

Curriculum Vitae

Clark Barrett

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Research Interests

Propositional satisfiability (SAT); Satisfiability modulo theories (SMT); Automated reasoning and applied logic; Automated proof generation and checking; Formal and semi-formal verification of hardware and software; Applications of automated reasoning to security.

Education

Ph.D.: Stanford University, 2003, Computer Science. Advisor: David L. Dill.
Thesis Title: *Checking Validity of Quantifier-Free Formulas in Combinations of First-Order Theories.*

M.S.: Stanford University, 1998, Computer Science. Advisor: David L. Dill.

B.S.: Brigham Young University, 1995, Electrical and Computer Engineering (with Honors), Computer Science, and Mathematics. Summa Cum Laude with University Honors. Minors: Physics, Music.

Appointments

Associate Professor (Research), Computer Science, Stanford University, Sept. 2016 to present.
Visiting Scientist, Google, Mountain View, CA, Jan. 2015 to present.
Visiting Associate Professor, Stanford University, Sept. 2013 to Aug. 2016.
Associate Professor, Computer Science, Courant Institute, NYU, Sept. 2008 to Aug. 2016
Assistant Professor, Computer Science, Courant Institute, NYU, Sept. 2002 to 2008.

Research Group

Graduated Ph.D. Students:

- *Kshitij Bansal*, “Decision Procedures for Finite Sets with Cardinality, and Local Theories Extensions,” Computer Science, New York University, 2016.
- *Wei Wang*, “Partition Memory Models for Program Analysis,” Computer Science, New York University, 2016.
- *Liana Hadarean*, “An Efficient and Trustworthy Theory Solver for Bit-vectors in Satisfiability Modulo Theories,” Computer Science, New York University, 2014.
- *Tim King*, “Effective Algorithms for the Satisfiability of Quantifier-Free Formulas Over Linear Real and Integer Arithmetic,” Computer Science, New York University, 2014.
- *Dejan Jovanović*, “SMT Beyond DPLL(T): A New Approach to Theory Solvers and Theory Combination,” Computer Science, New York University, 2012.
- *Igor Chikanian*, “Automatic Deduction for Theories of Algebraic Data Types,” Computer Science, New York University, 2011.
- *Chris Conway*, “Tools and Techniques for the Sound Verification of Low-Level Code,” Computer Science, New York University, 2011.

- *Yeting Ge*, “Solving Quantified First Order Formulas in Satisfiability Modulo Theories,” Computer Science, New York University, 2010.
- *Ying Hu*, “Translation Validation of Loop Optimizations,” Computer Science, New York University, 2005.

Postdocs and Research Scientists:

- *Guy Katz*, Postdoc, 2016 - present.
- *Morgan Deters*, Postdoc, 2008-2013; Senior Research Scientist, 2013-2015.
- *Dejan Jovanović*, Postdoc, 2012-2013.

Visiting Scholars:

- *Stéphane Demri*, CNRS, 2012-2014.

Awards and Honors

Personal

ACM Distinguished Scientist, December 2014.
 Haifa Verification Conference Award, October 2010.
 Member, IFIP Working Group 2.3 (Programming Methodology), elected March, 2010.
 IBM Software Quality Innovation Award, November 2008.
 National Science Foundation CAREER award, 2007-2012.
 Nominated for Miller Research Fellowship (declined), 2002.
Best Paper, Design Automation Conference, 1998.
 National Science Foundation Graduate Fellowship (declined).
 National Defense Science and Engineering Graduate Fellowship, 1995-1999.
 Karl G. Maeser Graduate Fellowship, 1995.
 Co-valedictorian, Brigham Young University, 1995.

Systems

SMT-COMP 2016: winner, main track (CVC4);
 SyGuS-COMP 2016: winner, linear-integer-arithmetic track (CVC4)
 CASC 2015: winner, TFN division (CVC4);
 SMT-COMP 2015: winner, main track (CVC4);
 SyGuS-COMP 2015: winner, general track and linear-integer-arithmetic track (CVC4);
 SV-COMP 2015: bronze medal, MemorySafety division (Cascade);
 CASC 2014: winner, TFA division (CVC4);
 SMT-COMP 2014: winner, ALIA, AUFLIA, AUFLIRA, LIA, LRA, QF_AUFBV, QF_LRA, QF_NRA, UF, UFLIA divisions (CVC4);
 SMT-COMP 2012: winner, QF_UFLRA division (CVC4);
 SMT-COMP 2007: winner, AUFLIRA division (CVC3);
 SMT-COMP 2006: winner, AUFLIRA division (CVC3);

Systems Under Development

Cascade: A program verification platform. Available at <http://cascade.cims.nyu.edu/>.

CVC4: An SMT solver. Available at <http://cvc4.cs.nyu.edu/>.

Previously Developed Systems

SMT Solvers: Stanford Validity Checker (SVC), Cooperating Validity Checker (CVC), CVC Lite, CVC3

TVOC: A Translation Validator for Optimizing Compilers. Available at <http://cs.nyu.edu/acsys/tv>.

Teaching

New York University

Computer Systems Organization, Fall 2012, Spring 2013.

Class web page available at <http://cs.nyu.edu/web/Academic/Courses/archive.html>.

Logic and Verification, Spring 2003, Spring 2004.

2003 class web page available at <http://www.cs.nyu.edu/~barrett/courses/spr03/index.html>. 2004 class web page available at <http://cs.nyu.edu/courses/spring04/G22.3033-003/index.htm>.

Logic in Computer Science, Fall 2003, Fall 2004, Fall 2007, Fall 2008, Fall 2009.

Class web pages available at <http://cs.nyu.edu/web/Academic/Courses/archive.html>.

Programming Languages, Fall 2008, Spring 2012.

Class web pages available at <http://cs.nyu.edu/web/Academic/Courses/archive.html>.

Software Engineering, Spring 2005, Spring 2006, Spring 2007, Spring 2008.

Class web pages available at <http://cs.nyu.edu/web/Academic/Courses/archive.html>.

Topics in Automated Deduction, Spring 2007, Spring 2009.

Class web pages available at <http://cs.nyu.edu/web/Academic/Courses/archive.html>.

Stanford University

Advanced Computer Organization: Processor Architecture (EE 482), Teaching assistant, Spring 1997. Instructor: Kunle Olukotun.

Discrete Structures, Accelerated (CS 103X), Teaching assistant, Spring 2000, Winter 2001. Instructors: David Dill and John Mitchell.

Techniques for Program Analysis and Verification (CS 357), Co-instructor, Fall 2013, Fall 2015. Other instructors: Alex Aiken and David Dill.

Professional Activities

Steering Committee

SMT: International Workshop on Satisfiability Modulo Theories, 2009-2012, 2014-2016.

Program/Event Chair

NASA Formal Methods Symposium, co-chair, 2017.

SAT/SMT Summer School, organizer, 2014; chair, 2015.

SMT-COMP: Satisfiability Modulo Theories Competition, co-chair, 2005, 2006, 2007, 2008, 2009, 2010.

Amir Pnueli Memorial Symposium, chair, 2010.

SMT: International Workshop on Satisfiability Modulo Theories, co-chair, 2008.

Program Committees

CAV: International Conference on Computer Aided Verification, 2006, 2008, 2009, 2016.

DIFTS: Workshop on Design and Implementation of Formal Tools and Systems, 2011.

FMCAD: International Conference on Formal Methods In Computer-Aided Design, 2006.

FroCoS: International Symposium on Frontiers of Combining Systems, 2005, 2011, 2013, 2015.

MEMOCODE: International Conference on Formal Methods and Models for Codesign, 2009.

NFM: NASA Formal Methods Symposium, 2016.

PAAR: Workshop on Practical Aspects of Automated Reasoning, 2012, 2014.

PDPAR: Workshop on Pragmatics of Decision Procedures in Automated Reasoning, 2003, 2004, 2005, 2006.

PXTP: Workshop on Proof eXchange for Theorem Proving, 2011.

SAT: International Conference on Theory and Applications of Satisfiability Testing, 2005.

SIGDA: Ph.D. Forum at the Design Automation Conference, 2004, 2005.

SMT: International Workshop on Satisfiability Modulo Theories, 2007, 2008, 2009, 2010, 2011, 2012.

TPHOLs: International Conference on Theorem Proving and Higher Order Logics, 2004, 2005.

VMCAI: International Conference on Verification, Model Checking and Abstract Interpretation, 2008.

VSTTE: Workshop on Verified Software: Theories, Tools and Experiments, 2012.

WING: Workshop on Invariant Generation, 2012.

Referee

Conference/Workshop papers: CADE, CAV, DAC, EMSOFT, FMCAD, FroCoS, FSTTCS, IJCAR, LPAR, MEMOCODE, PAAR, PDPAR, POPL, SMT, TACAS, STACS, TPHOLs, VMCAI.

Journal papers: *ACM Computing Surveys*, *ACM Transactions on Computational Logic*, *AI Communications*, *Artificial Intelligence Journal*, *Communications of the ACM*, *Formal Aspects of Computing*, *Information and Computation*, *IEEE Transactions on Computer-Aided Design*, *Journal of Formal Methods in System Design*, *Journal of Automated Reasoning*, *Journal of the ACM*, *Journal on Satisfiability, Boolean Modeling and Computation*, *Journal of Symbolic Computation*, *Journal of Zhejiang University-Science A*, *Logical Methods in Computer Science*, *Theoretical Computer Science*.

Departmental Service

Appointments Committee, 2008-2009.

Coordinator for departmental spring showcase, 2007, 2008.

Department chair search committee, 2005-2006, 2008.

Director of Undergraduate Studies, 2009-2010.

Fellowship committee (PhD student admission and oversight committee), 2004-2008.

Graduate curriculum committee, 2006-2009.

Teaching load committee, 2006-2007.

Teaching assignments committee, 2009-2014.

Undergraduate curriculum committee, 2004-2010.

Undergraduate mentor, 2003-2008.

Other Activities

Participant at NSF workshops and panels.

One of three coordinators of the SMT-LIB initiative (see <http://www.smtlib.org>). Responsible for collecting and maintaining the library of benchmarks; chair of the SMT-LIB working group on model generation; contributor to many other aspects of the initiative.

Industry Experience

Consulting: Reservoir Labs Inc., Calypto Design Systems, MIT Lincoln Laboratory, Mentor Graphics (formerly 0-in Design Automation).

Google, 2015 - present, Visiting Scientist (Domagoj Babic, host). Using SMT to find security vulnerabilities.

Intel, 1996, Summer Intern under Carl Seger. Prototyping and development of an early version of *Forte*, a formal verification tool suite.

Microsoft Research, 1993, Summer Intern under Charles Simonyi. Programmer on “Intentional Programming” project.

Publications

Conference Publications

- (1) Kshitij Bansal, Andrew Reynolds, Clark Barrett, and Cesare Tinelli. A new decision procedure for finite sets and cardinality constraints in SMT. In *Proceedings of the 8th International Joint Conference on Automated Reasoning (IJCAR '16)*, June 2016. Coimbra, Portugal.
- (2) Liana Hadarean, Clark Barrett, Andrew Reynolds, Cesare Tinelli, and Morgan Deters. Fine-grained SMT proofs for the theory of fixed-width bit-vectors. In Martin Davis, Ansgar Fehnker, Annabelle McIver, and Andrei Voronkov, editors, *Proceedings of the 20th International Conference on Logic for Programming, Artificial Intelligence, and Reasoning (LPAR '15)*, volume 9450 of *Lecture Notes in Computer Science*, pages 340–355. Springer, November 2015. Suva, Fiji.
- (3) David Lin, Eshan Singh, Clark Barrett, and Subhasish Mitra. A structured approach to post-silicon validation and debug using symbolic quick error detection. In *Proceedings of the 42nd International Test Conference (ITC '15)*, pages 1–10. IEEE, October 2015. Anaheim, CA.
- (4) Guy Katz, Clark Barrett, and David Harel. Theory-aided model checking of concurrent transition systems. In *Proceedings of the 15th International Conference on Formal Methods In Computer-Aided Design (FMCAD '15)*, pages 81–88. FMCAD Inc., September 2015. Austin, TX.
- (5) Tianyi Liang, Nestan Tsiskaridze, Andrew Reynolds, Cesare Tinelli, and Clark Barrett. A decision procedure for regular membership and length constraints over unbounded strings. In Carsten Lutz and Silvio Ranise, editors, *Proceedings of the 10th International Symposium on Frontiers of Combining Systems (FroCoS '15)*, volume 9322 of *Lecture Notes in Artificial Intelligence*, pages 135–150. Springer, September 2015. Wroclaw, Poland.
- (6) Andrew Reynolds, Morgan Deters, Viktor Kuncak, Clark Barrett, and Cesare Tinelli. Counterexample guided quantifier instantiation for synthesis in SMT. In Daniel Kroening and Corina S. Păsăreanu, editors, *Proceedings of the 27th International Conference on Computer Aided Verification (CAV '15)*, volume 9206 of *Lecture Notes in Computer Science*, pages 198–216. Springer, July 2015. San Francisco, CA.
- (7) Kshitij Bansal, Andrew Reynolds, Tim King, Clark Barrett, and Thomas Wies. Deciding local theory extensions via E-matching. In Daniel Kroening and Corina S. Păsăreanu, editors, *Proceedings of the 27th International Conference on Computer Aided Verification (CAV '15)*, volume 9206 of *Lecture Notes in Computer Science*, pages 87–105. Springer, July 2015. San Francisco, CA.
- (8) Wei Wang and Clark Barrett. Cascade (competition contribution). In Christel Baier and Cesare Tinelli, editors, *Proceedings of the 21st International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS '15)*, volume 9035 of *Lecture Notes in Computer Science*, pages 420–422. Springer, April 2015. London, UK.
- (9) Tim King, Clark Barrett, and Cesare Tinelli. Leveraging linear and mixed integer programming for SMT. In *Proceedings of the 14th International Conference on Formal Methods In Computer-Aided Design (FMCAD '14)*, pages 139–146. FMCAD Inc., October 2014. Lausanne, Switzerland.
- (10) Liana Hadarean, Clark Barrett, Dejan Jovanović, Cesare Tinelli, and Kshitij Bansal. A tale of two solvers: Eager and lazy approaches to bit-vectors. In Armin Biere and Roderick Bloem, editors, *Proceedings of the 26th International Conference on Computer Aided Verification (CAV '14)*, volume 8559 of *Lecture Notes in Computer Science*, pages 680–695. Springer, July 2014. Vienna, Austria.
- (11) Tianyi Liang, Andrew Reynolds, Cesare Tinelli, Clark Barrett, and Morgan Deters. A DPLL(T) theory solver for a theory of strings and regular expressions. In Armin Biere and Roderick Bloem, editors, *Proceedings of the 26th International Conference on Computer Aided Verification (CAV '14)*, volume 8559 of *Lecture Notes in Computer Science*, pages 646–662. Springer, July 2014. Vienna, Austria.
- (12) Wei Wang, Clark Barrett, and Thomas Wies. Cascade 2.0. In Kenneth L. McMillan and Xavier Rival, editors, *Proceedings of the 15th International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI '14)*, volume 8318 of *Lecture Notes in Computer Science*, pages 142–160. Springer Berlin Heidelberg, January 2014. San Diego, California.

- (13) Timothy King, Clark Barrett, and Bruno Dutertre. Simplex with sum of infeasibilities for SMT. In *Proceedings of the 13th International Conference on Formal Methods In Computer-Aided Design (FMCAD '13)*, pages 189–196. FMCAD Inc., October 2013. Portland, Oregon.
- (14) Dejan Jovanović, Clark Barrett, and Leonardo de Moura. The design and implementation of the model constructing satisfiability calculus. In *Proceedings of the 13th International Conference on Formal Methods In Computer-Aided Design (FMCAD '13)*. FMCAD Inc., October 2013. Portland, Oregon.
- (15) Clark Barrett, Stephané Demri, and Morgan Deters. Witness runs for counter machines. In Pascal Fontaine, Christophe Ringeissen, and Renate A. Schmidt, editors, *Proceedings of the 9th International Symposium on Frontiers of Combining Systems (FroCoS '13)*, volume 8152 of *Lecture Notes in Artificial Intelligence*, pages 120–150. Springer Berlin Heidelberg, September 2013. Nancy, France.
- (16) Andrew Reynolds, Cesare Tinelli, Amit Goel, Sava Krstic, Morgan Deters, and Clark Barrett. Quantifier instantiation techniques for finite model finding in SMT. In Maria Paola Bonacina, editor, *Proceedings of the 24th International Conference on Automated Deduction (CADE '13)*, volume 7898 of *Lecture Notes in Computer Science*, pages 377–391. Springer Berlin Heidelberg, 2013. Lake Placid, NY.
- (17) Dejan Jovanović and Clark Barrett. Sharing is caring: Combination of theories. In Cesare Tinelli and Viorica Sofronie-Stokkermans, editors, *Proceedings of the 8th International Symposium on Frontiers of Combining Systems (FroCoS '11)*, volume 6989 of *Lecture Notes in Computer Science*, pages 195–210. Springer, October 2011. Saarbrücken, Germany.
- (18) Clark Barrett, Christopher L. Conway, Morgan Deters, Liana Hadarean, Dejan Jovanović, Tim King, Andrew Reynolds, and Cesare Tinelli. CVC4. In Ganesh Gopalakrishnan and Shaz Qadeer, editors, *Proceedings of the 23rd International Conference on Computer Aided Verification (CAV '11)*, volume 6806 of *Lecture Notes in Computer Science*, pages 171–177. Springer, July 2011. Snowbird, Utah.
- (19) Dejan Jovanović and Clark Barrett. Polite theories revisited. In Christian G. Fermüller and Andrei Voronkov, editors, *Proceedings of the 17th International Conference on Logic for Programming, Artificial Intelligence, and Reasoning (LPAR '10)*, volume 6397 of *Lecture Notes in Computer Science*, pages 402–416. Springer, October 2010. Yogyakarta, Indonesia.
- (20) Christopher L. Conway and Clark Barrett. Verifying low-level implementations of high-level datatypes. In Tayssir Touili, Byron Cook, and Paul Jackson, editors, *Proceedings of the 22nd International Conference on Computer Aided Verification (CAV '10)*, volume 6174 of *Lecture Notes in Computer Science*, pages 306–320. Springer, July 2010. Edinburgh, Scotland.
- (21) Christopher L. Conway, Dennis Dams, Kedar S. Namjoshi, and Clark Barrett. Pointer analysis, conditional soundness, and proving the absence of errors. In María Alpuente and Germán Vidal, editors, *Proceedings of the 15th International Static Analysis Symposium (SAS '08)*, volume 5079 of *Lecture Notes in Computer Science*, pages 62–77. Springer, July 2008. Valencia, Spain.
- (22) Yeting Ge, Clark Barrett, and Cesare Tinelli. Solving quantified verification conditions using satisfiability modulo theories. In Frank Pfenning, editor, *Proceedings of the 21st International Conference on Automated Deduction (CADE '07)*, volume 4603 of *Lecture Notes in Artificial Intelligence*, pages 167–182. Springer-Verlag, July 2007. Bremen, Germany.
- (23) Clark Barrett and Cesare Tinelli. CVC3. In Werner Damm and Holger Hermanns, editors, *Proceedings of the 19th International Conference on Computer Aided Verification (CAV '07)*, volume 4590 of *Lecture Notes in Computer Science*, pages 298–302. Springer-Verlag, July 2007. Berlin, Germany.
- (24) Clark Barrett, Robert Nieuwenhuis, Albert Oliveras, and Cesare Tinelli. Splitting on demand in SAT modulo theories. In Miki Hermann and Andrei Voronkov, editors, *Proceedings of the 13th International Conference on Logic for Programming, Artificial Intelligence, and Reasoning (LPAR '06)*, volume 4246 of *Lecture Notes in Computer Science*, pages 512–526. Springer-Verlag, November 2006. Phnom Penh, Cambodia.
- (25) Nikhil Sethi and Clark Barrett. CASCADE: C assertion checker and deductive engine. In Thomas Ball and Robert B. Jones, editors, *Proceedings of the 18th International Conference on Computer*

Aided Verification (CAV '06), volume 4144 of *Lecture Notes in Computer Science*, pages 166–169. Springer-Verlag, August 2006. Seattle, Washington.

- (26) Clark Barrett, Leonardo de Moura, and Aaron Stump. SMT-COMP: Satisfiability modulo theories competition. In Kousha Etessami and Sriram K. Rajamani, editors, *Proceedings of the 17th International Conference on Computer Aided Verification (CAV '05)*, volume 3576 of *Lecture Notes in Computer Science*, pages 20–23. Springer-Verlag, July 2005. Edinburgh, Scotland.
- (27) Clark Barrett, Yi Fang, Ben Goldberg, Ying Hu, Amir Pnueli, and Lenore Zuck. TVOC: A translation validator for optimizing compilers. In Kousha Etessami and Sriram K. Rajamani, editors, *Proceedings of the 17th International Conference on Computer Aided Verification (CAV '05)*, volume 3576 of *Lecture Notes in Computer Science*, pages 291–295. Springer-Verlag, July 2005. Edinburgh, Scotland.
- (28) Ying Hu, Clark Barrett, and Benjamin Goldberg. Theory and algorithms for the generation and validation of speculative loop optimizations. In *Proceedings of the 2nd IEEE International Conference on Software Engineering and Formal Methods (SEFM '04)*, pages 281–289. IEEE Computer Society, September 2004. Beijing, China.
- (29) Clark Barrett and Sergey Berezin. CVC Lite: A new implementation of the cooperating validity checker. In Rajeev Alur and Doron A. Peled, editors, *Proceedings of the 16th International Conference on Computer Aided Verification (CAV '04)*, volume 3114 of *Lecture Notes in Computer Science*, pages 515–518. Springer-Verlag, July 2004. Boston, Massachusetts.
- (30) Aaron Stump, Clark W. Barrett, and David L. Dill. CVC: A cooperating validity checker. In Ed Brinksma and Kim Guldstrand Larsen, editors, *Proceedings of the 14th International Conference on Computer Aided Verification (CAV '02)*, volume 2404 of *Lecture Notes in Computer Science*, pages 500–504. Springer-Verlag, July 2002. Copenhagen, Denmark.
- (31) Clark W. Barrett, David L. Dill, and Aaron Stump. Checking satisfiability of first-order formulas by incremental translation to SAT. In Ed Brinksma and Kim Guldstrand Larsen, editors, *Proceedings of the 14th International Conference on Computer Aided Verification (CAV '02)*, volume 2404 of *Lecture Notes in Computer Science*, pages 236–249. Springer-Verlag, July 2002. Copenhagen, Denmark.
- (32) Aaron Stump, Clark W. Barrett, David L. Dill, and Jeremy Levitt. A decision procedure for an extensional theory of arrays. In *Proceedings of the 16th IEEE Symposium on Logic in Computer Science (LICS '01)*, pages 29–37. IEEE Computer Society, June 2001. Boston, Massachusetts.
- (33) Clark W. Barrett, David L. Dill, and Aaron Stump. A framework for cooperating decision procedures. In David McAllester, editor, *Proceedings of the 17th International Conference on Computer-Aided Deduction (CADE '00)*, volume 1831 of *Lecture Notes in Artificial Intelligence*, pages 79–97. Springer-Verlag, June 2000. Pittsburgh, Pennsylvania.
- (34) Clark W. Barrett, David L. Dill, and Jeremy R. Levitt. A decision procedure for bit-vector arithmetic. In *Proceedings of the 35th Design Automation Conference (DAC '98)*, pages 522–527. Association for Computing Machinery, June 1998. San Francisco, California. *Best paper award*.
- (35) Jeffrey X. Su, David L. Dill, and Clark W. Barrett. Automatic generation of invariants in processor verification. In Mandayam Srivas and Albert Camilleri, editors, *Proceedings of the 1st International Conference on Formal Methods In Computer-Aided Design (FMCAD '96)*, volume 1166 of *Lecture Notes in Computer Science*, pages 377–388. Springer-Verlag, November 1996. Palo Alto, California.
- (36) Clark W. Barrett, David L. Dill, and Jeremy R. Levitt. Validity checking for combinations of theories with equality. In Mandayam Srivas and Albert Camilleri, editors, *Proceedings of the 1st International Conference on Formal Methods In Computer-Aided Design (FMCAD '96)*, volume 1166 of *Lecture Notes in Computer Science*, pages 187–201. Springer-Verlag, November 1996. Palo Alto, California.

Book Chapters

- (37) Clark Barrett, Leonardo de Moura, and Pascal Fontaine. Proofs in satisfiability modulo theories. In David Delahaye and Bruno Woltzenlogel Paleo, editors, *All about Proofs, Proofs for All*, volume 55 of *Mathematical Logic and Foundations*, pages 23–44. College Publications, London, UK, January 2015.
- (38) Clark Barrett, Roberto Sebastiani, Sanjit Seshia, and Cesare Tinelli. Satisfiability modulo theories. In Armin Biere, Marijn J. H. Heule, Hans van Maaren, and Toby Walsh, editors, *Handbook of Satisfiability*, volume 185 of *Frontiers in Artificial Intelligence and Applications*, chapter 26, pages 825–885. IOS Press, February 2009.

Journal Articles

- (39) Eshan Singh, David Lin, Clark Barrett, and Subhasish Mitra. Symbolic quick error detection for pre-silicon and post-silicon validation: Frequently asked questions. *IEEE Design & Test*, PP(99), 2016.
- (40) Andrew Reynolds, Viktor Kuncak, Cesare Tinelli, Clark Barrett, and Morgan Deters. Refutation-based synthesis in SMT. *Formal Methods in System Design*, 2016. To appear.
- (41) Tianyi Liang, Andrew Reynolds, Nestan Tsiskaridze, Cesare Tinelli, Clark Barrett, and Morgan Deters. An efficient SMT solver for string constraints. *Formal Methods in System Design*, 2016.
- (42) Clark Barrett, Morgan Deters, Leonardo de Moura, Albert Oliveras, and Aaron Stump. 6 years of SMT-COMP. *Journal of Automated Reasoning*, 50(3):243–277, March 2013.
- (43) Dejan Jovanović and Clark Barrett. Being careful about theory combination. *Formal Methods in System Design*, 42(1):67–90, February 2013.
- (44) Yeting Ge, Clark Barrett, and Cesare Tinelli. Solving quantified verification conditions using satisfiability modulo theories. *Annals of Mathematics and Artificial Intelligence*, 55(1-2):101–122, February 2009.
- (45) Clark Barrett, Morgan Deters, Albert Oliveras, and Aaron Stump. Design and results of the 3rd annual satisfiability modulo theories competition (SMT-COMP 2007). *International Journal on Artificial Intelligence Tools (IJAIT)*, 17(4):569–606, August 2008.
- (46) Clark Barrett, Leonardo de Moura, and Aaron Stump. Design and results of the 2nd satisfiability modulo theories competition (SMT-COMP 2006). *Formal Methods in System Design*, 31(3):221–239, December 2007.
- (47) Clark Barrett, Igor Shikanian, and Cesare Tinelli. An abstract decision procedure for a theory of inductive data types. *Journal on Satisfiability, Boolean Modeling and Computation*, 3:21–46, 2007.
- (48) Clark Barrett, Leonardo de Moura, and Aaron Stump. Design and results of the 1st satisfiability modulo theories competition (SMT-COMP 2005). *Journal of Automated Reasoning*, 35(4):373–390, November 2005.
- (49) Lenore Zuck, Amir Pnueli, Benjamin Goldberg, Clark Barrett, Yi Fang, and Ying Hu. Translation and run-time validation of loop transformations. *Formal Methods in System Design*, 27(3):335–360, November 2005.
- (50) Carl-Johan H. Seger, Robert B. Jones, John W. O’Leary, Tom Melham, Mark D. Aagaard, Clark Barrett, and Don Syme. An industrially effective environment for formal hardware verification. *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, 24(9):1381–1405, September 2005.

Refereed Workshop Publications

- (51) Tim King and Clark Barrett. Exploring and categorizing error spaces using BMC and SMT. In *Proceedings of the 9th International Workshop on Satisfiability Modulo Theories (SMT ’11)*, July 2011. Snowbird, Utah.

- (52) Clark Barrett, Aaron Stump, and Cesare Tinelli. The SMT-LIB standard – version 2.0. In *Proceedings of the 8th International Workshop on Satisfiability Modulo Theories (SMT '10)*, July 2010. Edinburgh, Scotland.
- (53) Dejan Jovanović and Clark Barrett. Sharing is caring. In *Proceedings of the 8th International Workshop on Satisfiability Modulo Theories (SMT '10)*, July 2010. Edinburgh, Scotland.
- (54) Andrew Reynolds, Liana Hadarean, Cesare Tinelli, Yeting Ge, Aaron Stump, and Clark Barrett. Comparing proof systems for linear real arithmetic with LFSC. In *Proceedings of the 8th International Workshop on Satisfiability Modulo Theories (SMT '10)*, July 2010. Edinburgh, Scotland.
- (55) Clark Barrett, Igor Shikanian, and Cesare Tinelli. An abstract decision procedure for satisfiability in the theory of recursive data types. In Byron Cook and Roberto Sebastiani, editors, *Combined Proceedings of the 4th Workshop on Pragmatics of Decision Procedures in Automated Reasoning (PDPAR '06) and the 1st International Workshop on Probabilistic Automata and Logics (PaUL '06)*, volume 174(8) of *Electronic Notes in Theoretical Computer Science*, pages 23–37. Elsevier, June 2007. Seattle, Washington.
- (56) Sean McLaughlin, Clark Barrett, and Yeting Ge. Cooperating theorem provers: A case study combining HOL-Light and CVC Lite. In Alessandro Armando and Alessandro Cimatti, editors, *Proceedings of the 3rd Workshop on Pragmatics of Decision Procedures in Automated Reasoning (PDPAR '05)*, volume 144(2) of *Electronic Notes in Theoretical Computer Science*, pages 43–51. Elsevier, January 2006. Edinburgh, Scotland.
- (57) Ying Hu, Clark Barrett, Benjamin Goldberg, and Amir Pnueli. Validating more loop optimizations. In J. Knoop, G.C. Necula, and W. Zimmermann, editors, *Proceedings of the 4th International Workshop on Compiler Optimization meets Compiler Verification (COCV '05)*, volume 141(2) of *Electronic Notes in Theoretical Computer Science*, pages 69–84. Elsevier, December 2005. Edinburgh, Scotland.
- (58) Benjamin Goldberg, Lenore Zuck, and Clark Barrett. Into the loops: Practical issues in translation validation for optimizing compilers. In J. Knoop, G.C. Necula, and W. Zimmermann, editors, *Proceedings of the 3rd International Workshop on Compiler Optimization meets Compiler Verification (COCV '04)*, volume 132(1) of *Electronic Notes in Theoretical Computer Science*, pages 53–71. Elsevier, May 2005. Barcelona, Spain.
- (59) Sergey Berezin, Clark Barrett, Igor Shikanian, Marsha Chechik, Arie Gurfinkel, and David L. Dill. A practical approach to partial functions in CVC Lite. In Wolfgang Ahrendt, Peter Baumgartner, Hans de Nivelle, Silvio Ranise, and Cesare Tinelli, editors, *Selected Papers from the Workshops on Disproving and the Second International Workshop on Pragmatics of Decision Procedures (PDPAR '04)*, volume 125(3) of *Electronic Notes in Theoretical Computer Science*, pages 13–23. Elsevier, July 2005. Cork, Ireland.
- (60) Clark Barrett and Jacob Donham. Combining SAT methods with non-clausal decision heuristics. In Wolfgang Ahrendt, Peter Baumgartner, Hans de Nivelle, Silvio Ranise, and Cesare Tinelli, editors, *Selected Papers from the Workshops on Disproving and the Second International Workshop on Pragmatics of Decision Procedures (PDPAR '04)*, volume 125(3) of *Electronic Notes in Theoretical Computer Science*, pages 3–12. Elsevier, July 2005. Cork, Ireland.
- (61) Clark Barrett and Sergey Berezin. A proof-producing boolean search engine. In *Proceedings of the 1st International Workshop on Pragmatics of Decision Procedures in Automated Reasoning (PDPAR '03)*, July 2003. Miami, Florida.
- (62) Clark Barrett, Benjamin Goldberg, and Lenore Zuck. Run-time validation of speculative optimizations using CVC. In Oleg Sokolsky and Mahesh Viswanathan, editors, *Proceedings of the 3rd International Workshop on Run-time Verification (RV '03)*, volume 89(2) of *Electronic Notes in Theoretical Computer Science*, pages 89–107. Elsevier, October 2003. Boulder, Colorado.
- (63) Clark W. Barrett, David L. Dill, and Aaron Stump. A generalization of Shostak’s method for combining decision procedures. In Alessandro Armando, editor, *Proceedings of the 4th International Workshop on Frontiers of Combining Systems (FroCoS '02)*, volume 2309 of *Lecture Notes in Artificial Intelligence*, pages 132–146. Springer-Verlag, April 2002. Santa Margherita Ligure, Italy.

- (64) Aaron Stump, Clark W. Barrett, and David L. Dill. Producing proofs from an arithmetic decision procedure in elliptical LF. In Frank Pfenning, editor, *Proceedings of the 3rd International Workshop on Logical Frameworks and Meta-Languages (LFM '02)*, volume 70(2) of *Electronic Notes in Theoretical Computer Science*, pages 29–41. Elsevier, July 2002. Copenhagen, Denmark.

Technical Reports

- (65) Clark Barrett, Daniel Kroening, and Thomas Melham. Problem solving for the 21st century: Efficient solvers for satisfiability modulo theories. Technical Report 3, London Mathematical Society and Smith Institute for Industrial Mathematics and System Engineering, June 2014. Knowledge Transfer Report.
- (66) Dejan Jovanović and Clark Barrett. Sharing is caring: Combination of theories. Technical Report TR2011-940, Department of Computer Science, New York University, October 2011.
- (67) Clark Barrett, Morgan Deters, Albert Oliveras, and Aaron Stump. Design and results of the 4th annual satisfiability modulo theories competition (SMT-COMP 2008). Technical Report TR2010-931, Department of Computer Science, New York University, July 2010.
- (68) Dejan Jovanović and Clark Barrett. Polite theories revisited. Technical Report TR2010-922, Department of Computer Science, New York University, January 2010.
- (69) Christopher L. Conway, Dennis Dams, Kedar S. Namjoshi, and Clark Barrett. Points-to analysis, conditional soundness, and proving the absence of errors. Technical Report TR2008-910, Department of Computer Science, New York University, March 2008.
- (70) Clark Barrett, Robert Nieuwenhuis, Albert Oliveras, and Cesare Tinelli. Splitting on demand in SAT Modulo Theories. Technical Report 06-05, Department of Computer Science, University of Iowa, August 2006.
- (71) Clark Barrett, Igor Shikanian, and Cesare Tinelli. An abstract decision procedure for satisfiability in the theory of recursive data types. Technical Report TR2005-878, Department of Computer Science, New York University, November 2005.

Ph.D. Thesis

- (72) Clark W. Barrett. *Checking Validity of Quantifier-Free Formulas in Combinations of First-Order Theories*. PhD thesis, Stanford University, January 2003. Stanford, California.

Book Reviews

- (73) Clark Barrett. “Decision Procedures: An Algorithmic Point of View,” by Daniel Kroening and Ofer Strichman, Springer-Verlag, 2008. *Journal of Automated Reasoning*, 51(4):453–456, December 2013.

Patents

- (74) Jeremy R. Levitt, Christophe G. Gauthron, Clark W. Barrett, and Lawrence Curtis Widdoes Jr. Reuse of learned information to simplify functional verification of a digital circuit, December 2007. Patent No. 20070299648.

Invited Talks

“Satisfiability Modulo Theories,” Sixth Summer School on Formal Techniques, Menlo College, Menlo Park, CA, May 23, 2016.

“Satisfiability Modulo Theories,” SRI, Menlo Park, CA, November 10, 2015; Stanford University, Stanford, CA, November 11, 2015.

“The Satisfiability Revolution and the Rise of SMT,” Google, New York, NY, December 9, 2014; Samsung Research America, San Jose, CA, October 7, 2014; NASA Ames, Moffett Field, CA, August 14, 2015; UC Davis, Davis, CA, May 29, 2014.

“Satisfiability Modulo Theories,” Ed Clarke Symposium, Carnegie Mellon University, Pittsburg, PA, September 19, 2014.

“Proofs in Satisfiability Modulo Theories,” with Pascal Fontaine and Leonardo de Moura, All about Proofs, Proofs for All, Vienna, Austria, July 18, 2014.

“SMT: Where do we go from here?” 12th International Workshop on Satisfiability Modulo Theories, Vienna, Austria, July 17, 2014.

“Lazy and Eager Approaches to Solving Bit-vectors,” SRC GRC CADTS Verification Review, Austin, TX, April 15, 2014.

“The Satisfiability Revolution and the Rise of SMT,” ExCape Webinar, March 3, 2014, online at <https://excape.cis.upenn.edu/news-events.html>.

“Lazy Bit-Vector Solving using Subtheories,” SRC GRC CADTS Verification Review, Berkeley, CA, April 10, 2013.

“Bit-Precise Reasoning in Systems Analysis and Verification,” Yale University, New Haven, CT, February 14, 2013.

“The Satisfiability Revolution and the Rise of the Ingenious Machine,” Stanford University, Stanford, CA, January 10, 2013.

“Scalable and Accurate SMT-based Model Checking of Data Flow Systems,” AFOSR Annual Review, Washington, DC, November 27, 2012.

“Beyond DPLL(T): A New Model-Based Approach to Search in SMT and its Application to Solving Nonlinear Arithmetic,” Carnegie Mellon University, Pittsburgh, PA, October 5, 2012.

“From SAT to SMT: Successes and Challenges,” Harvard University, Cambridge, MA, August 19, 2012.

“New Insights on the Nelson-Oppen Method,” Northeastern University, Boston, MA, August 13, 2012.

“Beyond DPLL(T): A New Boolean Search Framework for Model-Based Theory Reasoning,” IFIP Working Group 2.3, Seattle, WA, July 18, 2012.

“Efficient SMT Solving for Bit-vectors and Arrays,” SRC GRC CADTS Verification Review, Boulder, CO, April 11, 2012.

“Scalable and Accurate SMT-based Model Checking of Data Flow Systems,” AFOSR Annual Review, Arlington, VA, October 26, 2011.

“From SVC to CVC4: 15 Years of Decision Procedures,” SMT Summer School, MIT, Cambridge, MA, June 13, 2011.

“An Abstract Decision Procedure for a Theory of Bit-Vectors,” SRC GRC CADTS Verification Review, Santa Barbara, CA, April 6, 2011.

“Tools and Techniques for the Sound Verification of Low-Level Code,” MIT, Cambridge, MA, March 31, 2011.

“Sharing is Caring: An Efficient New Theory Combination Method,” SRC GRC CADTS Verification Review, Austin, Texas, April 13, 2010.

“New Insights on the Nelson-Oppen Method,” IFIP Working Group 2.3, Lachen, Switzerland, March 2, 2010.

“An Introduction to Satisfiability Modulo Theories,” Tutorial (with Sanjit Seshia) at the International Conference on Computer-Aided Design (ICCAD), San Jose, CA, November 2, 2009.

“From SAT to SMT: Successes and Challenges,” Keynote address at the Eighth International Workshop On The ACL2 Theorem Prover and Its Applications, Northeastern University, Boston, MA, May 12, 2009.

“Improving Bit-Vector Reasoning in Satisfiability Modulo Theories,” SRC GRC CADTS Verification Review, Raleigh, NC, April 15, 2009.

“Satisfiability Modulo Theories: Successes and Challenges,” NSF Workshop on Symbolic Computation for Constraint Satisfaction, Arlington, VA, November 14, 2008.

“Satisfiability Modulo Theories,” MIT, Cambridge, MA, September 25, 2008.

“SAT Solvers: Theory and Practice,” and “SMT Solvers: Theory and Practice,” invited lectures at the Summer School on Verification Technology, Systems & Applications, Max-Planck-Institut für Informatik, Saarbrücken, Germany, September 15-19, 2008.

“SAT and SMT Solvers: Theory and Practice,” MIT Lincoln Laboratory, Lincoln, MA, September 5, 2008.

“Bit-Precise Reasoning Using Satisfiability Modulo Theories,” IFIP Working Group 2.3, Cambridge, UK, July 23, 2008.

“Satisfiability Modulo Theories,” IBM T. J. Watson Research Center, Hawthorne, New York, May 19, 2008.

“Satisfiability Modulo Theories,” UT Austin, April 18, 2008.

“Satisfiability Modulo Theories,” IFIP Working Group 2.3, Santa Fe, NM, October 11, 2007.

“Satisfiability Modulo Theories in Practice,” CMU, Pittsburgh, PA, April 16, 2007.

“An Abstract Decision Procedure for Satisfiability in the Theory of Recursive Data Types,” Microsoft Research, Redmond, Washington, November 6, 2006.

“Satisfiability Modulo Theories,” Reservoir Labs, New York, New York, October 20, 2006.

“Formal Software Verification,” Cooper Union, New York, New York, October 19, 2006.

“CASCADE: C Assertion Checker and Deductive Engine,” IBM T. J. Watson Research Center, Hawthorne, New York, August 31, 2006.

“Compiler Validation with Automated Decision Procedures,” University of Iowa, Iowa City, Iowa, November 11, 2005.

“DPLL(T) with Generalized Theory Propagation,” Workshop on Deduction and Applications, Schloß Dagstuhl, October 28, 2005.

“Satisfiability Modulo Theories,” Princeton University, Princeton, New Jersey, October 5, 2005.

“Theory and Practice of Decision Procedures for Combinations of Theories,” invited tutorial presented with Cesare Tinelli at the 17th International Conference on Computer Aided Verification (CAV '05), Edinburgh, Scotland, July 6, 2005.

“Compiler Validation using Automated Decision Procedures,” Microsoft Research, Redmond, Washington, December 16, 2004.

“Compiler Validation with Automated Decision Procedures,” Reservoir Labs Technical Presentation, Reservoir Labs, New York, New York, November 29, 2004; Bioinformatics Lab Talk, New York University, New York, New York, November 24, 2004; Computer Science Invited Lecture Series, Pace University, New York, New York, October 26, 2004.

“CVC Lite: Selected Stories from the Trenches,” Combination of Decision Procedures Summer School, SRI International, Menlo Park, California, August 11, 2004.

“Using Proofs for Fast and Reliable Boolean Reasoning in CVC Lite,” Intel Formal Verification Symposium, Hillsboro, Oregon, June 11, 2004.

“The Common Roots of Mathematics and Computing,” Faculty Resource Network, New York University, New York, New York, June 8, 2004.

“Formal Software Verification,” Pace University, New York, New York, March 22, 2004.

“Applying Automated Decision Procedures: Using CVC Lite in Compiler Validation,” Computer Science Colloquium, Washington University, St. Louis, Missouri, September 12, 2003.

“Efficiently Combining Boolean and First-Order Reasoning,” Max Planck Institut für Informatik, Saarbrücken, Germany, June 10, 2003.

“The Nelson-Oppen Method for Combining Decision Procedures,” Max Planck Institut für Informatik, Saarbrücken, Germany, June 5, 2003.

“Checking Validity of Quantifier-Free Formulas in Combinations of First-Order Theories,” Rice University, April 2002; University of Pisa, April 2002; California Institute of Technology, March 2002; Northrop Grumman, March 2002; NEC Laboratories, March 2002; New York University, March 2002; University of Utah, March 2002; Columbia University, March 2002; Brigham Young University, February 2002.

“A Framework for Cooperating Decision Procedures,” Intel Strategic CAD Laboratories, Hillsboro, Oregon, May 2000.

“A Unified Framework for Cooperating Decision Procedures,” Brigham Young University Computer Science Colloquium, Provo, Utah, March 2000.

“Bit-Vector Decision Procedures in the Stanford Validity Checker,” SRI International, Menlo Park, California, May 1998.