

Curriculum Vitae¹

Rajeev Alur

Address

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Personal Information

Date of birth: March 5, 1966.
Citizen of the United States.
Married with two children.

Research Interests

Formal methods: computer-aided verification, software analysis, and system synthesis;
Cyber-physical systems: embedded controllers, real-time systems, and hybrid systems;
Theoretical computer science: automata, logics, concurrency, and models of computation.

Education

Ph.D. in Computer Science (August 1991)
Stanford University, Stanford.
Thesis: *Techniques for automatic verification of real-time systems*
Advisors: Professor David Dill and Professor Zohar Manna.

Bachelor of Technology in Computer Science (May 1987)
Indian Institute of Technology, Kanpur, India.

Employment

- July 2003 onwards: Zisman Family Professor of Computer and Information Science, University of Pennsylvania.
- July 2001 onwards: Professor, Department of Computer and Information Science, University of Pennsylvania.
- July 1999–June 2001: Associate Professor with tenure, Department of Computer and Information Science, University of Pennsylvania.
- July 1997–June 1999: Associate Professor without tenure, Department of Computer and Information Science, University of Pennsylvania.
- September 1991–June 1997: Member of Technical Staff, Computing Sciences Research Center, Bell Laboratories, Murray Hill.

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Visiting Positions

- February – April 2018: Visiting Scientist, Simons Institute for Theoretical Computer Science, University of California at Berkeley.
- July 2006 – May 2009: Consulting Scientist, NEC Labs America, Princeton, NJ.
- July 1997–August 2001: Part-time Member of Technical Staff, Computing Sciences Research Center, Bell Laboratories, Murray Hill.
- August 1996 - June 1997: Visiting Faculty, Department of Electrical Engineering and Computer Science, University of California, Berkeley.
- January - May 1995: Visiting Faculty, Department of Computer Science, Columbia University, New York.
- June - September 1990: Summer Intern, IBM Almaden Research Center, San Jose.
- March - May 1989: Visiting Researcher, Department of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel.
- May - July 1986, and May - August 1987: Software Development Engineer, Kale Consultants, Pune, India.

Honors

- Best paper award, *17th ACM-IEEE International Conference on Formal Methods and Models for System Design (MEMOCODE)*, 2019 (with L. Nguyen, G. Mohan, J. Weimer, O. Sokolsky, and I. Lee).
- Distinguished Alumnus Award, Indian Institute of Technology, Kanpur, 2017.
- Fellow of the American Association for Advancement of Science, 2016.
- ACM SIGLOG / EATCS / EACSL / Kurt Gödel Society Alonzo Church Award for outstanding contributions to logic and computation, 2016 (with David Dill).
- Simons Investigator, Simons Foundation, 2013.
- Best Paper Award, *15th International Conference on Hybrid Systems: Computation and Control (HSCC)*, CPSWeek 2012 (with A. Trivedi and D. Wojtczak).
- The George H. Heilmeier Faculty Award for Excellence in Research, School of Engineering and Applied Science, University of Pennsylvania, 2010.
- LICS (IEEE Symposium on Logic in Computer Science) Test-of-Time award for LICS 1990 paper “Model checking for real-time systems,” 2010 (with David Dill and Costas Courcoubetis).
- The inaugural CAV (Computer Aided Verification) Award for *fundamental contributions to the theory of real-time systems verification*, 2008 (with David Dill).
- Best Paper Award, *8th ACM Conference on Embedded Software (EMSOFT)*, ESWeek 2008 (with Aditya Kanade, S. Ramesh, and K.C. Shashidhar)
- Fellow of the IEEE, 2008.
- Fellow of the ACM, 2007.
- ACM Distinguished Lecturer, 2006-08.

- Endowed Professorship: Zisman Family Professor of Computer and Information Science, University of Pennsylvania, 2003.
- Highly cited researcher, Institute for Scientific Information (Thomson-ISI), January 2005.
- National Science Foundation Information Technology Research Award, 2001.
- Alfred P. Sloan Faculty Fellowship, 1999–2001.
- National Science Foundation Faculty Early Career Development Award, 1998.
- President of India Gold Medal for Academic Excellence, Indian Institute of Technology, Kanpur, 1987.

Teaching

- Automata, Computability, and Complexity (CIS 262, undergraduate). University of Pennsylvania, Fall 2008, Fall 2009, Fall 2010, Fall 2011, Fall 2013, Fall 2015, Fall 2018, and Fall 2019.
- Principles of Embedded Computation (CIS 540, graduate). University of Pennsylvania, Fall 2009, Spring 2011, Spring 2012, Spring 2013, Spring 2014, Spring 2015, Spring 2016, Spring 2017, and Spring 2019.
- Theory of Computation (CIS 511, graduate). University of Pennsylvania, Spring 2005, Spring 2006, Spring 2007, and Spring 2008.
- Logic in Computer Science (CSE 482, undergraduate). University of Pennsylvania, Fall 2004 and Fall 2005.
- Operating Systems (CSE 380, undergraduate). University of Pennsylvania, Fall 2001 and Fall 2002.
- Operating Systems Lab (CSE 381, undergraduate). University of Pennsylvania, Fall 2001.
- Data Structures and Algorithms (CSE 220, undergraduate). University of Pennsylvania, Spring 1998, Spring 1999, and Spring 2000.
- Multi-processor Programming (CIS 640, graduate). University of Pennsylvania, Spring 2009.
- Computer-Aided Verification (CIS 673, graduate). University of Pennsylvania, Fall 1997, Fall 1999, Spring 2003, Fall 2006, Fall 2012, Fall 2014, Fall 2016, and Spring 2020, and Columbia University, Spring 1995.
- Program Analysis (CIS 670, graduate). University of Pennsylvania, Fall 2007.
- Hybrid Systems (CIS 640/EE 601, graduate). University of Pennsylvania, Fall 2000.
- Embedded Software (CIS 640, graduate). University of Pennsylvania, Fall 1998 and Spring 2002.

Research Group

Postdoctoral researchers

1. Thao Dang (January 2001–December 2001, now at CNRS, France)
2. Jyotirmoy Deshmukh (August 2010–April 2012, Computing Innovations Fellow, now on CS faculty at University of Southern California)
3. Dana Fisman (October 2013–July 2016, now on CS faculty at Ben Gurion University, Israel)

4. Radu Grosu (October 1998–August 2000, now on CE faculty at TU Vienna)
5. Radoslav Ivanov (August 2018–, co-supervised with George Pappas)
6. Aditya Kanade (June 2007–June 2009, now on CS faculty at Indian Institute of Science, Bangalore, India)
7. Konstantinos Mamouras (September 2015–June 2018, now on CS faculty at Rice University)
8. Supratik Mukhopadhyay (June 2001–July 2002, now on CS faculty at Louisiana State University)
9. Luan Viet Nguyen (June 2018–September 2019, now a postdoctoral researcher at University of Notre Dame)
10. Filip Niksic (October 2018–)
11. George Pappas (August 1999–February 2000, now on ESE faculty at University of Pennsylvania)
12. Madhusudan Parthasarathy (January 2002–November 2004, now on CS faculty at University of Illinois at Urbana-Champaign)
13. Arjun Radhakrishna (October 2014–June 2017, now at Microsoft)
14. Christos Stergiou (October 2013 – June 2015, co-supervised with Stavros Tripakis, now at Google)
15. Ashutosh Trivedi (January 2011–December 2012, now on CS faculty at University of Colorado, Boulder)
16. Gera Weiss (July 2006–June 2009, now on CS faculty at Ben Gurion University, Israel)

PhD students

1. Mikhail Bernadsky (PhD Spring 2008, first employment: Microsoft)
2. Sebastian Burckhardt (PhD Summer 2007, co-supervised with Milo Martin, now at Microsoft Research)
3. Pavol Černý (PhD Summer 2009, now on CS faculty at TU Vienna, Austria)
4. Swarat Chaudhury (PhD Summer 2007, Winner of the Rubinoff Award for the best PhD Thesis, Winner of the 2007 ACM SIGPLAN John C. Reynolds Doctoral Dissertation Award, now on CS faculty at University of Texas, Austin)
5. Loris D’Antoni (PhD Summer 2015, Winner of the Rubinoff Award for the best PhD Thesis, now on CS faculty at University of Wisconsin, Madison)
6. Franjo Ivancic (PhD Fall 2003, Winner of the Rubinoff Award for the best PhD Thesis, now at Google)
7. Kishor Jothimurugan (Since Fall 2017)
8. Konstantinos Kallas (Since Fall 2018)
9. Salvatore La Torre (PhD Fall 2001, now on CS faculty at University of Salerno, Italy)
10. Sela Mador-Haim (ABD, PhD student till Fall 2013, co-supervised with Milo Martin, first employment: Coverity)
11. Michael McDougall (PhD Spring 2005, co-supervised with Carl Gunter, now at Amazon)

12. Salar Moarref (PhD Summer 2016, co-supervised with Ufuk Topcu, now at Uber)
13. Wonhong Nam (PhD Spring 2007, now on faculty at Konkuk University, Korea)
14. Mukund Raghothaman (PhD Fall 2016, now on CS faculty at University of Southern California)
15. Nimit Singhania (PhD Summer 2018, co-supervised with Joe Deviette, now at Google)
16. Caleb Stanford (Since Fall 2016)
17. Aalok Thakkar (Since Fall 2018)
18. Abhishek Udupa (PhD Spring 2016, now at Microsoft)
19. Bow-Yaw Wang (PhD Summer 2001, now at Academia Sinica, Taiwan)
20. Zijiang Yang (PhD Fall 2003, now on CS faculty at Western Michigan University)
21. Yifei Yuan (PhD Summer 2016, co-supervised with Boon Thau Loo, now at Intentionet).

MS students

Himyanshu Anand (MS 2000)
 Arnabnil Bhattacharjee (MS, 1999)
 Arun Chandrasekharapuram (MS, 2005)
 Gunjan Gupta (MS, 2004)
 Minsu Kang (MS 2001)
 Jason Simas (MS 2004)

Departmental and University activities

- Founding Director, Embedded Systems Masters Program (EMBS), 2009–2015.
- Graduate Group Chair, Department of Computer and Information Science, 2005–2009 and 2018–.
- University Committee on Academic Planning and Budget, 2007–2010.
- Department of Computer and Information Science Colloquium Chair, 2004–2005.
- Computer and Information Science, Graduate Admissions, 1997–2000. Chair, 2000.
- Computer and Information Science, MS Curriculum Revision and initiation of the new Master of Computer and Information Technology Program, 1999-2000.
- School of Engineering and Applied Science, Library Committee, 1997–2000.
- School of Engineering and Applied Science, Faculty Personnel Committee, Member 2001–2002, Chair 2002–2003.
- University Research Council, 1999–2001.
- PhD Thesis Committee: Madhukar Anand, Kook Jin Anh, Zhuowei Bao, Colin Blundell, Richard Eisenberg, Georgios Fainekos, Alwyn Goodloe, Michael Greenberg, Yerang Hur, Zhihao Jiang, Andrew King, Sulekha Kulkarni, Hee-Hwan Kwak, Santosh Nagarakatte, Truong Nghiem, Davor Obradovic, Peter-Michael Osera, Junkil Park, Yuanfeng Peng, Jianping Shi, Insik Shin, Jangwoo Shin, Mahesh Viswanathan, Daniel Wagner, Anduo Wang, and Teng Zhang.

Professional Activities

Professional societies

- General Chair, ACM/IEEE Logic in Computer Science (LICS), 2009–2012.
- Chair, ACM SIGBED (Special Interest Group on Embedded Systems), 2005–2007.

Editorial board

- ACM Transactions on Embedded Computer Systems, 2003–2012.
- Formal Methods in System Design, Springer, 1995–2014.
- International Journal of Foundations of Computer Science, World Scientific, 2002–2011.
- Journal of the ACM, 2014 onwards.
- Logical Methods in Computer Science, 2004–2014.
- Electronic Proceedings in Theoretical Computer Science (EPTCS), 2008–2014.

Conference Organization

1. Co-organizer, *Syntax-Guided Synthesis Competition (SyGuS-Comp)*, Vienna, July 2014; San Francisco, July 2015; Toronto, July 2016; Heidelberg, July 2017; Oxford, July 2018; and New York City, July 2019.
2. Co-organizer, CCC Visioning Workshop on *Computer-Aided Personalized Education*, Washington DC, November 2015.
3. Co-organizer, *Exploiting Concurrency Efficiently and Correctly (EC²)*, CAV Workshop; Princeton, July 2008, Grenoble, France, July 2009, and Edinburgh, UK, July 2010.
4. Program Chair, *21st IEEE Symposium on Logic in Computer Science (LICS)*, Seattle, August 2006.
5. Program Co-chair and Conference Co-chair, *16th International Conference on Computer-Aided Verification (CAV)*, Boston, July 2004.
6. Program Co-chair and Conference Co-chair, *Seventh International Workshop on Hybrid Systems: Computation and Control (HSCC)*, Philadelphia, March 2004.
7. Program Co-chair and Conference Co-chair, *Third International Workshop on Embedded Software (EMSOFT)*, Philadelphia, October 2003.
8. Program Co-chair and Conference Co-chair, *Eighth International Conference on Computer-Aided Verification (CAV)*, New Brunswick, August 1996.
9. Program Co-chair and Conference Co-chair, *DIMACS Workshop on Verification and Control of Hybrid Systems*, New Brunswick, October 1995.

Selected Program committees

1. *International Conference on Computer Aided Verification (CAV)*: 2019, 2016, 2014, 2013, 2012, 2010, 2009, 2008, 2007, 2004, 2003, 2001, 2000, 1998, 1997, 1996, 1995, 1994, 1993, 1992.
2. *ACM Conference on Embedded Software (EMSOFT)*: 2013, 2010, 2009, 2007, 2006, 2003, 2002.

3. *International Conference on Hybrid Systems: Computation and Control (HSCC)*: 2006, 2004, 2003, 2002, 2001, 2000, 1999, 1998.
4. *IEEE Symposium on Logic in Computer Science (LICS)*: 2006, 2004, 1999.
5. *International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS)*: 2012, 2005, 2003, 2001, 1999.
6. *ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI)*: 2008.
7. *ACM Symposium on Principles of Programming Languages (POPL)*: 2010.
8. *IEEE Symposium on Foundations of Computer Science (FOCS)*: 2006.
9. *IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS)*: 2005.
10. *IEEE Real-Time Systems Symposium (RTSS)*: 2003, 1993.
11. *Annual Conference of the European Association for Computer Science Logic (CSL)*: 2002.
12. *International Conference on Concurrency Theory (CONCUR)*: 2001.
13. *International Joint Conference on Automated Reasoning (IJCAR)*: 2001.
14. *International Colloquium on Automata, Languages, and Programming (ICALP)*: 2000.
15. *ACM Symposium on Principles of Distributed Computing (PODC)*: 1998.
16. *International Conference on Foundations of Software Science and Computation Structures (FoSSaCS)*: 2013.
17. *International Symposium on Automated Technology for Verification and Analysis (ATVA)*: 2012, 2009, 2007, 2006, 2005.
18. *International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS)*: 2007, 2006, 2003.
19. *Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)*: 2003.
20. *IFIP International Conference on Theoretical Computer Science (TCS)*: 2008.
21. *International School and Symposium on Formal Techniques in Real-time and Fault-tolerant Systems (FTRTFT)*: 2002, 2000.
22. *International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI)*: 2003.
23. *ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP)*: 2003.

Other committees

1. Scientific Advisory Board, Max Plank Institute for Software Systems, Germany, 2014 onwards.
2. ACM Paris Kanellakis Theory in Practice Award Committee, 2007-2010 (Chair, 2008-09).
3. CAV (Computer-Aided Verification) Award committee, 2009-13 (Chair, 2012-13).
4. Steering committee, *International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS)*, 2003 onwards.

5. Steering committee, *International Conference on Hybrid Systems: Computation and Control* (HSCC), 2002–2020.
6. LICS Test-of-Time Award Committee, 2005–2007 (Chair, 2007).
7. Executive Board, Logical Methods in Computer Science, 2014 onwards.
8. Panelist and/or participant in DARPA/NSF workshops on various initiatives on embedded systems, 1998 onwards.
9. Panelist for National Science Foundation proposal reviews.
10. Conference committee, *Federated Logic Conference*, New Brunswick, July-August 1996.
11. Working group on formal methods, *ACM Workshop on Strategic Directions in Computing Research*, Boston, June 1996.
12. Working group on concurrency, *ACM Workshop on Strategic Directions in Computing Research*, Boston, June 1996.

External Reviewer on PhD Thesis Committee

Aws Albarghouthi (University of Toronto), Mohamed-Faouzi Atig (University of Paris VII, France), Guy Avni (Hebrew University), Nicolas Basset (University of Paris), Patricia Bouyer (ENS Cachan, France), Jatindra Deka (IIT Kharagpur, India), Victor Du (SUNY Stony Brook), Parasara Sridhar Duggirala (UIUC), Ansgar Fehnker (University of Nijmegen, Netherlands), Goran Frehse (University of Grenoble, France), William Harris (University of Wisconsin), Martijn Hendriks (Radboud University, Netherlands), Aditya Kanade (IIT Bombay, India), Etienne Kneuss (EPFL, Switzerland) Martin Lange (LMU Munich, Germany), Flavio Lerda (Carnegie Mellon University), Federico Mari (University of Rome, Italy), David Menendez (Rutgers University), Dejan Nickovic (University of Grenoble, France), Petr Novotny (Masaryk University, Czech Republic), Xiaokang Qiu (UIUC), Ocan Sankur (ENS Cachan, France), Gerardo Schneider (University of Grenoble, France), Bikram Sengupta (SUNY Stony Brook), Frederic Servais (Univeriste Libre de Bruxelles), Vasu Singh (EPFL, Switzerland), Ofer Strichman (Weizmann Inst. of Science, Israel), Stavros Tripakis (University of Grenoble, France), Dogan Ulus (University of Grenoble, France), Yaron Velner (Tel Aviv University, Israel).

Journal referee

Acta Informatica, ACM Transactions on Computational Logic, ACM Transactions on Design Automation of Electronic Systems, ACM Transactions on Embedded Computer Systems, ACM Transactions on Programming Languages and Systems, ACM Transactions on Software Engineering and Methodology, Bulletin of Symbolic Logic, Computer Architecture Letters, Distributed Computing, Formal Aspects of Computing, Formal Methods in System Design, Fundamenta Informaticae, IEEE Parallel & Distributed Technology, IEEE Software, IEEE Transactions on Computers, IEEE Transactions on Computer-Aided Design, IEEE Transactions on Automatic Control, IEEE Transactions on Software Engineering, Information and Computation, Information Processing Letters, International Journal on Foundations of Computer Science, Journal of the ACM, Journal of Algorithms, Journal of Automated Reasoning, Journal of Computer and System Sciences, Journal of Discrete Event Dynamic Systems, Journal of Logic and Computation, Journal of Parallel and Distributed Computing, Mathematics of Control Systems and Signals, Mathematical Structures in Computer Science, Science of Computer Programming, and Theoretical Computer Science.

Proposal reviewer

Air-Force Office for Scientific Research, Engineering and Physical Sciences Research Council, United Kingdom, Israel Science Foundation, National Science Foundation, Natural Sciences and Engineering Research Council, Canada, Science Foundation of Ireland, The Netherlands Computer Science Research Foundation, The Netherlands Organization for Scientific Research, and Swiss National Science Foundation.

Professional societies

AAAS, ACM (SIGACT, SIGBED, SIGLOG, SIGPLAN, SIGSOFT), IEEE Computer Society.

Invited Lectures

1. Model checking for safe autonomy. Keynote lecture, *21st International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI)*, New Orleans, January 2020.
2. Safety verification for learning-enabled control systems. Distinguished colloquium, Computer Science Research Week, National University of Singapore, Singapore, January 2020.
3. Model checking for safe autonomy. Keynote lecture, *17th ACM-IEEE International Conference on Formal Methods and Models for System Design (MEMOCODE)*, San Diego, October 2019.
4. Model checking for safe autonomy. Best of Model Checking: CAV Workshop in honor of Orna Grumberg, New York, July 2019.
5. Hybrid systems: The early years. Oded Maler - Barbaric Science from a Captive Poet, CPS-IoT Week, Montreal, Canada, April 2019.
6. Syntax-guided program synthesis. Distinguished Colloquium, Department of Computer Science, New York University, December 2018.
7. Programming abstractions for data processing systems. Keynote Lecture, 18th International Conference on Runtime Verification, Limassol, Cyprus, November 2018.
8. Syntax-guided program synthesis. Distinguished Colloquium, Department of Computer Science, Stony Brook University, November 2018.
9. Syntax-guided program synthesis. Keynote Lecture, Mid-west Verification Meeting, University of Iowa, September 2018.
10. Regular processing of data streams. Lectures at Lipa Summer School, Warsaw, Poland, June 2018.
11. Syntax-guided program synthesis. Distinguished Colloquium, Department of Electrical Engineering and Computer Science, University of California, Berkeley, April 2018.
12. Quantitative policies over streaming data. Distinguished Colloquium, Department of Computer Science, Rice University, January 2018.
13. Quantitative policies over streaming data. Department of Computer Science and Engineering, Indian Institute of Technology, Kanpur, November 2017.
14. Interfaces for stream processing systems. *Principles of Modeling: Symposium in honor of Edward A. Lee*, Berkeley, October 2017.
15. Quantitative policies over streaming data. *Kimfest: Symposium in honor of Kim G. Larsen*, Aalborg, Denmark, August 2017.

16. Syntax-guided synthesis. *Summer School on Symbolic Computation and Satisfiability Checking*, Saarbrücken, Germany, August 2017.
17. Quantitative policies over streaming data. *Summer School on Verification Technology, Systems, and Applications*, Saarbrücken, Germany, August 2017.
18. Syntax-guided synthesis. *Dill@60 Workshop, International Conference on Computer-Aided Verification*, Heidelberg, Germany, July 2017.
19. Reactive synthesis for multi-agent systems. *Workshop on Integrated Task and Motion Planning, Robotics: Science and Systems*, Boston, July 2017.
20. Syntax-guided synthesis. DARPA-ISAT Workshop on Augmented Developers, Arlington, February 2016.
21. Syntax-guided synthesis. Distinguished Colloquium, Academia Sinica, Taiwan, December 2016.
22. Principles of Cyber-Physical Systems, *Naval Academy Science and Engineering Conference*, The United States Naval Academy, Annapolis, November 2016.
23. Syntax-guided synthesis. Embedded tutorial, *ACM SIGBED International Conference on Embedded Software (EMSOFT)*, Pittsburgh, October 2016.
24. Quantitative policies over streaming data. Department of Electrical Engineering, University of Southern California, September 2016.
25. Regular functions: Foundations and applications to quantitative policies over streaming data. *International Summer School Marktoberdorf: Dependable Software Systems Engineering*, Marktoberdorf, Germany, August 2016.
26. Quantitative policies over streaming data. *MSR Workshop on Safe and Autonomous Cyber-Physical Systems*, Redmond, July 2016.
27. Quantitative policies over streaming data. *Fourth International Workshop on Strategic Reasoning (SR)*, New York, July 2016.
28. Quantitative policies over streaming data. Opening Keynote at *Cyber-Physical Systems Week (CPSWeek)*, Vienna, Austria, April 2016.
29. Syntax-Guided Synthesis. Tutorial at *43rd ACM Symposium on Principles of Programming Languages (POPL)*, January 2016.
30. Syntax-Guided Synthesis. *13th ACM-IEEE International Conference on Formal Methods and Models for System Design (MEMOCODE)*, Austin, September 2015.
31. Regular Functions. *Descriptive Complexity of Formal Structures (DCFS)*, Waterloo, Canada, June 2015.
32. Model Synthesis: New Challenges for Model-Based Design. *Toyota Workshop on Industrial Cyber-Physical Systems*, Los Angeles, December 2014.
33. Regular Functions. *Workshop on Software Correctness and Reliability*, ETH Zurich, October 2014.
34. Syntax-Guided Synthesis, *International Summer School Marktoberdorf: Dependable Software Systems Engineering*, Marktoberdorf, Germany, August 2014.
35. Syntax-Guided Synthesis, *13th International Conference on Formal Methods in Computer-Aided Design (FMCAD)*, Portland, October 2013.

36. Regular Functions. *Horizons in TCS: A celebration of Mihalis Yannakakis's 60th Birthday*, Princeton, August 2013.
37. Regular Functions. *28th ACM/IEEE Symposium on Logic in Computer Science (LICS)*, New Orleans, June 2013.
38. Regular Functions and Cost Register Automata. *Journées d'Informatique Fondamentale de Paris Diderot*, Paris, April 2013.
39. Computer Augmented Program Engineering. Distinguished Departmental Colloquium, University of Texas at Austin, November 2012.
40. Streaming Transducers. *IFIP Theoretical Computer Science Conference*, Amsterdam, The Netherlands, September 2012.
41. Computer Augmented Program Engineering. Distinguished Departmental Colloquium, University of California at San Diego, April 2012.
42. Computer Augmented Program Engineering. The Strachey Lecture, University of Oxford, March 2012.
43. Computer Augmented Program Engineering. Distinguished Departmental Colloquium, University of Illinois at Chicago, February 2012.
44. Computer Augmented Program Engineering. *13th International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI)*, Philadelphia, January 2012.
45. Formal verification of hybrid systems. *11th International Conference on Embedded Software (EMSOFT)*, Taipei, Taiwan, October 2011.
46. Interfaces for control components. *9th International Conference on Formal Modeling and Analysis of Timed Systems (FORMATS)*, Aalborg, Denmark, September 2011.
47. Interfaces for control components. *CAV Workshop on Formal Methods for Robotics and Automation*, Snowbird, July 2011.
48. Computer Augmented Program Engineering. *3rd International Workshop on Practical Synthesis for Concurrent Systems*, Snowbird, July 2011.
49. Streaming string transducers. *38th International Colloquium on Automata, Languages, and Programming (ICALP)*, Zurich, Switzerland, July 2011.
50. Streaming string transducers. *18th Workshop on Logic, Language, Information, and Computation (WoLLIC)*, Philadelphia, May 2011.
51. Streaming string transducers. *30th Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)*, Chennai, India, December 2010.
52. Interfaces for control components. ARTIST (Network of Excellence on Embedded Systems Design) Summer School Europe, Grenoble, France, September 2010.
53. Interfaces for control components. *10th International Workshop on Discrete Event Systems (WODES 2010)*, Plenary lecture, Berlin, Germany, August 2010.
54. Architecture-aware analysis of concurrent software. Amir Pnueli Memorial Symposium, New York, May 2010.
55. Software verification: From an unsolvable problem to useful tools. The George H. Heilmeier Faculty Award for Excellence in Research Lecture, University of Pennsylvania, March 2010.
56. Architecture-aware analysis of concurrent software. Distinguished Departmental Colloquium, Michigan State University, February 2010.

57. Architecture-aware analysis of concurrent software. Intel Symposium on Hardware and Software Co-design and Co-verification, Haifa, Israel, September 2009.
58. Temporal reasoning about program executions. The European Joint Conferences on Theory and Practice of Software (ETAPS), York, UK, March 2009.
59. Marrying words and trees. *Logic and Algorithms*, Edinburgh, UK, July 2008.
60. Software model checking. The Milner Lecture, Laboratory for Foundations of Computer Science, University of Edinburgh, July 2008.
61. Architecture-aware analysis of concurrent software. Distinguished Lecture Series, Max-Planck Institute for Software Systems, Saarbrücken, Germany, July 2008.
62. Marrying words and trees. *12th International Conference on Algebraic Methodology and Software Technology (AMAST)*, Urbana, July 2008.
63. Architecture-aware analysis of concurrent software. Jon Postel Distinguished Lecturer, Department of Computer Science, University of California at Los Angeles, November 2007.
64. Architecture-aware analysis of concurrent software. Distinguished Lecture Series, Department of Computer Science, University of Illinois at Urbana-Champaign, October 2007.
65. Marrying words and trees. *Computer Science Symposium in Russia (CSR'07)*, Ekaterinburg, Russia, September 2007.
66. Concurrent executions on relaxed memory models: Challenges and opportunities for software model checking. *14th International Workshop on Model Checking Software (SPIN)*, Berlin, Germany, July 2007.
67. Principles of embedded computation. Distinguished colloquium, Department of Computer Science and Engineering, Arizona State University, April 2007.
68. Software model checking. Distinguished colloquium, Department of Computer Science and Engineering, Pennsylvania State University, November 2006.
69. Logics, automata, and algorithms for analysis of structured programs. Minicourse, *Marktoberdorf Summer School on Software and System Reliability and Security*, Germany, August 2006.
70. Model checking: From tools to theory. *25MC: 25 Years of Model Checking*, Seattle, August 2006.
71. Hybrid systems modeling for regulatory pathways. *FLoC Workshop on Logic in Systems Biology (LSB)*, Seattle, August 2006.
72. Games for formal design and verification of reactive systems. Keynote lecture, *Fourth ACM-IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE)*, Napa, July 2006.
73. Nested words and trees. Tutorial, Workshop on Games and Verification, Newton Institute for Mathematical Sciences, Cambridge, UK, July 2006.
74. Adding nesting structure to words. Keynote lecture, *10th International Conference: Developments in Language Theory (DLT)*, Santa Barbara, June 2006.
75. The benefits of exposing calls and returns. Keynote lecture, Joint session of *16th International Conference on Concurrency Theory (CONCUR)* and *12th International SPIN Workshop on Model Checking of Software (SPIN)*, San Francisco, August 2005.

76. Modeling and analysis of hybrid and embedded systems. Minicourse at the Lipari School, Formal Methods: Theory and Practice, *17th International School for Computer Science Researchers*, Lipari Island, Italy, June 2005.
77. Games for formal design and verification of reactive systems. Keynote lecture, *Second International Symposium on Automated Technology for Verification and Analysis (ATVA)*, Taipei, Taiwan, November 2004.
78. Formal modeling and analysis of hybrid systems. Tutorial, *Second International Symposium on Automated Technology for Verification and Analysis (ATVA)*, Taipei, Taiwan, November 2004.
79. Timed automata and model checking. *Fourth International Summer School on Formal Methods for the Design of Computer, Communication, and Software Systems: Real Time*, Bertinoro, Italy, September 2004.
80. Analysis of scenario-based requirements. Distinguished Colloquium Series, Department of Electrical Engineering and Computer Science, Vanderbilt University, Nashville, November 2003.
81. Software synthesis from hybrid automata. *Monterrey Workshop on Software Engineering for Embedded Systems*, Chicago, September 2003.
82. Formal modeling and analysis of hybrid systems. *2003 Illinois International Multiconference on Measurement, Modelling, and Evaluation of Computer-Communication Systems*, Urbana, September 2003.
83. Analysis of hierarchical state machines. *Verification: Theory in Practice, Workshop in honor of Zohar Manna*, Taormina, Italy, July 2003.
84. Analysis of Message Sequence Charts. *CRM Workshop on Formal Methods*, Montreal, Canada, September 2002.
85. Reachability Analysis of Hybrid Systems using Predicate Abstraction. *18th Workshop on Mathematical Foundations of Programming Semantics (MFPS)*, New Orleans, March 2002.
86. Hybrid Systems: Modeling and Verification. *IFIP Working Group 2.3 School on Formal Software Engineering*, Pune, India, January 2002.
87. Hierarchical Hybrid Modeling of Embedded Systems. *First International Workshop on Embedded Software (EMSOFT)*, Tahoe City, October 2001.
88. Hybrid systems: Modeling and Verification. One-day minicourse for *Fifth Dynamics Workshop*, Brussels, July 2001.
89. Exploiting modularity in model checking. *11th International Conference on Concurrency Theory (CONCUR)*, State College, August 2000.
90. CHARON: Modular specification and simulation of hybrid systems. Keynote speaker at *Dagstuhl Seminar on Probabilistic Methods in Verification*, Wadern, Germany, May 2000.
91. Model checking of real-time and hybrid systems. *11th International Conference on Computer-Aided Verification (CAV)*, Trento, Italy, July 1999.
92. Efficient formal verification of hierarchical descriptions. *18th Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)*, Chennai, India, December 1998.
93. Model Checking. EECS Departmental Colloquium, Lehigh University, October 1998.

94. Model checking of probabilistic real-time systems. *Workshop on Probabilistic Methods in Verification* (PROBMIV), Indianapolis, June 1998.
95. Modeling and analysis of hybrid systems. Joint session of *12th International Workshop on Qualitative Reasoning* (QR) and *Ninth International Workshop on Principles of Diagnosis* (DX), Cape Cod, May 1998.
96. Formal verification of timed circuits. *Fifth ACM/IEEE International Workshop on Timing Issues in the Specification and Synthesis of Digital Systems* (TAU), Austin, December 1997.
97. Controller synthesis for timed and hybrid systems. *Fifth International Hybrid Systems Workshop*, Notre Dame, September 1997.
98. Timed automata. *NATO ASI Summer School on Verification of Digital and Hybrid Systems*, Antalya, Turkey, May 1997.
99. Modularity for timed and hybrid systems. *School on Methods and Tools for the Verification of Infinite State Systems*, Grenoble, France, March 1997.
100. Model checking for real-time and hybrid systems. *Workshop on Applied Formal Methods*, Hyderabad, India, December 1996.
101. Partial-order logics. *DIMACS Workshop on Partial-Order Methods in Verification*, Princeton, July 1996.
102. Reactive modules. *ONR Workshop on Automated Formal Methods*, Oxford, UK, June 1996.
103. Algorithmic verification of timed and hybrid systems. *Eighth Conference on Formal Description Techniques* (FORTE), Montreal, Canada, October 1995.
104. Timing analysis in COSPAN. *DIMACS Workshop on Verification and Control of Hybrid Systems*, New Brunswick, October 1995.
105. Hybrid automata. *11th International Conference on Analysis and Optimization of Systems*, Sophia-Antipolis, France, June 1994.
106. Real-time systems: Verification. *AMAST Workshop on Real-Time Systems* (ARTS), Iowa City, November 1993.
107. Model checking for real-time systems. *Fourth International Conference on Computer-Aided Verification* (CAV), Elounda, Greece, July 1993.
108. Automatic verification of real-time systems. *Third Conference on Concurrency Theory* (CONCUR), Stony Brook, August 1992.
109. Modeling and verifying real-time systems. *Workshop on temporal and real-time specification*, Berkeley, August 1990.

Seminar Talks

Bellcore (March 1991 and September 1992), Bell Laboratories (June 2016), Carnegie Mellon University (October 1992, December 2001), Columbia University (October 1994), Cornell University (February 1991, September 1992, and October 1993), EPFL, Switzerland (July 2005), IBM T.J. Watson Research Center (October 1994 and July 2007), Indian Institute of Science, Bengaluru, India (January 2019), Indian Institute of Technology at Kanpur (January 2008), Indian Institute of Technology at Mumbai (January 2003), Intel Design Labs (August 1998), IST Austria (August 2010), Loyola University of Chicago (April 1994), McMaster University (May 2002), Microsoft Research (May 2009), MIT (January 1994, April 1997, October 1999, August 2005, and March 2006), National University of Singapore (July 2017), NEC Research Labs (July 1999 and

September 2006), Pennsylvania State University (March 1991), Rice University (April 1995), Rutgers University (April 2004), Simons Institute for Theoretical Computer Science (March 2018), SRI International (April 1991, August 1996, March 2018), State University of New York at Stony Brook (November 1995), Stanford University (May 1990, February 1991, March 1992, April 1993, and March 2018), Temple University (September 2017), University of Brussels, Belgium (September 2012), University of California at Berkeley (September 1990, September 1996, November 1996, August 1998, and February 2018), University of California at Santa Barbara (January 1991), University of Delaware (March 2009), University of Paris (July 2003), University of Pennsylvania (March 1995, March 1997, November 1997, October 1999, October 2000, October 2002, October 2003, November 2003, September 2005, September 2006, September 2008, and October 2009), Verimag, Grenoble, France (July 2005), Villanova University (April 2016), and VMWare Research (April 2018).

Software

1. **AutomataTutor** (with L. D'Antoni, S. Gulwani, B. Hartmann, D. Kini, M. Viswanathan): a tool for automatic grading and feedback for basic problems in theory of computation course (www.automatatutor.com). The tool is now used in over twenty universities and by more than five thousand students.
2. **CheckFence** (with Sebastian Burckhardt and Milo Martin): a SAT-based verification tool for analyzing implementations of concurrent data types with respect to user specified memory model (<http://checkfence.sourceforge.net/>).
3. **Jist** (with students): a tool for automatic extraction of behavioral interfaces from Java classes (see www.cis.upenn.edu/jist/).
4. **CHARON** (with I. Lee, O. Sokolsky, and others): a modeling and analysis environment for hierarchical hybrid systems (see www.cis.upenn.edu/mobies/charon/).
5. **HERMES** (with students): a model checker for communicating hierarchical state machines (see www.cis.upenn.edu/sdrl/hermes/).
6. **MOCHA** (with T. Henzinger and others): a model checking environment for reactive systems (available at www.cis.upenn.edu/~mocha/).
7. **Timed COSPAN** (with R. Kurshan): Model checker to debug a description of a real-time system against correctness requirements.
8. **MSC Analyzer** (with G. Holzmann, B. Kernighan, and D. Peled): A CASE tool for creating, editing, and analyzing message sequence charts for specifying requirements for the telecommunication software.

Patents

Timing verification by successive approximation: An algorithm for timing analysis, that is implemented in COSPAN, and gives heuristic improvements in the time and space requirements of the verification task. US Patent 5483470, 1996 (with A. Itai, R. Kurshan, and M. Yannakakis).

Model checking of hierarchical state machines: Algorithms for analysis of hierarchical state machines. US Patent 6324,496, 2001 (with M. Yannakakis).

Model checking of message flow diagrams: Methodology and algorithms for automated analysis of scenario-based requirements. US Patent 6516306, 2003 (with M. Yannakakis).

Implied message sequence charts: Methodology and algorithms for inferring implied scenarios from input requirements. US Patent 6681264, 2004 (with K. Etessami and M. Yannakakis).

Scenario-based programming of SDN policies: Methods, systems, and computer readable media for generating software defined networking (SDN) policies (with B. T. Loo and Y. Yuan); US Patent 9729582, 2017

Books

Computer-Aided Verification 1999 (with T. Henzinger) See draft at www.cis.upenn.edu/cis673/

Principles of Cyber-Physical Systems, MIT Press, 2015; Chinese edition, 2017, Korean edition, 2019.

Edited Volumes

1. Logical Methods in Computer Science, Special Issue of Selected Papers of LICS 2006, 2009 (with R. Jagadeesan and L. Libkin).
2. Formal Methods in System Design, Vol. 32, No. 1, 2008 (with G.J. Pappas).
3. Proceedings, 21st Annual IEEE Symposium on Logic in Computer Science, 2006.
4. ACM Transactions on Embedded Computer Systems, Special issue on Embedded Software, Vol. 4, No. 4, 2005 (with I. Lee).
5. Computer Aided Verification, Proceedings of the 16th International Conference. Lecture Notes in Computer Science 3114, Springer 2004 (with D. Peled).
6. Hybrid Systems: Computation and Control, Seventh International Workshop, HSCC 2004, Proceedings. Lecture Notes in Computer Science 2993, Springer, 2004 (with G. Pappas).
7. Embedded Software, Third International Conference, EMSOFT 2003, Proceedings. Lecture Notes in Computer Science 2855, Springer, 2003 (with I. Lee).
8. Information and Computation, Vol. 164, No. 2, 2001 (with T. Henzinger).
9. Formal Methods in System Design, Vol 15, No. 1, July 1999 (with T. Henzinger).
10. Formal Methods in System Design, Vol 14, No. 3, May 1999 (with T. Henzinger).
11. CAV 96: Computer-Aided Verification. Lecture Notes in Computer Science 1102, Springer Verlag, 1996 (with T. Henzinger).
12. Hybrid Systems III: Verification and Control. Lecture Notes in Computer Science 1066, Springer Verlag, 1996 (with T. Henzinger and E. Sontag).

Refereed Journal Publications

1. Streamable regular functions. *Theoretical Computer Science*, **807**: 15–41, 2020 (with D. Fisman, K. Mamouras, M. Raghothaman, and C. Stanford). Invited submission.
2. Real-time decision policies with predictable performance. *Proceedings of the IEEE*, (Special issue on Cyber-Physical Systems), **106(9)**: 1593–1615, 2018 (with H. Abbas, K. Mamouras, R. Mangharam, A. Rodinova).
3. NetEgg: A scenario-based programming toolkit for SDN policies. *IEEE/ACM Transactions on Networking*, **26(5)**: 2104–2117, 2018 (with Y. Yuan, D. Lin, S. Anil, H. Verma, A. Chelluri, B.-T. Loo).

4. Search-based program synthesis, *Communications of the ACM*, **61(12)**: 84–93, 2018 (with D. Fisman, R. Singh, and A. Solar-Lezama).
5. Compositional and symbolic synthesis of reactive controllers for multi-agent systems, *Information and Computation* **261**: 616–633 (Special issue for SR2016), 2018 (with S. Moarref and U. Topcu).
6. Streaming tree transducers. *Journal of the ACM* **64(5)**: 31:1–31:55, 2017 (with L. D’Antoni).
7. Schedulability of bounded-rate multi-mode systems, *ACM Transactions on Embedded Computer Systems* **16(3)**: 85:1–85:27, 2017 (with V. Forejt, S. Moarref, and A. Trivedi).
8. How can automatic feedback help students construct automata? *ACM Transactions on Computer-Human Interactions*, **22(2)**, pp. 9:1–9:24, 2015 (with L. D’Antoni, D. Kini, S. Gulwani, M. Viswanathan, and B. Hartmann).
9. Closed-loop verification of medical devices with model abstraction and refinement, *Software Tools for Technology Transfer*, **16(2)**, pp. 191–213, 2014 (with Z. Jiang, M. Pajic, and R. Mangharam).
10. Algorithmic analysis of array-accessing programs, *ACM Transactions on Computational Logic*, **13(3)**: 27, 2012 (with P. Černý and S. Weinstein).
11. Time-triggered implementations on dynamic controllers, *ACM Transactions on Embedded Computer Systems*, **11(S2)**: 58, 2012 (with T. Nghiem, G.J. Pappas, and A. Girard).
12. Software model checking using languages of nested trees. *ACM Transactions on Programming Languages and Systems*, **33(5)**: 15, 2011 (with S. Chaudhuri and P. Madhusudan).
13. Compositional modeling and analysis of multi-hop control networks, *IEEE Transactions on Automatic Control* (Special issue on Wireless Sensor and Actuator Networks), **56(10)**, pp. 2345 – 2357, 2011 (with A. D’Innocenzo, K.H. Johansson, G.J. Pappas, and G. Weiss).
14. Adding nesting structure to words, *Journal of the ACM (JACM)* **56(3)**, 2009 (with P. Madhusudan).
15. First-order and temporal logics for nested words, *Logical Methods in Computer Science (LMCS)* **4(4: 11)**, 2008 (with M. Arenas, P. Barcelo, K. Etessami, N. Immerman, and L. Libkin). Invited submission to LICS 2007 special issue.
16. Automatic symbolic compositional verification by learning assumptions, *Formal Methods in System Design* **32(3)**, pp. 207–234, 2008 (with W.Nam and P. Madhusudan). Invited submission to special issue on Learning and Verification.
17. Dispatch sequences for embedded control models, *Journal of Computer and System Sciences* **73(2)**, pp. 156–170, 2007 (with A. Chandrashekharaipuram). Invited submission to special issue on real-time and embedded systems.
18. Predicate abstraction for reachability analysis of hybrid systems, *ACM Transactions on Embedded Computer Systems* **5(1)**, pp. 152–199, 2006 (with T. Dang and F. Ivancic).
19. Compositional modeling and refinement for hierarchical hybrid systems, *Journal of Logic and Algebraic Programming* **68(1-2)**, pp. 105–128, 2006 (with R. Grosu, I. Lee, and O. Sokolsky).
20. Deciding global partial order properties. *Formal Methods in System Design* **26**, pp. 7–25, 2005 (with K. McMillan and D. Peled).
21. Analysis of recursive state machines, *ACM Transactions on Programming Languages and Systems* **27(4)**, pp. 786–818, 2005 (with M. Benedikt, K. Etessami, P. Godefroid, T. Reps, and M. Yannakakis).

22. Modular strategies for recursive game graphs, *Theoretical Computer Science* **354**, pp. 230–249, 2006 (with S. La Torre and P. Madhusudan). Invited submission for TACAS’03 special issue.
23. Counterexample guided predicate abstraction of hybrid systems, *Theoretical Computer Science* **354**, pp. 250–271, 2006 (with T. Dang and F. Ivancic). Invited submission for TACAS’03 special issue.
24. Symbolic computational techniques for solving games, *Springer International Journal on Software Tools for Technology Transfer* **7(2)**, pp. 118–128, 2005 (with P. Madhusudan and W. Nam). Invited submission for BMC’03 special issue.
25. Optimal paths in weighted timed automata, *Theoretical Computer Science* **318(3)**, pp. 297–322, 2004 (with S. La Torre and G. Pappas).
26. Polyhedral flows in hybrid automata. *Formal Methods in System Design* **24(3)**, pp. 261–280, 2004 (with S. Kannan and S. La Torre).
27. Modular refinement of hierarchic state machines, *ACM Transactions on Programming Languages and Systems* **26(2)**, pp. 339–369, 2004 (with R. Grosu).
28. Formal specification and analysis of the computer-assisted resuscitation algorithm (CARA) infusion pump control system, *Software Tools for Technology Transfer* **5(4)**, pp. 308–319, 2004 (with D. Arney, E. Gunter, I. Lee, J. Lee, W. Nam, F. Pearce, S. van Albert, and J. Zhou). Invited submission to special issue on formal methods for medical devices.
29. Inference of message sequence charts, *IEEE Transactions on Software Engineering* **29(7)**, pp. 623–633, 2003 (with K. Etessami and M. Yannakakis).
30. Hierarchical modeling and analysis of embedded systems, *Proceedings of the IEEE* **91(1)**, pp. 11–28, 2003 (with T. Dang, J. Esposito, Y. Hur, F. Ivancic, V. Kumar, I. Lee, P. Mishra, G. Pappas, and O. Sokolsky). Invited submission to special issue on embedded systems.
31. A framework and architecture for multirobot coordination, *International Journal of Robotic Research*, to appear (with R. Fierro, A. Das, J. Spletzer, Y. Hur, J. Esposito, G. Grudic, V. Kumar, I. Lee, J. Ostrowski, G. Pappas, J. Southall, C.J. Taylor). Invited submission to ISER’00 special issue.
32. Deterministic generators and games for LTL fragments, *ACM Transactions on Computational Logic* **5(1)**, pp. 1–25, 2004 (with S. La Torre).
33. Realizability and verification of MSC graphs, *Theoretical Computer Science* **331**, pp. 97–114, 2005 (with K. Etessami and M. Yannakakis). Invited submission for ICALP’01 special issue.
34. Modeling and analyzing biomolecular networks, *IEEE Computing in Science and Engineering* **4(1)**, pp. 20–31, 2002 (with C. Belta, V. Kumar, M. Mintz, G. Pappas, H. Rubin, and J. Schug). Invited submission to special issue on Biocomputation.
35. Alternating-time Temporal Logic. *Journal of the ACM* **49(5)**, pp. 672–713, 2002 (with T. Henzinger and O. Kupferman).
36. Model checking of hierarchical state machines. *ACM Transactions on Programming Languages and Systems*, **23(3)**, pp. 273–303, 2001 (with M. Yannakakis).
37. Parametric temporal logic for model measuring, *ACM Transactions on Computational Logic*, **2(3)**, pp. 388–407, 2001 (with K. Etessami, S. La Torre, and D. Peled).
38. Discrete abstractions of hybrid systems. *Proceedings of the IEEE* **88(7)**, pp. 971–984, 2000 (with T. Henzinger, G. Lafferriere, and G. Pappas). Invited submission to a special issue on hybrid systems.

39. Partial order reduction in symbolic state space exploration. *Formal Methods in System Design*, **18(2)**, pp. 97–116, 2001 (with R. Brayton, T. Henzinger, S. Qadeer, and S. Rajamani). Invited submission to CAV'97 special issue.
40. Model-checking of correctness conditions for concurrent objects. *Information and Computation*, **160(1-2)**, pp. 167–188, 2000 (with K. McMillan and D. Peled). Invited submission to LICS'96 special issue.
41. Undecidability of partial order logics. *Information Processing Letters* **69(3)**, pp. 137–143, 1999 (with D. Peled).
42. Finitary fairness. *ACM Transactions on Programming Languages and Systems* **20(6)**, pp. 1171-1194, 1998 (with T. Henzinger).
43. Reactive modules. *Formal Methods in System Design* **15(1)**, pp. 7–48, 1999 (with T. Henzinger). Invited submission to the FLoC'96 special issue.
44. Real-time system = Discrete system + Clock variables. *Springer International Journal on Software Tools for Technology Transfer* **1(1)**, pp. 86-109, 1997 (with T. Henzinger). Invited submission.
45. A determinizable class of timed automata. *Theoretical Computer Science* **211**, pp. 253–273, 1999 (with L. Fix and T. Henzinger).
46. Computing accumulated delays in real-time systems. *Formal Methods in System Design* **11(2)**, pp. 137-155, 1997 (with C. Courcoubetis and T. Henzinger). Invited submission to the CAV-93 special issue.
47. Time-adaptive algorithms for synchronization. *SIAM Journal on Computing* **26(2)**, pp. 539–556, 1997 (with H. Attiya and G. Taubenfeld).
48. The benefits of relaxing punctuality. *Journal of the ACM* **43(1)**, pp. 116-146, 1996 (with T. Feder and T. Henzinger).
49. An analyzer for message sequence charts. *Software: Concepts and Tools* **17(2)**, pp. 70-77, 1996 (with G. Holzmann and D. Peled). Invited submission.
50. Automatic symbolic verification of embedded systems. *IEEE Transactions on Software Engineering* **22(3)**, pp. 181–201, 1996 (with T. Henzinger and P. Ho).
51. Contention-free complexity of shared memory algorithms. *Information and Computation* **126(1)**, pp. 62-73, 1996 (with G. Taubenfeld).
52. Fast timing-based algorithms. *Distributed Computing* **10(1)**, pp. 1-10, 1996 (with G. Taubenfeld).
53. Timing verification by successive approximation. *Information and Computation* **118(1)**, pp. 142–157, 1995 (with A. Itai, R. Kurshan and M. Yannakakis).
54. The algorithmic analysis of hybrid systems. *Theoretical Computer Science* **138** pp. 3–34, 1995 (with C. Courcoubetis, N. Halbwachs, T. Henzinger, P. Ho, X. Nicollin, A. Olivero, J. Sifakis and S. Yovine). Invited submission to the special issue on hybrid systems.
55. A really temporal logic. *Journal of the ACM* **41(1)**, pp. 181–204, 1994 (with T. Henzinger).
56. A theory of timed automata. *Theoretical Computer Science* **126**, pp. 183–235, 1994 (with D. Dill).
57. Model-checking in dense real-time. *Information and Computation* **104(1)**, pp. 2–34, 1993 (with C. Courcoubetis and D. Dill). Invited submission to the LICS-90 special issue.
58. Real-time logics: Complexity and expressiveness. *Information and Computation* **104(1)**, pp. 35–77, 1993 (with T. Henzinger). Invited submission to the LICS-90 special issue.

Invited Contributions

1. Continuous-Time Models for System Design and Analysis, *Computing and Software Science*, pp. 452-477, LNCS 10000, Springer, 2019 (with M. Giacobbe, T. A. Henzinger, K. G. Larsen, and M. Mikucionis).
2. Model checking procedural programs, In *Handbook of Model Checking*, pp. 541-572, Springer, 2018 (with A. Bouajjani and J. Esparza).
3. Interfaces for stream processing systems, *Principles of Modeling: Essays dedicated to Edward A. Lee on the occasion of his 60th birthday*, Springer Festschrift, LNCS 10760, pp. 38-60, 2018 (with K. Mamouras, V. Tannen, and C. Stanford).
4. An Introduction to the StreamQRE Language. *Dependable Software Systems Engineering*, pp. 1-24, 2017 (with K. Mamouras).
5. Derivatives of quantitative regular expressions, *Models, Algorithms, Logics and Tools: Essays dedicated to Kim G. Larsen*, LNCS 10460, Springer Festschrift, pp. 75-95, 2017 (with K. Mamouras and D. Ulus).
6. Automatic synthesis of distributed protocols, *SIGACT News*, **48(1)**: 55-90, 2017 (with S. Tripakis).
7. Computer-Aided Personalized Education. *Computing Community Consortium Whitepaper*, 2016 (with R. Baraniuk, R. Bodik, A. Drobnis, S. Gulwani, B. Hartmann, Y. Kafai, R. Libeskind-Hadas, D. Richardson, A. Solar-Lezama, C. Thille, and M. Vardi).
8. SyGuS-Com 2016: Results and analysis, *Proceedings of the Fifth Workshop on Synthesis (SYNT)*, EPTCS 229, pp. 178-202, 2016 (with D. Fisman, R. Singh, and A. Solar-Lezama).
9. Systems computing challenges in the Internet of Things. *Computing Community Consortium Whitepaper*, 2016 (with E. Berger, A. Drobnis, L. Fix, K. Fu, G. Hager, D. Lopresti, K. Nahrstedt, E. Mynatt, S. Patel, J. Rexford, J. Stankovic, and B. Zorn).
10. Automata Tutor and what we learned from building an online teaching tool. *The Bulletin of the EATCS*, **117**: 144-158, 2015 (with L. D'Antoni, M. Weaver, and A. Weinert).
11. Results and analysis of SyGuS-Comp'15, *Proceedings of the Fourth Workshop on Synthesis (SYNT)*, EPTCS 202, pp. 3-26, 2015 (with D. Fisman, R. Singh, and A. Solar-Lezama).
12. Syntax-Guided Synthesis. *Dependable Software Systems Engineering*, NATO Science for Peace and Security Series, pp. 1-25, 2015 (with R. Bodik, E. Dallah, D. Fisman, P. Garg, G. Juniwal, H. Kress-Gazit, P. Madhusudan, M.M.K. Martin, M. Raghothaman, S. Saha, S.A. Seshia, R. Singh, A. Solar-Lezama, E. Torlak, and A. Udupa).
13. Theory in practice for system design and verification, *SIGLOG News* **2(1)**: 46-51, 2015 (with T.A. Henzinger and M.Y. Vardi).
14. Can we verify cyber-physical systems?: technical perspective. *Communications of the ACM* **56(10)**: 96, 2013.
15. Syntax-guided Synthesis. *13th IEEE International Conference on Formal Methods in Computer-Aided Design (FMCAD)*, pp. 1-8, 2013 (with R. Bodik, G. Juniwal, M.M.K. Martin, M. Raghothaman, S.A. Seshia, R. Singh, A. Solar-Lezama, E. Torlak, and A. Udupa).
16. Regular functions and cost register automata. *28th ACM/IEEE Symposium on Logic in Computer Science (LICS)*, pp. 13-22, 2013 (with L. D'Antoni, J. Deshmukh, M. Raghothaman, and Y. Yuan).
17. Formal verification of hybrid systems. *11th International Conference on Embedded Software (EMSOFT)*, pp. 273-278, 2011.

18. Nondeterministic streaming string transducers. *Automata, Languages, and Programming, Proceedings of the 38th International Colloquium (ICALP) Part II*, pp. 1–20, LNCS 6756, Springer, 2011 (with J. Deshmukh).
19. Expressiveness of streaming string transducers. *Proceedings of the 30th Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)*, pp. 1–12, LIPIcs 8, 2010 (with P. Černý).
20. Model checking: From tools to theory. *25 Years of Model Checking*, pp. 89–106, LNCS 5000, Springer, 2008.
21. Logics and automata for software model checking. *Software System Reliability and Security, NATO Security through Science Series, Vol. 9*, pp. 1–21, 2007 (with S. Chaudhuri).
22. Trends and challenges in algorithmic software verification. *Verified Software: Theories, Tools, Experiments*, pp. 245–250, LNCS 4171, Springer, 2005.
23. Adding nesting structure to words, *Developments in Language Theory: 10th International Conference*, LNCS 4036, pp. 1–13, 2006 (with P. Madhusudan).
24. Decision problems for timed automata: A survey, *Formal Methods for the Design of Real-Time Systems*, LNCS 3185, pp. 1–24, 2004 (with P. Madhusudan).
25. Formal analysis of hierarchical state machines, *Verification: Theory and Practice, Essays dedicated to Zohar Manna*, LNCS 2772, pp. 42–66, 2004.
26. Hierarchical hybrid modeling of embedded systems, *First International Workshop on Embedded Software (EMSOFT)*, LNCS 2211, pp. 14–31, 2001 (with T. Dang, J. Esposito, R. Fierro, Y. Hur, F. Ivancic, V. Kumar, I. Lee, P. Mishra, G. Pappas, and O. Sokolsky).
27. Timed automata. *Proceedings of the 11th International Conference on Computer-Aided Verification (CAV)*, LNCS 1633, pp. 8–22, 1999.
28. Symbolic analysis of hybrid systems. *Proceedings of the 37th IEEE Conference on Decision and Control (CDC)*, 1997 (with T. Henzinger and H. Wong-Toi).
29. Timed Automata. *Verification of Digital and Hybrid Systems*, NATO ASI Series Vol. 170, (M.K. Inan, R.P. Kurshan, eds.), pp. 233–264, 2000.
30. Alternating-time temporal logic. *Compositionality—the significant difference* (W.-P. de Roever, H. LangMaack, A. Pnueli, eds.), LNCS 1536, pp. 23–60, 1998 (with T. Henzinger and O. Kupferman).
31. Automata-theoretic verification of real-time systems. *Formal Methods for Real-Time Computing* (C. Heitmeyer, D. Mandrioli, eds.), John Wiley & Sons Publishers, Trends in Software Series, pp. 55–81, 1996 (with D. Dill).
32. Timing analysis in COSPAN. *Hybrid Systems III* (R. Alur, T. Henzinger, E. Sontag, eds.), LNCS 1066, pp. 220–231, 1996 (with R. Kurshan).
33. Real-time system = Discrete system + Clock variables. *Theories and Experiences for Real-Time System Development* (T. Rus, C. Rattray, eds.), AMAST Series in Computing **2**, pp. 1–30, 1994 (with T. Henzinger).
34. The algorithmic analysis of hybrid systems. *11th International Conference on Analysis and optimization of systems: Discrete Event Systems* (G. Cohen, J. Quadrat, eds.), LNCIS 199, pp. 331–351, 1994 (with C. Courcoubetis, T. Henzinger, P. Ho, X. Nicollin, A. Olivero, J. Sifakis and S. Yovine).

35. Hybrid automata: An algorithmic approach to the specification and verification of hybrid systems. *Hybrid Systems* (R. Grossman, A. Nerode, A. Ravn, H. Rischel, eds.), LNCS 736, pp. 209–229, 1993 (with C. Courcoubetis, T. Henzinger and P. Ho).
36. Time for logic. *SIGACT News* **22(3)**, pp. 6–12, 1991 (with T. Henzinger).
37. Logics and models of real time: A survey. *Real-Time: Theory in Practice* (J. de Bakker, C. Huizing, W.-P. de Roever, G. Rozenberg, eds.), LNCS 600, pp. 74–106, 1991 (with T. Henzinger).
38. Verifying automata specifications of probabilistic real-time systems. *Real-Time: Theory in Practice* (J. de Bakker, C. Huizing, W. de Roever, G. Rozenberg, eds.), LNCS 600, pp. 28–44, 1991 (with C. Courcoubetis and D. Dill).

Refereed Conference Publications

1. Case study: Verifying the safety of an autonomous racing car with a neural network controller, *23rd ACM International Conference on Hybrid Systems: Computation and Control* (HSCC), 2020 (with R. Ivanov, T. Carpenter, J. Weimer, G.J. Pappas, and I. Lee).
2. A composable specification language for reinforcement learning tasks, *32nd Annual Conference on Neural Information Processing Systems* (NeurIPS), pp. 13021–13030, 2019 (with K. Jothimurugan and O. Bastani).
3. Detecting security leaks in hybrid systems with information flow analysis, *17th ACM-IEEE International Conference on Formal Methods and Models for System Design* (MEMOCODE), pp. 14:1–14:11, 2019 (with L. Nguyen, G. Mohan, J. Weimer, O. Sokolsky, and I. Lee).
4. Data-trace types for distributed stream processing systems, *40th ACM SIGPLAN Conference on Programming Language Design and Implementation* (PLDI), pp. 436–449, 2019 (with K. Mamouras, C. Stanford, Z.G. Ives, and V. Tannen).
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145. Contention-free complexity of shared memory algorithms. *13th ACM Symposium on Principles of Distributed Computing (PODC)*, pp. 61–70, 1994 (with G. Taubenfeld).
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151. How to share an object: A fast timing-based solution. *Fifth IEEE Symposium on Parallel and Distributed Processing (SPDP)*, pp. 470–477, 1993 (with G. Taubenfeld).
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164. A really temporal logic. *30th IEEE Symposium on Foundations of Computer Science (FOCS)*, pp. 164–169, 1989 (with T. Henzinger).

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1. Equilibria in quantitative concurrent games. CoRR abs/1809.10503, 2018 (with S. Almagor and S. Bansal).
2. Learning plans for safety and reachability goals with partial observability, Technical report MS-CIS-07-16, 2007 (with W. Nam).
3. HSIF semantics, 2004 (with O. Sokolsky and I. Lee).
4. Dynamic synchronous architectures, 2003 (with R. Grosu).
5. Coherency of shared memory in ad-hoc networks, Technical Report MS-CIS-01-29, University of Pennsylvania, 2001 (with M. Greenwald).
6. Ordered choice diagrams for symbolic analysis, Technical Report MS-CIS-98-12, University of Pennsylvania, 1998.

Research Grants

1. PI, NSF award CCF 1763514, “Enabling real-time quantitative decision-making over streaming data,” 6/1/2018–5/31/2022, \$1,200,000 (with Z.G. Ives, S. Khanna, and B.-T. Loo).
2. CoPI, ARO award, “ASPIRE: Automatically subsetting protocol implementations reliably and efficiently,” 1/11/18–12/31/22, \$6,100,000 (with M. Naik, I. Lee, B.-T. Lou, and O. Sokolsky).
3. PI, DARPA CASE award, “REAFFIRM: Scenario-based design and verification of resilient cyber-physical systems,” 2/14/18–2/13/19, \$1,000,000 (with I. Lee, R. Mangharam, M. Naik, O. Sokolsky, and J. Weimer).
4. CoPI, DARPA Assured Autonomy award, “Integrated static and dynamic approaches to high-assurance for learning-enabled cyber-physical systems,” 4/18–4/22, \$4,800,000 (with I. Lee, D. Lee, M. Morari, G.J. Pappas, O. Sokolsky, J. Weimer, and N. Bezzo).
5. PI, NSF award CCF 1723567, “Formal analysis and synthesis of multiagent systems with incentives,” 8/1/2017 – 7/31/2020, \$400,000.
6. Simons Investigator Fellowship, 8/1/2013 – 7/31/2018, \$600,000.
7. Lead PI, NSF Expeditions in Computing Award CCF 1138996, “Expeditions in Computer Augmented Program Engineering (ExCAPE): Harnessing synthesis for software design,” 4/1/2012 – 3/31/2017, \$10,000,000.

8. CoPI, NSF award CNS 1035715 (Cyber-physical systems program), “Assuring the safety, security and reliability of medical device cyber physical systems,” 10/1/2010–9/30/2015, \$5,000,000 (multi-institution proposal, PI: I. Lee).
9. PI, Gigascale Systems Research Center, 11/1/2009–10/30/2012, \$300,000.
10. CoPI, NSF award CNS 0931239, “Quantitative analysis and design of control networks,” 9/1/2009–8/31/2012, \$1,500,000 (with I. Lee, R. Mangharam, G.J. Pappas, and A. Ribeiro).
11. PI, NSF award CCF 0915777, “Scalable symbolic analysis of hybrid systems,” 9/1/2009–8/31/2012, \$376,430.
12. PI, NSF award CCF 0905464, “Formal analysis of concurrent software on relaxed memory models,” 9/1/2009–8/31/2012, \$1,200,000 (with M.M.K. Martin).
13. PI, General Motors, “Formal modeling and analysis of hybrid systems,” 6/1/2007–5/31/2009, \$232,741.
14. PI, NSF award CPA 0541149, “Behavioral interfaces for software components,” 9/1/2006–8/31/2009, \$300,000.
15. CoPI, NSF Cybertrust award CNS 0524059, “Resource guided implementation of secure embedded software,” 9/1/2005–8/31/2009, \$1,000,000 (with A. Scedrov and S. Zdancewic).
16. CoPI, NSF award CSR-EHS 0509143, “A hierarchy of models for embedded software,” 8/1/2005–7/31/2008, \$500,000 (with I. Lee and W. Wolf).
17. PI, NSF award CCR-0410662, “Synthesis of embedded software from hybrid models,” 9/1/2004–8/31/2007, \$400,001 (with I. Lee and G. Pappas).
18. PI, NSF award CCR-0401049, “Workshop on hybrid systems,” 4/15/2004–4/15/2005, \$20,000 (with G.J. Pappas).
19. CoPI, NSF award CCR-0318299, “Workshop on embedded software,” 7/15/2003–6/30/2004, \$15,000 (with I. Lee).
20. PI, NSF award CCR-0306382, “Games for formal design and verification of reactive systems,” 6/1/2003–5/31/2006, \$270,000.
21. CoPI, NSF award CCR-0209990, “Third party programmability of embedded systems,” 7/1/2002–6/30/2004, \$180,000 (with C. Gunter).
22. PI, NSF ITR award ITR/SY 0121431, “Formal Design and Analysis of Hybrid Systems,” 9/1/2001–8/31/2006, \$1,000,000 (with G.J. Pappas).
23. CoPI, ARO URI award DAAD19-01-1-0473, “Advanced Tool Integration for Embedded Systems Assurance,” 5/1/2001–4/30/2006, \$4,984,330 (with C. Gunter, S. Kannan, I. Lee, and O. Sokolsky).
24. CoPI, DARPA BIOCAMP program award, “Modeling, Analysis, Simulation, and Synthesis of Biomolecular Networks,” 8/24/2001–8/23/2004, \$298,635 (with V. Kumar, G.J. Pappas, H. Rubin, and J. Schug).
25. CoPI, DARPA ITO Mobies award F33615-00-C-1707, “Design, Implementation, and Validation of Embedded Software,” 7/1/2000–6/30/2003, \$2,250,000 (with V. Kumar, I. Lee, and G. Pappas).
26. PI, SRC (Semiconductor Research Corporation) award 99-TJ-688, “Exploiting hierarchical structure for efficient formal verification,” 7/1/1999–6/30/2002, \$366,000.

27. PI, NSF award CCR99-70925, "Specification, analysis, and testing of scenario-based requirements," 9/15/1999-8/31/2002, \$215,000.
28. CoPI, DARPA ITO MARS award 130-1303-4-534328, "Control of Multiple Autonomous Robots," 7/1/1999-6/30/2002, \$1,800,000 (with K. Daniilidis, V. Kumar, I. Lee, C.J. Taylor, and L. Unger).
29. PI, Alfred P. Sloan Faculty Fellowship, 9/1/1999-8/31/2001, \$35,000.
30. PI, NSF CAREER award CCR97-34115, "Computer-aided verification of reactive systems," 7/1/1998-6/31/2002, \$200,000.
31. CoPI, DARPA/NASA grant NAG2-1214, "MOCHA: Modularity in model checking," 5/1/98-4/30/00, \$850,000 (with T.A. Henzinger).