Herbrand Award Talk

Armin Biere

universität freiburg

International Joint Conference on Automated Reasoning

IJCAR’2024

July 4, 2024, Nancy, France
Dean back at JKU asked for a slide what I am doing ...
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My Journey from CADE to CAV and SAT to IJCAR!

- CAV in the 90ies was the “new kid on the block”
- Symbolic Model Checking with BDDs [Clarke..., McMillan] at CMU
  - Binary Decision Diagrams [Bryant] saved the day
  - renaissance of formal methods / automated reasoning
  - from the theory perspective: boring finite systems (10^{20} states)
  - was the first to do model checking in the group (of Deussen, Karlsruhe)
    Institut für Logik, Komplexität und Deduktionssysteme
- 1997 PhD on BDD based $\mu$-calculus model checking $\mu$cke in C++
  - first paper at CAV’97 in Haifa (looking for Post-Doc opportunities)
  - invited talk by Arne Borälv on Stålmarck’s Method
  - Post-Doc with Ed Clarke at CMU, i.e., BMC
  - got into SAT afterwards at ETH and Linz reluctantly and sceptically
- 25 years later FLOCC’22 in Haifa
  - with SAT + IJCAR + CP + CAV: Shankar presenting the Herbrand Award
  - Herbrand Award on SAT Applications and contributions in SAT at IJCAR’24
Verysys Design Automation
Symbolic model checking without BDDs

Authors Armin Biere, Alessandro Cimatti, Edmund Clarke, Yunshan Zhu

Publication date 1999


Pages 193-207

Publisher Springer Berlin Heidelberg

Description Symbolic Model Checking [3], [14] has proven to be a powerful technique for the verification of reactive systems. BDDs [2] have traditionally been used as a symbolic representation of the system. In this paper we show how boolean decision procedures, like Stålmarck’s Method [16] or the Davis & Putnam Procedure [7], can replace BDDs. This new technique avoids the space blow up of BDDs, generates counterexamples much faster, and sometimes speeds up the verification. In addition, it produces counterexamples of minimal length. We introduce a bounded model checking procedure for LTL which reduces model checking to propositional satisfiability. We show that bounded LTL model checking can be done without a tableau construction. We have implemented a model checker BMC, based on bounded model checking, and preliminary results are presented.

Total citations Cited by 3431
TACAS’14 Most Influential Paper in 25 Years of TACAS
ETAPS Test of Time Award 2017
was awarded to
Armin Biere, Alessandro Cimatti,
Edmund M. Clarke and Yunshan Zhu
for their ground-breaking TACAS 1999 paper
*Symbolic model-checking without BDDs*

ETAPS 2017 Uppsala, Sweden April 24 - 28, 2017
CAV 2018 Award

SAT-based and Bounded Model Checking

- Armin Biere
- Alessandro Cimatti
- Edmund M. Clarke
- Daniel Kroening
- Flavio Lerda
- Yunshan Zhu

Short Citation

For their outstanding contribution to the enhancement and scalability of model checking by introducing Bounded Model Checking based on Boolean Satisfiability (SAT) for hardware (BMC) and software (CBMC).
Symbolic model checking using SAT procedures instead of BDDs

Authors  Armin Biere, Alessandro Cimatti, Edmund M Clarke, Masahiro Fujita, Yunshan Zhu

Publication date  1999/6/1

Book  Proceedings of the 36th annual ACM/IEEE Design Automation Conference

Pages  317-320

Description  In this paper, we study the application of propositional decision procedures in hardware verification. In particular, we apply bounded model checking, as introduced in [1], to equivalence and invariant checking. We present several optimizations that reduce the size of generated propositional formulas. In many instances, our SAT-based approach can significantly outperform BDD-based approaches. We observe that SAT-based techniques are particularly efficient in detecting errors in both combinational and sequential designs.

Total citations  Cited by 1064
At 60th DAC’23 Most Impact Award (MIP) 1990ies DAC paper
2024 DAC MOST INFLUENTIAL PAPER (MIP) AWARD WINNERS


2023 DAC MOST INFLUENTIAL PAPER (MIP) AWARD WINNERS

1960s "Sketch pad a man-machine graphical communication system" by Ivan E. Sutherland, 1964.


My SAT, QBF and SMT Solvers

- QDDP 1998 at CMU
- DolSAT 1999 at Verysys
- Limmat 2000 - 2002 ETH
- CompSAT 2002 - 2005 ETH / JKU
- FunEx 2002 - 2004 ETH
- Quantor 2003 - 2004 ETH, QBF
- NanoSAT 2003 - 2004 ETH
- eBDDSRes 2005 - 2007 JKU, BDD
- BooleForce 2005 - 2006 JKU
- PicoSAT 2006 (JSAT’08) 2012 (Knuth comments)
- Boolector 2008 - 2019 JKU, SMT

- PrecoSAT 2009 JKU in C++
- Lingeling, Plingeling, Treengeling 2010 - 2018 in C
- Cleaneling 2012 (Summer School)
- YalSAT 2014 JKU Local-Search
- Splat 2015-2016 JKU
- CaDiCaL 2016 (Fields) JKU in C++
  inc++ 2024 UFR V 2.0.0 (CAV’24)
- Kissat 2019 - 2024 JKU / UFR in C
- Satch 2021 JKU (Simons) JKU
- TabularaSAT 2022-2024 UFR
- Gimsatul 2022 - 2024 UFR

and many more I started but at the end did not see the light of the day
SAT Competition All Time Winners on SAT Competition 2022 Benchmarks

https://cca.informatik.uni-freiburg.de/satmuseum

The SAT Museum.
Armin Biere and Mathias Fleury and Nils Froleyks and Marijn J.H. Heule.
[ paper - bibtex - data - zenodo - ceur - workshop - proceedings ]
SAT Competition 2022

Affiliated with the 25th International Conference on Theory and Applications of Satisfiability Testing taking place on the 2nd - 5th of August 2022 in Haifa, Israel.

Results

Main Track, Sequential Solvers

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The Results of SAT Competition 2023
A New Hope
... Strikes Back
The Return of ...

Tomáš Balyo, Marijn J. H. Heule, Markus Iser,
Matti Järvisalo, and Martin Suda

SAT 2023 Conference, Alghero (Italy)

July 7, 2023
All Time Winners on SAT Competition 2023 Benchmarks

- sbva-cadical-2023
- kissat-mab-hywalk-2022
- kissat-mab-2021
- kissat-2020
- maple-lcm-disc-cb-dl-v3-2019
- maple-lcm-dist-2017
- maple-lcm-dist-cb-2018
- maple-comsps-drup-2016
- lingeling-2014
- abcdsat-2015
- glucose-2011
- cryptominisat-2010
- lingeling-2013
- glucose-2012
- minisat-2008
- precosat-2009
- minisat-2006
- rsat-2007
- satelite-gti-2005
- chaff-2001
- limmat-2002
- berkmin-2003
- zchaff-2004
- boehm1-1992
- posit-1995
- grasp-1997
Legacy Solvers on SAT Competition 2023 Benchmarks
Legacy Solvers on SAT Competition 2023 Benchmarks

- sbva−cadical−2023
- cadical−2019
- kissat−mab−hywalk−2022
- kissat−mab−2021
- kissat−2020
- maple−lcm−disc−cb−dl−v3−2019
- maple−lcm−dist−2017
- maple−lcm−dist−cb−2018
- maple−comsp−drup−2016
- lingeling−2014
- abcdsat−2015
- glucose−2016
- glucose−2011
- lingeling−2010
- cryptominisat−2010
- lingeling−2013
- lingeling−2012
- lingeling−2011
- lingeling−2013
- minisat−2008
- precosat−2009
- minisat−2006
- rsat−2007
- satelite−gti−2005
- minisat−2005
- chaff−2001
- siege−2003
- limmat−2002
- picosat−2007
- berkmin−2003
- zchaff−2007
- zchaff−2004
- march−2011
- boehm1−1992
- posit−1995
- grasp−1997
Lessons under a Survivor Bias

- **“Recommendations” I did **NOT** follow:**
  - “You will not succeed (earn a PhD) if you continue programming!”
  - “We all know that SAT does not work, so why bother?”

- **“Recommendations” I do follow:**
  - “You only understand an algorithm after you have implemented it!”
  - review, review and review again
    until one round went through without any changes

- **My “Recommendations”**
  - classification (problem complexity ) results can be useful
  - do not take classification results too serious
    EXPSPACE approximation of PSPACE hard problem using an NP oracle
  - fuzz first (might also give you a theorem)
  - be curious, search for the unexpected