

WALTER RANCE CLEVELAND II

Department of Computer Science
University of Maryland at College Park
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- **Research interests:** Automated and interactive tools for reasoning about computer systems. Specification and verification of concurrent and distributed systems. Formal methods in system design and analysis. Semantics of programming languages and logics. Applications of logic in Computer Science.

- **Work experience:**

From 2005 Professor of Computer Science, University of Maryland at College Park.

From 2005 Executive and Scientific Director, Fraunhofer USA Center for Experimental Software Engineering, Maryland.

From 1999 CEO, Reactive Systems, Inc.

1998–2005 Professor of Computer Science, SUNY at Stony Brook.

1994–1998 Associate Professor of Computer Science, NC State University.

1989–1994 Assistant Professor of Computer Science, NC State University.

1987–1989 Research Fellow in Computer Science, Sussex University, England.

- **Education:**

Cornell University: PhD May 1987, MS June 1985

Subject: Computer Science

Thesis: *Type-Theoretic Models of Concurrency*

Supervisor: Robert L. Constable

Awards: National Science Foundation Graduate Fellow

IBM Graduate Fellow

Sage Graduate Fellow

Duke University: BS *summa cum laude* May 1982

Majors: Mathematics, Computer Science

Awards: Phi Beta Kappa, Angier B. Duke Scholar, National Merit Scholar

- **Awards:**

1998 Elected Member of IFIP Working Group 2.2.

1994 Alcoa Foundation Engineering Research Achievement Award.

1992 National Science Foundation National Young Investigator Award.

1992 Office of Naval Research Young Investigator Award.

1991 Shell Undergraduate Teaching Award, North Carolina State University.

- **Patents:**

U.S. Patent 6,385,765, “Specification and Verification for Concurrent Systems with Graphical and Textual Editors,” issued May 7, 2002.

- **Research Funding:**

National Science Foundation. Proposal title: “Verification of Open-Loop Embedded Control Systems.” Duration: August 2008–July 2011. Amount: \$350,000.

Office of Naval Research (Small Business Innovation Research). Proposal title: “A Software Hub for High Assurance Model-Driven Development and Analysis.” Co-PI: Steve Sims. Duration: October 2007–September 2009. Amount: \$375,000.

Office of Naval Research (Small Business Innovation Research). Proposal title: “A Software Hub for High Assurance Model-Driven Development and Analysis.” Co-PI: Steve Sims. Duration: August 2006–January 2007. Amount: \$100,000.

Army Research Office. Proposal title: “Advanced Formal Methods for Reliable Systems Engineering.” Co-PIs: Scott Smolka, Eugene Stark. Duration: February 2001–January 2005. Amount: \$408,000.

Army Research Office. Proposal title: “An Integrated Environment for Control Software Engineering.” Co-PIs: Scott Smolka, Eugene Stark. Duration: November 2000–October 2004. Amount: \$365,000.

National Science Foundation. Proposal title: “Heterogeneous Specification Formalisms for Reactive Systems.” Duration: May 2000–April 2005. Amount: \$325,000.

National Science Foundation. Proposal title: “Automated Analysis of Probabilistic Open Systems” Co-PI: Purushothaman Iyer Duration: May 2001–May 2003 Amount: \$210,000.

National Science Foundation (Small Business Innovation Research). “Advanced Formal Techniques for Dependable Reactive Systems.” Co-PIs: Steve Sims, Scott Smolka. Duration: March 2001–March 2003. Amount: \$499,890.

National Science Foundation (Small Business Innovation Research). “Advanced Formal Techniques for Dependable Reactive Systems.” Co-PIs: Steve Sims, Scott Smolka. Duration: January 2000–June 2000. Amount: \$99,726.

National Science Foundation. Proposal title: “Specification Formalisms for Component-Based Concurrent Systems.” Duration: July 1998–June 2001. Amount: \$148,000.

Army Research Office. Proposal title: “Abstraction-Based Approaches to Correct Reactive Software.” Co-PI: S. Purushothaman Iyer. Duration: July 1998–June 2001. Amount: \$270,000.

DARPA. Proposal Title: “GIANT: Global Intrusion Assessment Through Distributed Decision Making” Co-PI: Felix Wu. Duration: May 1998–November 1999. Amount: \$1,022,402.

National Science Foundation. Proposal title: “Verification Tools for Net-based Programming.” NSF Postdoctoral Researcher Award. Duration: April 1998–April 2000. Amount: \$66,000.

National Science Foundation. Proposal title: “Development and Implementation of Heterogeneous Verification Methods for Distributed Systems.” International collaboration with University of Passau, Germany. Duration: April 1997–March 1999. Amount: \$16,395.

DARPA. Proposal title: “Scalable Intrusion Detection for Network Infrastructure.” Co-PI: Felix Wu. Duration: September 1996–September 1999. Amount: \$189,527.

National Science Foundation. Proposal title: “Practical Techniques for the Design, Specification, Verification, and Implementation of Concurrent Systems.” Co-PIs: Scott Smolka and Philip Lewis, SUNY–Stony Brook. Duration: February 1996–January 1999. Amount: \$309,000.

Air Force Office of Scientific Research. Proposal title: “Advanced Formal Methods for Reliable Critical Systems Software.” Co-PIs: Insup Lee, University of Pennsylvania, and Scott Smolka, SUNY–Stony Brook. Duration: August 1995–August 1998. Amount: \$1,220,000.

National Science Foundation. Proposal title: “Analysis and Verification of Concurrent Systems” (equipment grant). Co-PIs: S. Purushothaman Iyer, K.C. Tai, Mladen Vouk. Duration: May 1995–April 1996. Amount: \$37,083.

National Science Foundation. Proposal title: “Methodologies for the Automatic Verification of Concurrent Systems.” Duration: September 1994–August 1997. Amount: \$165,632.

National Science Foundation National Young Investigator Award. Duration: August 1992–July 1997. Amount: \$212,500.

Office of Naval Research Young Investigator Award. Duration: June 1992–October 1996. Amount: \$375,000.

National Science Foundation. Proposal title: “Automated Generation of Verification Tools.” International collaboration with INRIA-Sophia Antipolis, France. Duration: June 1992–April 1996. Amount: \$22,235.

National Science Foundation. Proposal title: “The Concurrency Factory—Practical Tools for the Automated Verification of Concurrent Systems.” Co-PIs: Scott Smolka and Philip Lewis, SUNY–Stony Brook. Duration: March 1992–February 1996. Amount: \$523,064.

National Science Foundation. Proposal title: “CONCUR ’92—Third International Conference on Concurrency Theory.” Co-PI: Scott Smolka, SUNY–Stony Brook. Duration: February 1992–December 1992. Amount: \$3,000.

Joint National Science Foundation/DARPA Initiative on Formal Methods in Software Engineering. Proposal title: “Methodologies for the Automated Verification of Concurrent Systems.” Duration: September 1990–July 1994. Amount: \$309,903.

National Science Foundation, Research Initiation Award. Proposal title: “Automated Verification of Concurrent Systems.” Duration: June 1990–June 1992. Proposal approved; funding included in above grant.

• **Publications:**

- [1] C. Ackermann, A. Ray, R. Cleaveland, J. Heit, C. Martin, and C. Shelton. Model based design verification: A monitor based approach. In *Society for Automotive Engineering World Congress*, Detroit, Michigan, April 2008. Society for Automotive Engineering. Paper #2008-01-0741.
- [2] M. Bernardo and R. Cleaveland. A theory of testing for Markovian processes. In C. Palamidessi, editor, *CONCUR 2000*, volume 1877 of *Lecture Notes in Computer Science*, pages 305–319, State College, Pennsylvania, August 2000. Springer-Verlag.
- [3] M. Bernardo, R. Cleaveland, S. Sims, and W. Stewart. TwoTowers: A tool integrating functional and performance analysis of concurrent systems. In S. Budkowski, A. Cavalli, and E. Najm, editors, *Formal Description Techniques and Protocol Specification, Testing and Verification (FORTE XI/PSTV XVIII '98)*, pages 457–467, Paris, November 1998. Chapman and Hall.
- [4] G. Bhat and R. Cleaveland. Efficient local model checking for fragments of the modal μ -calculus. In T. Margaria and B. Steffen, editors, *Tools and Algorithms for the Construction and Analysis of Systems (TACAS '96)*, volume 1055 of *Lecture Notes in Computer Science*, pages 107–126, Passau, Germany, March 1996. Springer-Verlag.
- [5] G. Bhat and R. Cleaveland. Efficient model checking via the equational μ -calculus. In *Eleventh Annual Symposium on Logic in Computer Science (LICS '96)*, pages 304–312, New Brunswick, New Jersey, July 1996. IEEE Computer Society Press.
- [6] G. Bhat, R. Cleaveland, and A. Groce. Efficient model checking via Buechi tableau automata. In G. Berry, H. Comon, and A. Finkel, editors, *Computer Aided Verification (CAV 2001)*, volume 2102 of *Lecture Notes in Computer Science*, pages 38–52, Paris, July 2001. Springer-Verlag.
- [7] G. Bhat, R. Cleaveland, and O. Grumberg. Efficient on-the-fly model checking for CTL*. In *Tenth Annual Symposium on Logic in Computer Science (LICS '95)*, pages 388–397, San Diego, July 1995. IEEE Computer Society Press.
- [8] G. Bhat, R. Cleaveland, and G. Luetzgen. Dynamic priorities for modeling real-time. In T. Mizuno, N. Shiratori, T. Higashino, and A. Togashi, editors, *Formal Description Techniques and Protocol Specification, Testing and Verification (FORTE X/PSTV XVII '97)*, pages 321–336, Osaka, November 1997. Chapman and Hall.
- [9] G. Bhat, R. Cleaveland, and G. Luetzgen. A practical approach to implementing real-time semantics. *Annals of Software Engineering*, 7:127–155, October 1999. special issue on real-time software engineering.
- [10] E. Brinksma, R. Cleaveland, K.G. Larsen, and B. Steffen, editors. *Tools and Algorithms for the Construction and Analysis of Systems (TACAS '95)*, volume 1019 of *Lecture Notes in Computer Science*, Aarhus, Denmark, May 1995. Springer-Verlag.

- [11] U. Celikkan and R. Cleaveland. Computing diagnostic tests for incorrect processes. In *Proceedings of the IFIP Symposium on Protocol Specification, Testing and Verification*, pages 263–278, Lake Buena Vista, Florida, June 1992. North-Holland.
- [12] U. Celikkan and R. Cleaveland. On computing diagnostic information for pre-order checking. In G.v. Bochmann and D.K. Probst, editors, *Computer Aided Verification (CAV '92)*, volume 663 of *Lecture Notes in Computer Science*, pages 370–383, Montréal, June/July 1992. Springer-Verlag.
- [13] U. Celikkan and R. Cleaveland. Generating diagnostic information for behavioral preorders. *Distributed Computing*, 9:61–75, 1995.
- [14] R. Cleaveland. On automatically distinguishing inequivalent processes. In E.M. Clarke and R.P. Kurshan, editors, *Computer-Aided Verification '90*, volume 3 of *DIMACS Series in Discrete Mathematics and Theoretical Computer Science*, pages 463–477, Piscataway, NJ, June 1990. American Mathematical Society.
- [15] R. Cleaveland. On automatically explaining bisimulation inequivalence. In E.M. Clarke and R.P. Kurshan, editors, *Computer Aided Verification (CAV '90)*, volume 531 of *Lecture Notes in Computer Science*, pages 364–372, Piscataway, NJ, June 1990. Springer-Verlag.
- [16] R. Cleaveland. Tableau-based model checking in the propositional mu-calculus. *Acta Informatica*, 27(8):725–747, September 1990.
- [17] R. Cleaveland, editor. *CONCUR '92*, volume 630 of *Lecture Notes in Computer Science*. Springer-Verlag, Stony Brook, New York, August 1992.
- [18] R. Cleaveland. Analyzing concurrent systems using the Concurrency Workbench. In P.E. Lauer, editor, *Functional Programming, Concurrency, Simulation and Automated Reasoning*, volume 693 of *Lecture Notes in Computer Science*, pages 129–144. Springer-Verlag, 1993.
- [19] R. Cleaveland. An operational semantics of value-passing. In *Proceedings of the North American Process Algebra Workshop*, Cornell University Technical Report TR 93-1369, Ithaca, New York, August 1993.
- [20] R. Cleaveland. Formality and software design. *ACM Computing Surveys*, 28(4es), December 1996. Article 117, URL <http://www.acm.org/surveys>.
- [21] R. Cleaveland. Semantic theories and system design. *ACM Computing Surveys*, 28(4es), December 1996. Article 41, URL <http://www.acm.org/surveys>.
- [22] R. Cleaveland. Pragmatics of model checking: An STTT special section. *Software Tools for Technology Transfer*, 2(3):208–218, November 1999.
- [23] R. Cleaveland, editor. *Tools and Algorithms for the Construction and Analysis of Systems (TACAS '99)*, volume 1579 of *Lecture Notes in Computer Science*, Amsterdam, March 1999. Springer-Verlag.
- [24] R. Cleaveland. Alternative approaches to symbolic verification: An STTT special section. *Software Tools for Technology Transfer*, 3(3):247–249, August 2001.

- [25] R. Cleaveland, Z. Dayar, S. Smolka, and S. Yuen. Testing preorders for probabilistic processes. *Information and Computation*, 154(2):93–148, November 1999.
- [26] R. Cleaveland, X. Du, and S. Smolka. GCCS: A graphical coordination language for system specification. In A. Porto and G.-C. Roman, editors, *COORDINATION 2000*, volume 1906 of *Lecture Notes in Computer Science*, pages 284–298, Limassol, Cyprus, September 2000. Springer-Verlag.
- [27] R. Cleaveland, J. Gada, P. Lewis, S. Smolka, O. Sokolsky, and S. Zhang. The Concurrency Factory—Practical tools for the specification, simulation, verification, and implementation of concurrent systems. In G.E. Blelloch, K.M. Chandy, and S. Jagannathan, editors, *Specification of Parallel Algorithms*, volume 18 of *DI-MACS Series in Discrete Mathematics and Theoretical Computer Science*, pages 75–90, Piscataway, NJ, May 1994. American Mathematical Society.
- [28] R. Cleaveland and H. Garavel, editors. *FMICS’02: 7th International ERCIM Workshop in Formal Methods for Industrial Critical Systems*, volume 66 of *Electronic Notes in Theoretical Computer Science*. Elsevier, University of Málaga, Spain, December 2002. ISBN 0444513418, URL <http://www.elsevier.com/locate/entcs/volume66.html>.
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- [30] R. Cleaveland and M.C.B. Hennessy. Testing equivalence as a bisimulation equivalence. In J. Sifakis, editor, *Automatic Verification Methods for Finite State Systems*, volume 407 of *Lecture Notes in Computer Science*, pages 11–23, Grenoble, June 1989. Springer-Verlag.
- [31] R. Cleaveland and M.C.B. Hennessy. Priorities in process algebra. *Information and Computation*, 87(1/2):58–77, July/August 1990.
- [32] R. Cleaveland and M.C.B. Hennessy. Testing equivalence as a bisimulation equivalence. *Formal Aspects of Computing*, 5:1–20, 1993.
- [33] R. Cleaveland and S. Purushothaman Iyer. Branching time probabilistic model checking. In J.D.P. Rolim, A.Z. Broder, A. Corradini, R. Gorrieri, R. Heckel, J. Hromkovic, U. Vaccaro, and J.B. Wells, editors, *ICALP Workshops 2000*, volume 8 of *Proceedings in Informatics*, pages 487–500, Geneva, July 2000. Carleton Scientific.
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- [50] R. Cleaveland, T. Magaria, and B. Steffen. Editorial. *Software Tools for Technology Transfer*, 1(1+2):1–5, December 1997.
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- [67] R. Cleaveland and B. Steffen. A linear-time model-checking algorithm for the alternation-free modal mu-calculus. In K.G. Larsen and A. Skou, editors, *Computer Aided Verification (CAV '91)*, volume 575 of *Lecture Notes in Computer Science*, pages 48–58, Aalborg, Denmark, July 1991. Springer-Verlag.
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- on Foundations of Software Engineering*, pages 120–129, San Diego, California, November 2000. ACM.
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 - [86] V. Natarajan, L. Christoff, I. Christoff, and R. Cleaveland. Priorities and abstraction in process algebra. In P.S. Thiagarajan, editor, *Foundations of Software Technology and Theoretical Computer Science*, volume 880 of *Lecture Notes in Computer Science*, pages 217–230, Madras, India, December 1994. Springer-Verlag.
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- [117] D. Zhang, R. Cleaveland, and E. Stark. The integrated CWB-NC/PIOATool for functional verification and performance analysis of concurrent systems. In H. Garavel and J. Hatcliff, editors, *Tools and Algorithms for the Construction and Analysis of Systems (TACAS 2003)*, volume 2619 of *Lecture Notes in Computer Science*, pages 431–436, Warsaw, Poland, April 2003. Springer-Verlag.

- **Systems Work**

Reactis® One of chief designers and implementors of this tool, which is a testing and validation tool for Simulink® / Stateflow® models of embedded software. Software is being distributed by Reactive Systems, Inc.

The Concurrency Workbench One of chief designers and implementors of this tool, which supports a variety of different automatic techniques for verifying finite-state concurrent systems. Software has been acquired by, and used at, numerous sites around the world.

PAC With group at INRIA in Sophia-Antipolis, France, designed and built a front-end generator, the Process Algebra Compiler, for the Concurrency Workbench. All Workbench front ends are now built using this tool.

The Concurrency Factory With group at SUNY-Stony Brook, am building C++/X-based design and verification tool for concurrent systems. Prototype has been completed.

VTVIEW/VTSIM One of chief designers of these systems, which support the graphical editing and simulation of structured networks of communicating finite-state processes. Tools are being incorporated into Concurrency Factory (see below).

GDR One of chief designers of this system, an X-based graph algorithm animation tool. Tool has been used for instructional purposes at N.C. State University in discrete math and automata theory classes.

- **Conference Presentations and Invited Lectures:**

1. “Model-Based Verification of Embedded Control Software” at Siemens Corporate Research, Princeton, New Jersey, June 2008.
2. “Modeling in Certification: An FAA Experience” at Workshop on Software Certification, Arlington, Virginia, April 2008.
3. “Model Based Design Verification: A Monitor Based Approach” at 2008 Society for Automotive Engineering World Congress, Detroit, Michigan, April 2008.
4. “Formal Methods in Control System Design” invited talk at Car Testing Japan 2008, Tokyo, Japan, March 2008.

5. “Formal Methods: Past, Present, Future” at Division of Software Engineering and Systems Assurance, Center for Systems and Software Engineering, Office of the Secretary of Defense, Arlington, Virginia, February 2008.
6. “An Instrumentation-Based Approach to Controller Validation” at Dagstuhl Workshop on Model-Based Engineering of Embedded Real-Time Systems, Dagstuhl, Germany, November 2007.
7. “Does Certification = Verification? Formal Methods and Software Certification” at Workshop on Software Certification, Arlington, Virginia, August 2007.
8. “Model-Based Validation of Embedded Control Software” at Software Engineering Consortium meeting, Raleigh, North Carolina, May 2007.
9. “There, and Back Again: Lessons Learned on the Way to the Marketplace” invited talk at the European Joint Symposia on Theory and Practice of Software, Braga, Portugal, March 2007.
10. “An Instrumentation-Based Approach to Controller Validation” invited talk at the GM R&D Workshop on Next Generation Design and Verification Methodologies for Distributed Embedded Control Systems, Bangalore, India, January 2007.
11. “Model-Based Validation of Embedded Software” at Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, Pennsylvania, November 2006.
12. “Model Based Verification and Validation of Distributed Control Architectures” at the 2006 Convergence Transportation Electronics Conference, Detroit, Michigan, October 2006.
13. “Does Certification = Verification? Formal Methods and Software Certification” invited talk at CERTSOFT 2006, Hamilton, Ontario, Canada, August 2006.
14. “An Instrumentation-Based Approach to Controller Model Validation” at the Automotive Software Workshop, San Diego, California, March 2006.
15. “Verification and Validation within Model-Based Design using Reactis” at the 2005 MATLAB Expo, Tokyo, Japan, December 2005.
16. “Fast Generic Model-Checking for Data-Based Systems” at Formal Techniques for Networked and Distributed Systems, Taipei, Taiwan, October 2005.
17. “Model-Based Validation for Embedded Software,” invited tutorial at Formal Techniques for Networked and Distributed Systems, Taipei, Taiwan, October 2005.
18. “Model-Based Processes for Embedded System Development,” invited presentation at High-Tech Connections 2005, Cambridge, Massachusetts.
19. “Automating Software Validation in Model-Based Development” at the 2004 MATLAB Expo, Tokyo, Japan, December 2004.
20. “Executable Software Architectures Using Architectural Interaction Diagrams” at University of Maryland, College Park, Maryland, October 2004.

21. “Commercial Tool Integration: The Reactis Experience” at the 2004 Monterey Workshop on Software Engineering Tools: Compatibility and Integration, Vienna Austria, October 2004.
22. “Validating Embedded Software Using Reactis” at the Fraunhofer Institute for Experimental Software Engineering, College Park, Maryland, September 2004.
23. “Perspectives on Software V&V: The Story of Reactive Systems” to Japanese MathWorks Automotive Advisory Board, Tokyo, Japan, December 2003.
24. “Automated Software Validation Using Reactis, Simulink and Stateflow” at the 2003 MATLAB Expo, Tokyo, Japan, December 2003.
25. “Model Verification Using Reactis Validator” at General Motors Research and Development Center, Warren, Michigan, November 2003.
26. “Model Verification Using Reactis Validator” at Delphi Technical Research Center, Brighton, Michigan, November 2003.
27. “Validating Embedded Software Using Reactis” at University of York, United Kingdom, July 2003.
28. “Crossing Boundaries, Compositionally” at the Centrum voor Wiskunde en Informatica, Amsterdam, the Netherlands, February 2003.
29. “Understanding Behavior in Software Design Languages: A Compositional Semantics of Statecharts” at University of Málaga, Málaga, Spain, July 2002.
30. “Adventures in Early-Stage Finance at Reactive Systems, Inc.” at National Science Foundation SBIR Grantees Workshop, Washington DC, April 2002.
31. “Understanding Behavior in UML: A Compositional Semantics of Statecharts” at DePaul University, October 2001.
32. “A Semantic Theory for Heterogeneous System Design” at DePaul University, October 2001.
33. “Distributed Prototyping from Validated Specifications” at the Twelfth IEEE International Workshop on Rapid System Prototyping, Monterey, California, June 2001.
34. “Simulation Revisited” at the Seventh International Conference on Tools and Algorithms for the Construction and Analysis of Systems, Genoa, Italy, April 2001.
35. “A Compositional Approach to Statecharts Semantics” at the Eighth International Symposium on Foundations of Software Engineering, San Diego, California, November 2000.
36. “GCCS: A Graphical Coordination Language for System Specification” at COORDINATION 2000, Limassol, Cyprus, September 2000.
37. “Branching-Time Probabilistic Model Checking” at the Eighth International Workshop on Process Algebra and Performance Modelling, Geneva, Switzerland, July 2000.

38. “Probabilistic Model Checking via the Modal Mu-Calculus.” Invited talk at the Workshop on Mathematical Foundations of Programming Semantics, Hoboken, New Jersey, April 2000.
39. “A Temporal Process Logic.” Invited talk at CONCUR '99, Eindhoven, the Netherlands, August 1999.
40. “Statecharts via Process Algebra” at CONCUR '99, Eindhoven, the Netherlands, August 1999.
41. “Probabilistic Model Checking via the Modal Mu-Calculus.” Invited talk at the Workshop on Probabilistic Methods in Verification, Eindhoven, the Netherlands, August 1999.
42. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at Institute for Computer Applications in Science and Engineering, NASA Langley Research Center, Hampton, Virginia, June 1999.
43. “Probabilistic Temporal Logics via the Modal Mu-calculus” at the 1999 Conference on Foundations of Software Science and Computation Structures, Amsterdam, the Netherlands, March 1999.
44. “A Tool Framework for Verifying Concurrent Systems” at Indiana University, December 1998.
45. “An Operational Semantics of Temporal Logic” at Indiana University, December 1998.
46. “A Tool Framework for Verifying Concurrent Systems” at the 1998 ARO/ONR/NSF/DARPA Monterey Workshop on Engineering Automation of Computer-Based Systems, Monterey, California, October 1998.
47. “An Operational Semantics of Temporal Logic” at Institute for Computer Applications in Science and Engineering, NASA Langley Research Center, Hampton, Virginia, September 1998.
48. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at Army Research Office Workshop on Software Design Automation for Reactive Systems, Durham, North Carolina, July 1998.
49. “Observational Equivalences for Process Algebras with Priority” at IFIP Working Group 2.2 meeting, Shelter Island, New York, June 1998.
50. “Observational Equivalences for Process Algebras with Priority” at INRIA-Rhône-Alpes, Grenoble, France, April 1998.
51. “A Tool Framework for Verifying Concurrent Systems” at State University of New York at Stony Brook, March 1998.
52. “Building Better Büchi Automata: An Operational Semantics of Temporal Logic” at the meeting of IFIP Working Group 2.2, Graz, Austria, September 1997.
53. “A Tool Framework for Verifying Concurrent Systems” at the National University of Singapore, July 1997.

54. “A Tool Framework for Verifying Concurrent Systems.” Invited talk at the Second International Workshop on Applied Formal Methods in System Design, Zagreb, Croatia, June 1997.
55. “A Tool Framework for Verifying Concurrent Systems” at the University of Passau, Germany, June 1997.
56. “A Tool Framework for Verifying Concurrent Systems” at State University of New York at Stony Brook, March 1997.
57. “A Tool Framework for Verifying Concurrent Systems” at Kansas State University, November 1996.
58. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at Kansas State University, October 1996.
59. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at the University of North Carolina, April 1996.
60. “The Concurrency Factory Software Development Environment” at Second International Workshop on Tools and Algorithms for the Construction and Analysis of Systems, Passau, Germany, March 1996.
61. “Mu-Calculus Model Checking via LTL Model Checking” at AT&T/SUNY Stony Brook Workshop on Verification, Stony Brook, NY, November 1995.
62. “Verifying Fault-Tolerant Active Structural Control Systems” at AT&T Bell Laboratories, Murray Hill, NJ, October 1995.
63. “Divergence and Fair Testing” at IFIP Working Group 2.2 meeting, Amsterdam, June 1995.
64. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at University of Maryland at College Park, April 1995.
65. “Verifying Active Structural Control Systems: A Case Study in Formal Analysis” at State University of New York at Stony Brook, March 1995.
66. “Testing-Based Abstractions for Value-Passing Systems” at University of Illinois at Chicago, October 1994.
67. “A Uniform Approach to Real-Time Schedulability Analysis” at Institut National de Recherche en Informatique et en Automatique, Sophia-Antipolis, France, May 1994.
68. “An Operational Framework for Value-Passing Processes” at University of Passau, Germany, February 1994.
69. “Model Checking in the Modal Mu-Calculus” at Dagstuhl Workshop on Algorithms in Automata Theory, Dagstuhl, Germany, February 1994.
70. “An Operational Semantics of Value Passing” at *Second North American Process Algebra Workshop*, Ithaca, New York, August 1993.
71. “Practical Approaches to Proving Systems Correct” at Alcatel Network Systems, Raleigh, NC, June 1993.

72. “Model Checking in the Modal Mu-Calculus” at University of Maryland Computer Science Department, March 1993.
73. “Model Checking in the Modal Mu-Calculus” at Chalmers University of Technology, Gothenburg, Sweden, March 1993.
74. “Model Checking in the Modal Mu-Calculus” at the Swedish Institute of Computer Science, Kista, Sweden, March 1993.
75. “Model Checking in the Modal Mu-Calculus” at Uppsala University, Uppsala, Sweden, March 1993.
76. “Model Checking in the Modal Mu-Calculus” at L’Institut National de Recherche en Informatique et en Automatique, Sophia-Antipolis, France, December 1992.
77. “Model Checking in the Modal Mu-Calculus.” Invited talk at the *Workshop on Theory and Practice in Verification*, sponsored by the European Research Consortium in Informatics and Mathematics, Pisa, Italy, December 1992.
78. “The Concurrency Workbench” at University of Maryland Computer Science Department, October 1992.
79. “On Computing Diagnostic Information for Preorder Checking” at *Third Annual Workshop on Computer-Aided Verification*, Montréal, Canada, June 1992.
80. “The Concurrency Workbench” at the Naval Research Laboratory, Washington, DC, May 1992.
81. “The Concurrency Workbench” at the University of Southern California Computer Science Department, April 1992.
82. “The Concurrency Workbench” at IBM Research Triangle Park, March 1992.
83. “Computing Behavioral Equivalences.” Invited tutorial at *CONCUR ’91*, Amsterdam, Holland, August 1991.
84. “Computing Behavioral Relations, Logically” at *Eighteenth International Colloquium on Automata, Languages and Programming*, Madrid, Spain, July 1991.
85. “The Concurrency Workbench” at McMaster University Computer Science Department, Hamilton, Ontario, Canada, March 1991. Part of *Functional Programming, Concurrency and Automated Reasoning* international lecture series.
86. “The Concurrency Workbench” at the University of Pennsylvania Computer Science Department, October 1990.
87. “On Automatically Distinguishing Inequivalent Processes” at University of Aarhus Computer Science Department, Aarhus, Denmark, August 1990.
88. “On Automatically Distinguishing Inequivalent Processes” at Hewlett-Packard European Research Labs, Bristol, England, August 1990.
89. “On Automatically Distinguishing Inequivalent Processes” at *Second Annual Workshop on Computer-Aided Verification*, Piscataway NJ, June 1990.
90. “Implementing the Concurrency Workbench Using Standard ML” at *Standard ML Workshop*, Princeton NJ, June 1990.

91. “When Is ‘Partial’ Adequate? A Logic-Based Proof Technique Using Partial Specifications” at *Fifth Annual Symposium on Logic in Computer Science*, Philadelphia PA, June 1990.
92. “Testing Equivalence as a Bisimulation Equivalence” at *Workshop on Automatic Verification Methods for Finite-State Systems*, Grenoble France, June 1989.
93. “The Concurrency Workbench” at Carnegie-Mellon University Computer Science Department, April 1989.
94. “The Concurrency Workbench” at Johns-Hopkins University Computer Science Department, March 1989.
95. “Priorities in Process Algebras” at *Third Annual Symposium on Logic in Computer Science*, Edinburgh Scotland, July 1988.
96. “Priorities in Process Algebras” at Cambridge University Computer Science Department, Cambridge, England, June 1988.

- **Professional activities:**

Co-editor-in-chief, *Software Tools for Technology Transfer* journal (Springer-Verlag), 1997–2001; editorial board member 1997–.

Associate editor, *Formal Methods in System Design* journal (Kluwer), 1997–.

Associate editor, *Electronic Notes in Theoretical Computer Science*, 2000–.

Associate editor, *IEEE Transactions on Software Engineering*, 2006–.

Associate editor, *Journal of Computing Science and Engineering*, 2007–.

Co-editor, special issue of *Journal of Automated Software Engineering*, 1998.

Member, Steering Committee, Conference on Tools and Algorithms for the Construction and Analysis of Systems, 1995–.

Member, Steering Committee, European Joint Conferences on Theory and Practice of Software, 1998–1999.

Co-organizer, 1998 IFIP Working Conference on Programming Concepts and Methods, Shelter Island, New York.

Co-organizer, 1997 DARPA-ITO Workshop on Software-Enabled Control, Atlanta, Georgia.

Co-chairman, 1997 Workshop on Automated Analysis of Software, Paris, France.

Co-chairman, 2002 Workshop on Formal Methods in Industrial Critical Systems, Málaga, Spain.

Chairman, Program Committee, 1999 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Amsterdam, the Netherlands.

Chairman, Program Committee, CONCUR '92 conference, Stony Brook, New York.

Member of following Program Committees:

1. 2009 Conference on Tools and Algorithms for the Construction and Analysis of Systems, to be held in York, England.
2. 2008 Real-Time Systems Symposium, to be held in Barcelona, Spain.
3. 2008 International Conference on Software Engineering (Automotive Experience Track), Leipzig, Germany, May 2008.
4. 2008 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Budapest, Hungary, March 2008.
5. 2007 Monterey Workshop on Innovations for Requirements Analysis: From Stakeholders Needs to Formal Designs, Monterey, California, September 2007.
6. 2007 Workshop on Software Engineering for Automotive Systems, Minneapolis, Minnesota, May 2007.
7. 2007 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Braga, Portugal, March 2007.
8. 2007 Hawaii International Conference On System Sciences (Automated Software Testing and Analysis: Techniques, Practices and Tools topic), The Big Island, Hawaii, January 2007.
9. 2006 International Workshop on Software Certification, Hamilton, Ontario, Canada, August 2006.
10. 2006 International Workshop on Formal Methods for Industrial Critical Systems, Bonn, Germany, August 2006.
11. 2006 Annual ACM Conference on Embedded Software, Seoul, South Korea, August 2006.
12. 2006 ACM-IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE'06), Napa Valley, California, July 2006.
13. 2006 Workshop on Software Engineering for Automotive Systems, Shanghai, China, May 2006.
14. 2006 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Vienna, Austria, March 2006.
15. 2005 Workshop on Software Engineering for Automotive Systems, St. Louis, Missouri.
16. 2005 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Edinburgh, Scotland.
17. 2004 Real-Time Systems Symposium, Lisbon, Portugal.
18. 2004 Workshop on Software Engineering for Automotive Systems, Edinburgh, Scotland.
19. 2004 Workshop on Semantic Foundations of Engineering Design Languages, Barcelona, Spain.
20. 2004 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Barcelona, Spain.
21. 2003 Workshop on Radical Innovations of Software and Systems Engineering in the Future, to be held in Venice, Italy.
22. 2003 Workshop on Run-Time Verification, Boulder, Colorado.

23. 2003 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Warsaw, Poland.
24. 2002 Workshop on Real-Time Tools, Copenhagen, Denmark.
25. 2002 Workshop on Run-Time Verification, Copenhagen, Denmark.
26. 2002 Workshop on Formal Methods in Industrial Critical Systems, Málaga, Spain.
27. 2002 Conference on Tools and Algorithms for the Construction and Analysis of Systems, to be held in Grenoble, France.
28. 2002 Workshop on Semantic Foundations of Engineering Design Languages, to be held in Grenoble, France.
29. 2001 Workshop on Runtime Verification, Paris, France.
30. 2001 Workshop on Expressiveness Issues in Concurrency (EXPRESS 2001), Aalborg, Denmark.
31. 2001 Workshop on Probabilistic Methods in Verification, Aachen, Germany.
32. 2001 Symposium on Logic in Computer Science, Boston, Massachusetts.
33. 2001 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Genoa, Italy.
34. 2000 Real-Time Systems Symposium, Orlando, Florida.
35. 2000 Symposium on Foundations of Software Technology and Theoretical Computer Science, New Delhi, India.
36. 2000 Workshop on Expressiveness Issues in Concurrency (EXPRESS 2000), State College, Pennsylvania.
37. 2000 International Colloquium on Automata, Languages and Programming, Geneva, Switzerland.
38. 2000 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Berlin, Germany.
39. 2000 Symposium on Principles of Programming Languages, Boston, Massachusetts.
40. 1999 Workshop on Process Algebra and Performance Modelling, Zaragoza, Spain.
41. 1999 Symposium on Principles of Distributed Computing, Atlanta, Georgia.
42. 1999 AMAST Workshop on Real-Time and Probabilistic Systems, Bamberg, Germany.
43. 1999 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Amsterdam, the Netherlands.
44. 1998 Conference on Tools and Algorithms for the Construction and Analysis of Systems, Lisbon, Portugal.
45. 1997 Second Joint US/Brazil Workshop on Formal Foundations of Software Systems, New Orleans.
46. 1997 Conference on Computer-Aided Verification, Haifa, Israel.
47. 1997 Workshop on Tools and Algorithms for the Construction and Analysis of Systems, Enschede, the Netherlands.

48. 1996 Asian Computing Science Conference, Singapore.
49. CONCUR '96, Pisa, Italy.
50. 1996 Workshop on Tools and Algorithms for the Construction and Analysis of Systems, Passau, Germany.
51. 1996 Symposium on Principles of Programming Languages, St. Petersburg, Florida.
52. 1996 International Symposium on Software Testing and Analysis, San Diego.
53. CONCUR '95 conference, Philadelphia.
54. 1995 Workshop on Tools and Algorithms for the Construction and Analysis of Systems, Aarhus, Denmark.
55. 1995 Symposium on Principles of Programming Languages, San Francisco.
56. 1994 Conference on Computer-Aided Verification, Palo Alto, California.
57. 1993 North American Process Algebra Workshop, Ithaca, New York.
58. CONCUR '93 conference, Hildesheim, Germany.
59. 1993 Conference on Computer-Aided Verification, Heraklion, Greece.
60. 1993 Symposium on Protocol Specification, Testing and Verification, Liège, Belgium.
61. 1992 North American Process Algebra Workshop, Stony Brook, New York.
62. 1992 Symposium on Logic in Computer Science, Santa Cruz, California.
63. 1991 Workshop on Computer-Aided Verification, Aalborg, Denmark.

Distinguished Lecturer, DePaul University, October 2001.

Distinguished Lecturer, Kansas State University, October 1996.

Distinguished Lecturer, University of Maryland at College Park, October 1992.

Invited speaker at following conferences and workshops:

1. 2008 Car Testing Japan, Tokyo, Japan.
2. 2007 European Joint Symposia on Theory and Practice of Software, Braga, Portugal.
3. 2007 GM R&D Workshop on Next Generation Design and Verification Methodologies for Distributed Embedded Control Systems, Bangalore, India, January 2007.
4. 2006 CERTSOFT Workshop, Hamilton, Ontario, Canada.
5. 2004 MATLAB Expo, Tokyo, Japan.
6. 2004 Monterey Workshop, Vienna, Austria.
7. 2003 MATLAB Expo, Tokyo, Japan.
8. 2000 Workshop on Process Algebra and Performance Modeling, Geneva, Switzerland.
9. 2000 Workshop on Mathematical Foundations of Programming Semantics, Hoboken, New Jersey.
10. CONCUR '99 conference, Eindhoven, the Netherlands.

11. 1999 Workshop on Probabilistic Methods in Verification, Eindhoven, the Netherlands.
12. 1997 International Workshop on Applied Formal Methods in System Design, Zagreb, Croatia.
13. 1992 ERCIM Workshop on Theory and Practice in Verification, Pisa, Italy.
14. CONCUR '91 conference, Amsterdam, the Netherlands.

Panel organizer and moderator, 1999 European Joint Conferences on Theory and Practice of Software.

Co-chair of tools session, 1994 Workshop on Mathematical Foundations of Program Semantics, Manhattan, Kansas.

Guest Professor in Department of Computer Science, Technical University of Aachen, Germany, July 1991.

External examiner for PhD theses of Sergio Campos (Carnegie-Mellon University, September 1996), Linda Christoff (Uppsala University, Sweden, March 1993), Craig Damon (Carnegie-Mellon University, May 2000), Hakan Erdogmus (University of Quebec, October 1993), C.-C. Jou (SUNY Stony Brook, November 1992), Misa Keinänen (Helsinki University of Technology, Finland, December 2006), Gerald Lüttgen (University of Passau, Germany, March 1998), Radu Mateescu (L'Institut National Polytechnique de Grenoble, France, April 1998), Vasumathi Narayanan (Concordia University, Montréal, April 1997), Huajun Qin (SUNY Stony Brook, March 1991), Usa Sammapun (University of Pennsylvania, January 2007), Oleg Sokolsky (SUNY Stony Brook, April 1996), Simone Tini (University of Pisa, Italy, December 1999), Emilio Tuosto (University of Pisa, Italy, March 2003), Tim Willemse (Technical University of Eindhoven, February 2003), Daniel Yankelevich (University of Pisa, Italy, January 1993), Shipei Zhang (SUNY Stony Brook, May 1995).

External examiner for MS thesis of David Hansel (Technical University of Munich, July 2000).

Thesis reviewer for 1993 ACM Doctoral Dissertation Award.

Panel Member, 2004 CUE Workshop, Vienna Austria.

Panel Member, special session on Models and Formalisms for Reasoning about Temporal Phenomena, 1994 Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems, Austin, Texas.

Session chair at following conferences:

1. 2006 International Conference on Software Engineering.
2. 2006 Conference on Tools and Algorithms for the Construction and Analysis of Systems.
3. 2002 Workshop on Formal Methods in Industrial Critical Systems.
4. 2001 Conference on Tools and Algorithms for the Construction and Analysis of Systems.

5. CONCUR 2000.
6. 2000 International Colloquium on Automata, Languages and Programming.
7. CONCUR '99.
8. 1999 Conference on Tools and Algorithms for the Construction and Analysis of Systems.
9. 1998 Conference on Tools and Algorithms for the Construction and Analysis of Systems.
10. 1997 Workshop on the Automated Analysis of Software.
11. CONCUR '96.
12. 1996 International Workshop on Tools and Algorithms for the Construction and Analysis of Systems.
13. 1996 International Symposium on Software Testing and Analysis.
14. CONCUR '95.
15. 1995 Symposium on Principles of Programming Languages.
16. 1993 Conference on Computer-Aided Verification.
17. CONCUR '92.
18. 1992 Symposium on Logic in Computer Science.
19. 1991 Workshop on Computer-Aided Verification.

Member, Review Team, INRIA Research Direction, Paris, France, 2003.

Member, Review Panel, National Science Foundation Software Engineering and Languages Program, 2004.

Member, Review Panel, National Science Foundation Information Technology Research (Large-scale) Preproposals, 2003.

Member, Review Panel, National Science Foundation Information Technology Research (Medium-Size), 2001.

Member, Review Panel, National Science Foundation National Science Foundation Information Technology Research (Medium-Size) Preproposals, 2001.

Member, Review Panel, National Science Foundation CISE Postdoctoral Research Associates in Experimental Computer Science, 2000.

Member, Review Panel, National Science Foundation Experimental Software Systems Program, 1997.

Member, Review Panel, National Science Foundation Evolutionary Development of Complex Systems Initiative, 1996.

Member, Review Panel, 1991 National Science Foundation Research Initiation Awards.

Invited participant, Strategic Research Directions workshop of Army Research Office, 2001.

Member, Formal Methods and Concurrency working groups, 1996 ACM Workshop on Strategic Directions in Computing Research.

Member: ACM, IEEE Computer Society.

Referee for numerous scholarly journals, including *ACM Transactions on Programming Languages and Systems*, *Distributed Computing*, *Formal Methods in System Design*, *Formal Aspects of Computing*, *IEEE Transactions on Software Engineering*, *Information and Computation*, *Information Processing Letters*, *International Journal of Parallel Processing*, *Journal of the ACM*, *Journal of Parallel and Distributed Computation*, *Science of Computer Programming*, and *Theoretical Computer Science*.

Grant proposal reviewer for Army Research Office, Canadian National Science and Engineering Research Council, French Institute for Computer Science and Automation (INRIA), Italian Ministry for Universities and Research, Israel Science Foundation, National Science Foundation.

Book referee for Cambridge University Press, Macmillan Publishing, Oxford University Press.

Invited lecturer at *Reasoning about Concurrent and Communicating Systems*, University of Edinburgh Department of Computer Science, September 1988.

- **Thesis students:**

Christopher Ackermann, Ph.D. University of Maryland (expected 2011).

Girish Bhat, Ph.D. NCSU 1998. Thesis title: *Tableau-Based Approaches to Model Checking*. Current position: Technical staff, Motorola, San Diego, California.

Ufuk Celikkan, Ph.D. NCSU 1995. Thesis title: *Semantic Preorders in the Automated Verification of Concurrent Systems*. Current position: Technical staff, IBM, Austin, Texas.

André Fredette, Ph.D. NCSU 1993. Thesis title: *A Generalized Approach to the Schedulability Analysis of Real-Time Computer Systems*. Current position: Senior Director of Software Engineering, hatteras Networks, Research Triangle Park, North Carolina.

Arnab Ray, Ph.D. Stony Brook 2004. Thesis title: *Compositional Modeling of Interaction-centric Distributed Systems*. Current position: Research Scientist, Fraunhofer Center for Experimental Software Engineering, College Park, Maryland.

James Riely, Ph.D. UNC 1999. Thesis title: *Applications of Abstraction for Concurrent Programs*. Current position: Associate Professor, DePaul University.

Bikram Sengupta, Ph.D. Stony Brook 2003. Thesis title: *Triggered Message Sequence Charts*. Current position: Research staff, IBM India Research Laboratory, New Delhi, India.

Steven Sims, Ph.D. NCSU 1997. Thesis title: *Customizable Tools for Verifying Concurrent Systems*. Current position: Chief Technical Officer, Reactive Systems Inc.

Li Tan, Ph.D. Stony Brook 2002. Thesis title: *Evidence-Based Verification*. Current position: Assistant Professor, Washington State University at Tri-Cities, Richland, Washington.

- Natarajan Vaidhynathan, Ph.D. NCSU 1996. Thesis title: *Degrees of Delay: Semantic Theories for Priority, Efficiency, Fairness and Predictability in Process Algebra*. Current position: Technical staff, IBM, Research Triangle Park, North Carolina.
- Dezhuang Zhang, Ph.D. Stony Brook 2005. Thesis title: *Model Checking for Data-based Concurrent Systems*. Current position: Technical staff, Bloomberg, New York, New York.
- Sunil Jain, M.S. 1994. Thesis title: *VTSIM: A Graphical Simulator for Finite-State Networks*. Current position: Technical staff, Cisco Systems, Raleigh, North Carolina.
- Granville Miller, M.S. 1993. Thesis title: *The Reuse of Objects: 'Compile Time' Garbage Collection for Object-Oriented Languages*. Current position: Project Recovery Team member, Microsoft, Durham, Carolina.
- Jayesh N. Gada, M.S. 1995. Thesis title: *The Concurrency Factory—A Graphical Verification Tool Set for Concurrent Systems*. Current position: Software Engineering Manager, Decru, Redwood City, California.
- Roderic Hughes-Oliver, M.S. 1993. Thesis title: *Verifying IEEE 802.3: A Case Study Using Automatic Verification Methods*. Current position: Technical team leader, IBM, Research Triangle Park, North Carolina.
- Pranav Tiwari, M.S. 1997. Thesis title: *VPL: Tool Support for Specification and Verification of Concurrent Systems*. Current position: Technical staff, Cisco Systems, Bangalore, India.
- Vikas Trehan, M.S. 1992. Thesis title: *VTVIEW: A Graphical Editor for Hierarchical Networks of Finite-State Processes*. Current position: Director of Product Management and Alliances, InfoVista, Herndon, Virginia.
- Christopher Ackermann, Ph.D. UMD expected 2010.

- **Teaching:**

Undergraduate Discrete Mathematics. *Spring 1999*

Undergraduate Automata and Formal Language Theory. *Fall 1991, 1993, 1994, 1996; Spring 1993, 1996, 2000*

Undergraduate Data Structures and Algorithms. *Summer 1984, Fall 1989*

Undergraduate Programming Concepts. *Fall 1995*

Undergraduate Introductory Programming. *Fall 1997, 2006*

Undergraduate Programming Languages. *Fall 1992, 2000; Spring 1991, 2005*

Undergraduate Senior Design Project. *Fall 1994; Spring 1994, 1995*

Graduate Automata and Formal Language Theory. *Fall 1999*

Graduate Operating Systems. *Fall 1990*

Graduate Specification and Verification of Concurrent Systems. *Fall 1992, 1998, 1999, 2001; Spring 1990, 1994, 1995, 1997, 2000, 2001, 2007, 2008*

- **Personal information:** USA citizen. Born July 1961. Married, three children.