exploiting Positive Equality in a Logic of Equality With Uninterpreted Functions,” Computer-Aided Verification, CAV ’99, Trento Italy.
- 7/9/99 “Optimizing Symbolic Model Checking for Constraint-Rich Models,” Computer-Aided Verification, CAV ’99, Trento Italy.
- \*6/8/99 “Microprocessor Verification Using Uninterpreted Functions,” Tableaux ’99, Saratoga Springs, NY.
- \*4/2/98 “Formal Verification of Pipelined Processors,” European Joint Conferences on Theoretical and Practical Aspects of Software, Lisbon, Portugal.
- \*12/11/97 “Formal Verification of Pipelined Processors,” Third Asian Computing Science Conference, Kathmandu, Nepal.
- 6/24/97 “Exploiting Symmetry When Verifying Transistor Circuits by Symbolic Trajectory Evaluation,” Computer-Aided Verification, CAV ’97, Haifa Israel.
- 6/6/96 “Bit-Level Analysis of an SRT Divider Circuit,” 32nd Design Automation Conference, Las Vegas CA.
- 3/25/96 “BDDs and Beyond: Enabling Technologies for Formal Verification,” DIMACS Workshop on Formal Verification.
- 3/11/96 “BDDs Applied to SAT and Related Problems,” DIMACS Workshop on Satisfiability, Rutgers University.
- 11/6/95 “BDDs and Beyond: Enabling Technologies for Formal Verification,” Embedded tutorial, ICCAD ’95, San Jose, CA.
- \*7/3/95 “Multipliers and Dividers: Insights on Arithmetic Circuit Verification,” Computer-Aided Verification, CAV ’95, Liege, Belgium.
- 2/17/95 “Formal Verification of Arithmetic Circuits with Binary Moment Diagrams,” Computer Systems Seminar, Dagstuhl Seminar on Computer-Aided Design, Dagstuhl, Germany.
- \*5/25/94 “Digital Circuit Verification using Partially-Ordered State Models,” 24th International Symposium on Multiple-Valued Logic, Boston, MA.
- \*11/29/93 “Symbolic Analysis Methods for Masks, Circuits, and Systems,” GMD 25th Anniversary Symposium, Bonn, Germany.
- 11/4/93 “Beyond Digital CAD: New Applications for Binary Decision Diagrams,” ARPA Microsystem Contractors Meeting, Seattle, WA.
- \*10/4/93 “Symbolic Analysis Methods for Masks, Circuits, and Systems,” CAD Plenary Session, International Conference on Computer Design, Cambridge, MA.
- 5/93 “Geometric Characterization of Series-Parallel Variable Resistor Networks,” International Symposium on Circuits and Systems, Chicago, IL.
- \*3/26/92 “Privileged but Illiterate, Report on a Year in Japan,” MIT/Brown Conference on Advanced Research in VLSI and Parallel Systems, Providence, RI.
- 11/14/91 “Privileged but Illiterate, Report on a Year in Japan,” DARPA VLSI Contractors Meeting, Pasadena, CA.

- 11/12/91 “Extraction of Gate Level Models from Transistor Circuits by 4-Valued Symbolic Analysis.” International Conference on Computer-Aided Design, Santa Clara, CA.
- \*6/19/91 “Formal Verification, a Slow, but Certain Evolution,” Panel on Formal Methods, 28th Design Automation Conference.
- 2/4/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Second Makuhari Conference on High Technology, Chiba, Japan.
- \*10/24/90 “Formal Hardware Verification by Symbolic Simulation,” 1990 Synthesis and Simulation Meeting and International Interchange, Kyoto, Japan.
- \*8/31/90 “Symbolic Simulation—Techniques and Applications,” Japanese Design Automation Workshop, Gamagouri, Japan.
- 6/27/90 “Symbolic Simulation—Techniques and Applications,” 27th Design Automation Conference.
- \*11/15/89 “Symbolic Analysis and Verification of MOS Circuits,” IFIP Workshop on Applied Formal Methods for Correct VLSI Design, Hengelhof, Belgium.
- \*7/5/89 “Verification of Synchronous Circuits by Symbolic Logic Simulation,” Workshop on Hardware Specification, Verification, and Synthesis, Cornell University.
- 6/27/89 “Test Pattern Generation for Sequential MOS Circuits by Symbolic Fault Simulation,” 26th Design Automation Conference.
- \*5/8/89 “Physical/Functional Tool Integration,” panel discussion at 1989 Synthesis and Simulation Meeting and International Interchange, Osaka, Japan.
- 4/3/89 “Test Pattern Generation for Combinational and Sequential MOS Circuits by Symbolic Fault Simulation,” DARPA VLSI Contractor’s Meeting, Snowbird, UT.
- 11/9/88 “Data Parallel Switch-Level Simulation,” International Conference on Computer-Aided Design.
- 6/15/88 “CAD Tool Needs for System Designers,” Panel Session Chairman, 25th Design Automation Conference.
- 3/30/88 “Verifying a Static RAM Design by Logic Simulation,” Fifth MIT Conference on Advanced Research in VLSI.
- 2/1/88 “Verifying a Static RAM Design by Logic Simulation,” IEEE VLSI Workshop, Clearwater Beach, FL.
- 11/16/87 “COSMOS Makes its Debut,” DARPA VLSI Contractors Meeting, Berkeley, CA.
- \*9/15/87 “Transistor-Level Logic Simulation,” Semiconductor Research Conference Topical Research Conference on Design Verification, Pittsburgh, PA.
- 6/29/87 “COSMOS: A Compiled Simulator for MOS Circuits,” 24th Design Automation Conference, Miami Beach, FL.
- \*5/26/87 “Symbolic Analysis of MOS Circuits,” U.S./Israel Joint Workshop on VLSI Architecture and Design, Tiberias, Israel.
- 2/24/87 “COSMOS: A Compiled Simulator for MOS Circuits,” IEEE VLSI Workshop, Clearwater Beach, FL.
- \*10/28/86 “Compiled Simulation of MOS Circuits,” Canadian Conference on VLSI, Montreal.
- 10/1/85 “Formal Verification of Digital Circuits by Logic Simulation,” DARPA VLSI Contractors Meeting, Seattle, WA.
- \*7/2/85 “Can a Simulator Verify a Circuit?,” Workshop on Formal Aspects of VLSI, Edinburgh University, Scotland.

- 6/27/85 "Performance Evaluation of FMOSSIM: a Concurrent, Switch-Level Fault Simulator," 22nd Design Automation Conference, Las Vegas, Nevada.
- 6/27/85 "Symbolic Manipulation of Boolean Functions Using a Graphical Representation," 22nd Design Automation Conference, Las Vegas, Nevada.
- 5/17/85 "Symbolic Verification of MOS Circuits," 1985 Chapel Hill Conference on VLSI, Chapel Hill, North Carolina.
- 4/24/85 "Test Generation for MOS Circuits by Symbolic Fault Simulation," IEEE Workshop on Design for Testability, Beaver Creek, Colorado.
- 3/18/85 "Symbolic Verification of MOS Circuits," DARPA VLSI Contractors Meeting, Salt Lake City, UT.
- \*10/84 "Simulators (Will Always) Provide Superior Models," Panel on Testability Measures, 1984 International Test Conference, Philadelphia, Pennsylvania.
- \*4/84 "Experiments with a Switch-Level Fault Simulator," IEEE Workshop on Design for Testability, Vail, Colorado.
- \*11/28/83 "Switch-Level Models for MOS Digital Systems," Mathematical Methods of VLSI, Mathematisches Forschungsinstitut, Oberwolfach, Germany.
- 8/16/83 "Race Detection in MOS Circuits by Ternary Simulation," VLSI 83, Trondheim, Norway.
- \*6/28/83 "The Role of Simulation in VLSI Design," VLSI for the 80's, Victoria B. C., Canada.
- \*4/25/83 "Switch-Level Fault Simulation," IEEE West Coast Test Workshop, Napa, Calif.
- \*5/10/82 "Switch-Level Modeling of MOS Digital Circuits," IEEE International Symposium on Circuits and Systems, Rome, Italy.
- 8/21/81 "A Switch-Level Model of MOS Logic Circuits," VLSI 81, Edinburgh, Scotland.
- 7/1/81 "MOSSIM: A Logic Simulator for MOS LSI," 18th Design Automation Conference, Nashville, Tennessee.
- 10/5/79 "Simulation on a Distributed System," First International Conference on Distributed Systems, Huntsville, Ala.
- 7/78 "Analytical Models of Interconnection Networks," Workshop on Data Flow Computer and Program Organization, Dedham, MA.

### **Seminars and Colloquia**

- 1/6/09 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," National University of Singapore, Singapore.
- 1/5/09 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," Nanyang Technical University, Singapore.
- 11/14/08 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," University of Kentucky, Computer Science Department Distinguished Lecture.
- 10/20/08 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," RAND Corporation, Washington DC.
- 10/20/08 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," National Science Foundation, CISE Distinguished Lecture.
- 10/14/08 "Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search," Oxford University Strachey Distinguished Lecture, Oxford, England.

- 10/03/08 “Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search,” University of Michigan, Computer Science and Engineering Seminar.
- 05/05/08 “Data-Intensive Scalable Computing: Taking Google-Style Computing Beyond Web Search,” Carnegie Mellon University Qatar Campus.
- 3/21/08 “Data-Intensive Super Computing: Taking Google-Style Computing Beyond Web Search,” Barr Systems Lecture Series, University of Florida.
- 3/10/08 “Data-Intensive Super Computing: Taking Google-Style Computing Beyond Web Search,” IT Eminent Lecture Series, Louisiana State University.
- 11/14/07 “Data-Intensive Super Computing: Taking Google-Style Computing Beyond Web Search,” Kent State University, Kent, OH.
- 1/12/07 “Bit-Vector Decision Procedures: A Basis for Reasoning about Hardware and Software,” Microsoft Research, Redmond, WA.
- 1/3/07 “Automated Formal Verification of Software: Status and Prospects,” Department of Computer Science, National University of Singapore.
- 5/26/06 “Computer Systems: A Programmer’s Perspective,” Southeast University, Nanjing, China.
- 2/8/06 “Verifying Infinite-State Systems Using Boolean Methods,” MIT CSAIL Michael Derouzos Distinguished Lecture, MIT.
- 7/12–14/05 Seminars at Intel in Haifa, Israel:
- “SAT-Based Decision Procedures for Linear Arithmetic and Uninterpreted Functions”
  - “System Modeling and Verification with UCLID”
  - “Symbolic Approaches to Invariant Checking and Automatic Predicate Abstraction”
- 6/7/05 “Binary Decision Diagrams and Their Applications,” Information and Communications University, Daejeon, Korea.
- 9/5/04 “Binary Decision Diagrams and Their Applications,” Kuwait University Department of Math and Computer Science.
- 9/3/04 “SAT-Based Decision Procedures for Subsets of First-Order Logic,” Kuwait University Department of Math and Computer Science.
- 8/19/04 “Reasoning about Infinite-State Systems Using Boolean Methods,” Distinguished Lecture, Cadence Corporation, San Jose, CA.
- 4/26/04 “Verifying Infinite-State Systems Using Boolean Methods,” Harvard University.
- 4/14/04 “Verifying Infinite-State Systems Using Boolean Methods,” Distinguished Lecture, Southern Methodist University.
- 10/23/03 “Verifying Infinite-State Systems Using Boolean Methods,” Distinguished Lecture, University of Pennsylvania Computer Science Department.
- 7/14/03 “Verifying Infinite-State Models Using Boolean Methods,” Synopsys, Inc., Hillsboro, OR.
- 4/21/03 “Formal Verification Using Infinite-State Models,” Fujitsu Laboratories, Kawasaki, Japan.
- 3/6/03 “Formal Verification Using Infinite-State Models,” Distinguished Lecture, UCLA Computer Science Department.
- 11/14/02 “Introducing Computer Systems from a Programmer’s Perspective,” Distinguished Lecture, School of Computing, Georgia Institute of Technology, Atlanta, Georgia.

- 7/13/99 “Optimizing Symbolic Model Checking for Constraint-Rich Models,” IBM Haifa Research Laboratory, Haifa, Israel.
- 7/12/99 “Processor Verification Using Efficient Reductions of the Logic of Uninterpreted Functions to Propositional Logic,” Intel Logic Verification Symposium, Haifa, Israel.
- 6/26/98 “Bit-Level Verification of Pipelined Processors,” Intel Corp., Hillsboro, OR.
- 3/26/97 “Hierarchical Verification Based on Symbolic Trajectory Evaluation” Lucent Technologies Bell Laboratories, Murray Hill, NJ
- 12/6/96 “Hierarchical Verification based on Symbolic Trajectory Evaluation” Intel Corp., Hillsboro, OR.
- 10/24/96 “Multipliers and Dividers, Insights on Arithmetic Circuit Verification,” Distinguished Lecture, Department of Computer Science, University of Washington.
- 4/12/96 “Formal Verification of Sequential Processors”, Intel Frontiers in CAD Symposium, Hillsboro, OR.
- 2/22/96 “Multipliers and Dividers, Insights on Arithmetic Circuit Verification,” Distinguished Lecture, Department of Computer Science, University of Utah.
- 12/4/95 “Division Pentium Style: An Analysis of Intel’s Mistake(s),” Distinguished Speaker Series, Cadence Design Systems, Chelmsford, MA.
- 11/8/95 “Multipliers and Dividers, Insights on Arithmetic Circuit Verification,” SRI International, Menlo Park, CA.
- 10/11/95 “Multipliers and Dividers, Insights on Arithmetic Circuit Verification,” EECS CAD Seminar, U. C. Berkeley.
- 7/17/95 “Multipliers and Dividers, Insights on Arithmetic Circuit Verification,” EECS Dept., University of Michigan.
- 4/21/95 “Formal Verification of Arithmetic Circuits with Binary Moment Diagrams,” Distinguished Lecture, University of Southern California.
- 2/22/95 “Division Pentium Style: An Analysis of Intel’s Mistake(s),” Computer Systems Seminar, Carnegie Mellon University Computer Science Department.
- 10/21/94 “Formal Verification of Arithmetic Circuits with Binary Moment Diagrams,” Computer Systems Seminar, Carnegie Mellon University Computer Science Department.
- 10/5/94 “Formal Verification of Arithmetic Circuits with Binary Moment Diagrams,” Distinguished Lecture, University of Texas Computer Science Department.
- 10/3/94 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Distinguished Lecture, University of Texas Computer Science Department.
- 12/1/93 “Symbolic Analysis Methods for Masks, Circuits, and Systems,” University of Trier, Trier, Germany.
- 5/93 “A Methodology for Formal Hardware Verification, with Application to a Real Microprocessor,” University of Grenoble, Grenoble, France.
- 5/93 “A Methodology for Formal Hardware Verification, with Application to a Real Microprocessor,” Digital Equipment Corp., Paris Research Laboratory, Paris, France.
- 10/30/92 “Formal Hardware Verification by Symbolic Trajectory Evaluation,” Motorola Corp., Austin, TX.
- 10/29/92 “Formal Hardware Verification by Symbolic Trajectory Evaluation,” IBM Corp., Austin, TX.
- 7/14/92 “Formal Hardware Verification by Symbolic Trajectory Evaluation,” Intel Corp., Hills-

- boro, OR.
- 3/3/92 “Formal Hardware Verification and Logic Abstraction,” Digital Equipment Corporation, Hudson, MA.
- 3/2/92 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Harvard University.
- 5/23/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Fujitsu International Institute for Advanced Study of Social Information Science, Numazu, Japan.
- 5/22/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Tokyo Institute of Technology, Tokyo, Japan.
- 5/20/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Kyushu Institute of Technology, Iizuka, Japan.
- 5/13/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Fujitsu Laboratories, Kawasaki, Japan.
- 5/9/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Dept. of Information Science, Kyoto University, Kyoto, Japan.
- 3/15/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Nippon Electric Corporation, Kawasaki, Japan.
- 3/15/91 “The COSMOS Project: Switch-Level Modeling and Simulation,” Nippon Electric Corporation, Kawasaki, Japan.
- 3/1/91 “Symbolic Boolean Manipulation with Ordered Binary Decision Diagrams,” Electrotechnical Laboratory, Tsukuba, Japan.
- 6/8/90 “Formal Verification of MOS Circuits by Symbolic Simulation,” Siemens AG, Munich, Germany.
- 6/5/90 “Formal Verification of MOS Circuits by Symbolic Simulation,” Bull Research Center, Paris, France.
- 10/23/89 “The COSMOS Project: Switch-Level Modeling and Simulation,” Gateway Design Automation Corp., Lowell, MA.
- 6/7/89 “Test Pattern Generation for Sequential MOS Circuits by Symbolic Fault Simulation,” Hewlett Packard, Palo Alto, CA.
- 6/2/89 “Test Pattern Generation for Sequential MOS Circuits by Symbolic Fault Simulation,” General Electric, Schenectady, NY.
- 5/11/89 “COSMOS: A COMpiled Simulator for MOS Circuits,” Fujitsu Laboratories, Kawasaki, Japan.
- 5/10/89 “Switch-Level Simulation,” Matsushita Electric Industrial Co., Osaka Japan.
- 1/20/89 “Graph-Based Algorithms for Boolean Function Manipulation,” University of Colorado.
- 11/7/88 “Test Pattern Generation for Sequential MOS Circuits by Symbolic Fault Simulation,” CAD Seminar, University of California, Berkeley.
- 11/3/88 “Test Pattern Generation for Sequential MOS Circuits by Symbolic Fault Simulation,” CMU Center or Dependable Systems Seminar.
- 10/20/88 “COSMOS: A COMpiled Simulator for MOS Circuits,” Syracuse University.
- 7/18/88 “Graph-Based Algorithms for Boolean Function Manipulation,” IBM Watson Research Center, Yorktown Hts., NY.
- 6/9/88 “COSMOS: A COMpiled Simulator for MOS Circuits,” Digital Equip. Corp., Hudson, MA.

- 4/22/88 "COSMOS: A COMpiled Simulator for MOS Circuits," University of Illinois, Coordinated Sciences Laboratory.
- 4/13/88 "COSMOS: A COMpiled Simulator for MOS Circuits," University of Waterloo, Ontario.
- 3/8/88 "COSMOS: A COMpiled Simulator for MOS Circuits," MIT VLSI Seminar.
- 11/18/87 "COSMOS: A COMpiled Simulator for MOS Circuits," Xerox Palo Alto Research Center.
- 11/17/87 "COSMOS: A COMpiled Simulator for MOS Circuits," CAD Seminar, University of California, Berkeley.
- 5/13/87 "COSMOS: A COMpiled Simulator for MOS Circuits," Dept. Elec. Eng., Texas A&M Univ.
- 4/10/87 "COSMOS: A COMpiled Simulator for MOS Circuits," VLSI Seminar, IBM Watson Research Center, Yorktown Hts., NY.
- 1/30/87 "COSMOS: A COMpiled Simulator for MOS Circuits," Computer Systems Seminar, Carnegie Mellon University.
- 12/18/86 "COSMOS: A COMpiled Simulator for MOS Circuits," Dept. Comp. Sci., Univ. of Washington.
- 12/18/86 "Fault Simulation of MOS Circuits," Dept. Comp. Sci., Univ. of Washington.
- 12/1/86 "COSMOS: A COMpiled Simulator for MOS Circuits," AT&T Bell Laboratories, Murray Hill, NJ.
- 10/29/86 "Formal Verification of Digital Circuits by Logic Simulation," Dept. Elec. Engineering, McGill University, Montreal, Canada.
- 10/21/86 "COSMOS: A COMpiled Simulator for MOS Circuits," Design Automation Seminar, CMU Dept. Electrical and Computer Engineering.
- 3/4/86 "Symbolic Verification of MOS Circuits," Computer Science Seminar, Caltech.
- 1/28/86 "Formal Verification of Digital Circuits by Logic Simulation," Computer Science Seminar, Univ. of Utah.
- 11/6/85 "Formal Verification of Digital Circuits by Logic Simulation," Computer Science Seminar, Univ. of Waterloo, Ontario.
- 10/22/85 "Symbolic Verification of MOS Circuits," VLSI Seminar, MIT Dept. of EECS.
- 10/4/85 "Symbolic Verification of MOS Circuits," Stanford Dept. of Elec. Eng.
- 10/3/85 "Symbolic Verification of MOS Circuits," Schlumberger Research, Palo Alto, CA.
- 6/12/85 "Symbolic Methods for MOS Circuits," Texas Instruments, Dallas, TX.
- 4/23/85 "Symbolic Verification of MOS Circuits," ECE Dept. Univ. of Colorado.
- 11/30/84 "Graph-Based Algorithms for Boolean Function Manipulation," AT&T Bell Laboratories, Murray Hill, N.J.
- 11/29/84 "A Switch-Level Model of MOS Circuits," AT&T Bell Laboratories, Murray Hill, N.J.
- 6/84 "The MOSSIM Simulation Engine," Dept. Comp. Sci., Univ. of Washington.
- 6/84 "Experiments with a Switch-Level Fault Simulator," Boeing Corp., Seattle, WA.
- 6/84 "The MOSSIM Simulation Engine," Tektronix, Inc., Portland, OR.
- 6/84 "The MOSSIM Simulation Engine," Intel Corp., Santa Clara, CA.
- 12/6/83 "Concurrent Fault Simulation of MOS Digital Circuits," Universität des Saalandes, Saarbrücken, Germany.
- 11/3/83 "Switch-Level Simulation," Texas Instruments, Dallas, TX.

- 6/26/83 "Switch-Level Simulation," Intel Corp., Santa Clara, CA.
- 5/7/83 "Introduction to VLSI," California Polytechnical Institute, Pomona, CA.
- 10/20/82 "Architectures for VLSI," Fairchild Research Laboratories, Palo Alto, CA.
- 10/19/82 "Switch-Level Simulation and the Verification of MOS Digital Circuits," UCLA Computer Science Seminar, Los Angeles, CA.
- 9/21/82 "Switch-Level Simulation and the Verification of MOS Digital Circuits," VLSI Seminar, MIT Dept. of EECS.
- 9/20/82 "Switch-Level Simulation and the Verification of MOS Digital Circuits," Digital Equip. Corp., Hudson, MA.
- 4/26/82 "A Switch-Level Model of MOS Circuits," IBM Watson Research Center, Yorktown Hts., NY.
- 2/16/82 "A Switch-Level Model of MOS Circuits," Oregon Graduate Center, Hillsboro, OR.
- 4/14/80 "MOSSIM: A Logic Simulator for MOS LSI," IBM Watson Research Center, Yorktown Hts., NY.

## **Outreach**

- 11/06/09 "Computers and Robots," KIPP LA Prep middle school, Los Angeles, CA.
- 11/05/09 "Computers and Robots," Locke High School, Los Angeles, CA.
- 07/08/09 "Data-Intensive Scalable Computing," Andrew's Leap Program, Pittsburgh, PA.
- 07/11/08 "Data-Intensive Scalable Computing," Andrew's Leap Program, Pittsburgh, PA.

## **Students**

### **Ph.D. Advisees**

- 2005 Sanjit Seshia, CMU CS. Now on the faculty at U. C., Berkeley.
- 2004 Miroslav Velez, CMU ECE. Now independent consultant.
- 2004 Shuvendu, Lahiri, CMU ECE. Now at Microsoft Research.
- 2004 Amit Goel, CMU ECE. Intel Corporation.
- 2003 Rune Jensen, CMU CS (jointly advised by Manuela Veloso). Now at IT University of Copenhagen.
- 2001 Clayton McDonald. Now at Synopsys, Inc.
- 1999 Kyle Nelson, CMU ECE, now at Bethel College, Minnesota.
- 1997 Alok Jain, CMU ECE. Now at Cadence Design Systems.
- 1998 Yirng-An Chen, CMU CS. Now at Synopsys, Inc.
- 1997 Manish Pandey, CMU CS. Now at Cadence Design Systems.
- 1993 Derek Beatty, CMU CS. Now at Sun Microsystems.
- 1992 Karl Brace, CMU ECE. Now at Intel Corporation.
- 1992 Tom Sheffler, CMU ECE. Now at Rambus, Inc.
- 1991 Larry Huang, CMU ECE.
- 1989 Saul Kravitz, CMU ECE (jointly advised by Rob Rutenbar). Now at Celera Genomics.
- 1988 Kyeongsoon Cho, CMU ECE. Now on the faculty at Hankuk University of Foreign Studies, Korea.

## MS Advisees

- 1998 Vishnu Patankar, CMU ECE. Now at Microsoft.
- 1994 Samir Jain, CMU ECE. Now at Fluke, Portland, OR.
- 1984 Michael Schuster, Caltech CS. Now at Adobe Systems.
- 1984 Wen-Chi Chen, Caltech CS. Now President of VIA Technologies, Inc., Taiwan.
- 1984 Yen-Jen Oyang, Caltech CS. Now a professor at National Taiwan University.
- 1983 Jimmy Lam, Caltech CS.

## Thesis Committees

- 2008 David Brumley, CMU CS Ph.D.
- 2007 Pankaj Chauhan, CMU CS Ph.D.
- 2006 Murali Talupur, CMU CS Ph.D.
- 2006 Anubhav Gupta, CMU CS Ph.D.
- 2006 Alberto Oliveras, Technical University of Catalonia, Barcelona Spain, CS Ph.D.
- 2006 Zhong Xiu, CMU ECE Ph.D.
- 2005 Sagar Chaki, CMU CS Ph.D.
- 2004 Hui Xu, CMU ECE Ph.D.
- 2003 Noppant Utamaphethai, CMU ECE Ph.D.
- 2003 Dong Wang, CMU ECE Ph.D.
- 2003 Chris Wilson, Stanford University, CS Ph.D.
- 2001 Sergei Berezin, CMU CS Ph.D.
- 2001 Marius Minea, CMU CS Ph.D.
- 2000 Yuan Lu, CMU ECE Ph.D.
- 2000 Rony Kay, CMU ECE Ph.D.
- 1999 Bwolen Yang, CMU CS Ph.D.
- 1998 Margaret Reid-Miller, CMU CS Ph.D.
- 1997 Mukund Sivaraman, CMU ECE Ph.D.
- 1997 Derek Noonburg, CMU ECE Ph.D.
- 1997 Denis Zampuniéris, Universitaires Notre-Dame de la Paix, Namur, Belgium, CS Ph.D.
- 1996 Xudong Zhao, CMU CS Ph.D.
- 1994 Samir Naik, CMU ECE Ph.D.
- 1994 Aarti Gupta, CMU CS Ph.D.
- 1993 Ken McMillan, CMU CS Ph.D.
- 1993 Jean-Christophe Madre, Habilitation, Université Joseph Fourier, Grenoble, France.
- 1993 David Long, CMU CS Ph.D.
- 1991 Tom Storey, CMU ECE Ph.D.
- 1991 John Willis, CMU ECE Ph.D.
- 1991 Jerry Burch, CMU CS Ph.D.
- 1991 Erik Brunvand, CMU CS Ph.D.
- 1990 Phil Nigh, CMU ECE Ph.D.
- 1990 Jean-Christophe Madre, Ph.D., Ecole Nationale Supérieure de Télécommunication, Paris, France.

- 1989 Larry Pillage, CMU ECE Ph.D.
- 1989 David Geiger, CMU ECE Ph.D.
- 1989 David Dill, CMU CS Ph.D.
- 1987 Carl Seger, Univ. Waterloo, Canada, CS Ph.D.
- 1986 William Dally, Caltech CS Ph.D.
- 1985 Ed Frank, CMU CS Ph.D.
- 1984 Tzu-Mu Lin, Caltech CS Ph.D.
- 1983 Erik P. DeBenedictis, Caltech CS Ph.D.
- 1982 Charles Lang, Caltech CS Ph.D.

## **Community Service**

- 2001–present Board of Directors, Steel City Rowing Club, Pittsburgh, PA. Board president 2005–present.
- 1998–2000, 2003–2006 Board of Session, Bellefield Presbyterian Church, Pittsburgh, PA.
- 1986–1990 Board of Trustees, Bellefield Presbyterian Church, Pittsburgh, PA.