

The Results of SAT Competition 2022

Tomáš Balyo, Marijn Heule, **Markus Iser**,
Matti Järvisalo, and Martin Suda

SAT 2022 Conference, Haifa (Israel)

August 5, 2022

Competition Anniversary

Anniversary of SAT Competitions

- 3 competitions in the 90s (1992,1993, 1996)
- 14 SAT Competitions (2002–)
- 5 SAT Races (2006, 2008, 2010, 2015, 2019)
- 1 SAT Challenge (2012)

Goals

- Promotion of SAT solvers and their development
- Compilation of new challenging benchmarks
- Evaluation of current state-of-the-art solvers

Key rules

- Certified results of unsatisfiability using DRAT proof logging
 - ▶ Instance is “not solved” if proof checker finds inconsistency in proof
- Disqualification of buggy solvers
 - ▶ Producing an incorrect model
 - ▶ Report UNSAT on a known satisfiable instance
- Mandatory solver descriptions + open source
- Ranking scheme: PAR-2
 - ▶ Favors solvers that are faster (not only count solved instances)
- BYOB (Bring Your Own Benchmarks)
 - ▶ At most 20 instances per participant are used

Competition Summary

Main Track

- 400 benchmarks (300 new submission, 100 of previous competitions)
- 52 sequential solvers
- 10 parallel solvers
- 2 cloud solvers

Anniversary Track (20 years of SAT competition)

- 5355 benchmarks (all past application/crafted/main tracks)
- 29 sequential solvers
- 6 parallel solvers
- 2 cloud solvers

Anniversary Track

Track Data

- Large Dataset: 5355 benchmarks \times 37 solvers
- Subject to Post-Competition Analysis
- Will be published at Zenodo
- In this Competition: Pandas saved my life!
 - ▶ 1 TB of Competition Data
 - ▶ 827 LoC for Aggregation and Analysis

Anniversary Cloud Track

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	279.27	4687
2	Paracooba	Maximilian Heisinger	725.07	3619

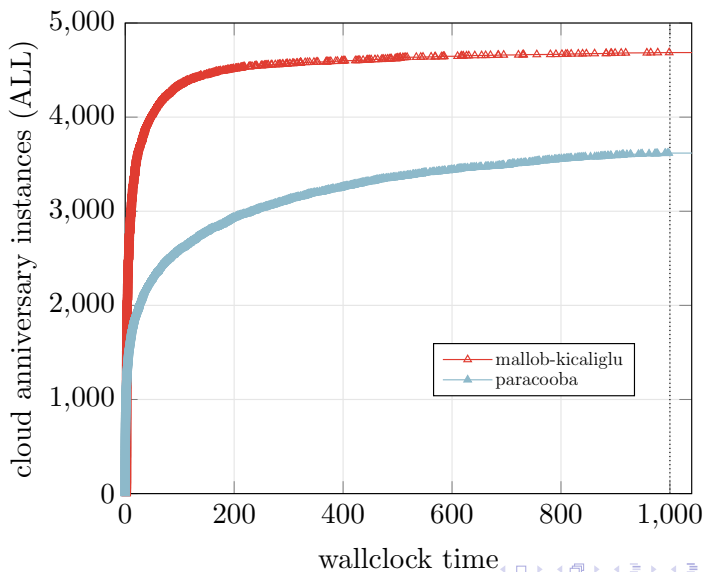
Results for Satisfiable Instances (Claimed SAT)

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	34.57	2170
2	Paracooba	Maximilian Heisinger	411.18	1808

Results for Unsatisfiable Instances (Claimed UNSAT)

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	56.85	2517
2	Paracooba	Maximilian Heisinger	674.69	1811

Anniversary Cloud Track



Anniversary Parallel Track SAT

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Mergesat-aws	Norbert Manthey	890.65	2047
2	Mallob-Ki	Dominik Schreiber	927.81	2031
3	DPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi Inoue	1586.13	1911

Anniversary Parallel Track UNSAT

Winning Solvers

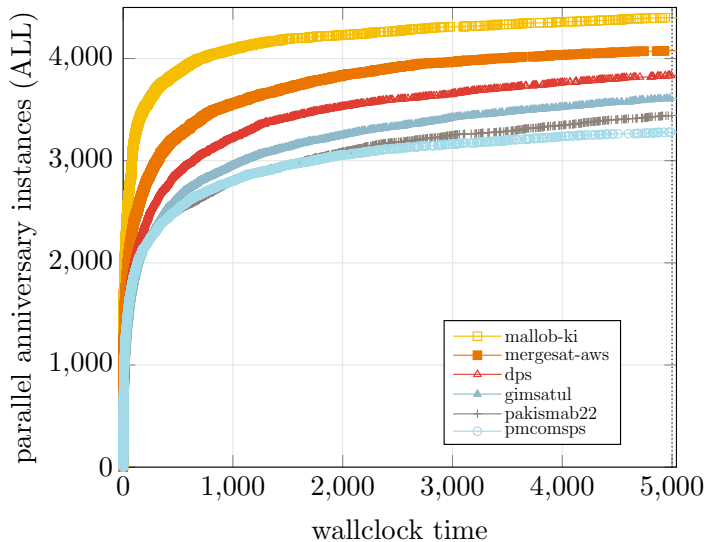
	Solver	Authors	PAR-2	Solved
1	Mallob-Ki	Dominik Schreiber	893.52	2369
2	Mergesat-aws	Norbert Manthey	2400.30	2029
3	DPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi Inoue	2881.27	1925

Anniversary Parallel Track

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Mallob-Ki	Dominik Schreiber	1992.46	4400
2	Mergesat-aws	Norbert Manthey	2689.75	4076
3	DPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi Inoue	3200.95	3836

Anniversary Parallel Track



Anniversary Sequential Track SAT

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Kissat-sc2022-bulky	Armin Biere and Mathias Fleury	1161.18	1962
2	Kissat-MAB-UCB	Mohamed Sami Cherif, Djamal Habet, and Cyril Terrioux	1168.71	1949
3	eKissat-MAB-gb-db	Md Solimul Chowdhury	1168.76	1947

Anniversary Sequential Track UNSAT

Winning Solvers

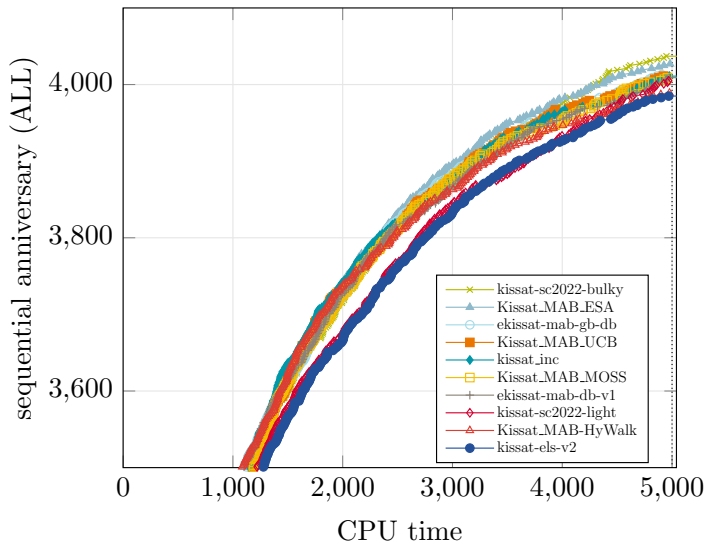
	Solver	Authors	PAR-2	Solved
1	hKis-unsat	Rodrigue Konan Tchinda and Clementin Tayou Djamegni	1071.99	2080
2	Kissat-MAB-ESA	Shuolin Li, Jordi Coll, Chu-Min Li, Mao Luo, Djamal Habet, and Felip Manyà	1093.82	2078
3	Kissat-sc2022-bulky	Armin Biere and Mathias Fleury	1115.26	2076

Anniversary Sequential Track

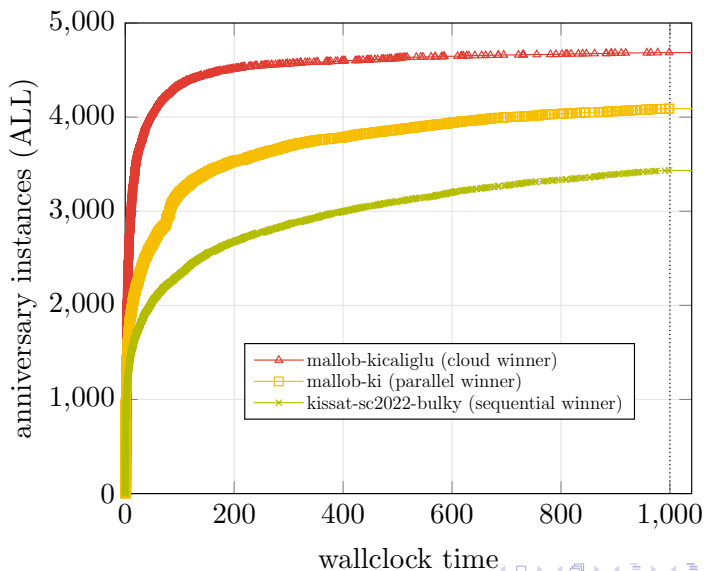
Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Kissat-MAB-ESA	Shuolin Li, Jordi Coll, Chu-Min Li, Mao Luo, Djamal Habet, and Felip Manyà	2806.15	4029
2	Kissat-sc2022-bulky	Armin Biere and Mathias Fleury	2810.70	4038
3	eKissat-MAB-gb-db	Md Solimul Chowdhury	2829.88	4015

Anniversary Sequential Track



Anniversary Track Winners: Sequential, Parallel, Cloud



Main Cloud Track

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	344.78	341
2	Paracooba	Maximilian Heisinger	1025.51	221

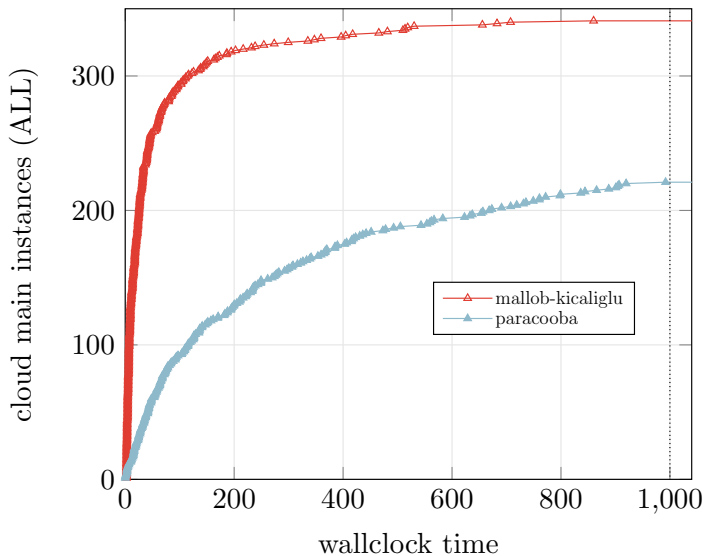
Results for Satisfiable Instances (Claimed SAT)

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	108.36	165
2	Paracooba	Maximilian Heisinger	795.02	111

Results for Unsatisfiable Instances (Claimed UNSAT)

	Solver	Authors	PAR-2	Solved
1	Mallob-KiCaLiGlu	Dominik Schreiber	179.48	176
2	Paracooba	Maximilian Heisinger	1012.13	110

Main Cloud Track



Main Parallel Track SAT

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	parKissat-rs	Xindi Zhang, Zhihan Chen, and Shaowei Cai	654.27	163
2	DPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi Inoue	1445.86	153
	NPS		1448.02	152
3	PaKis22	Rodrigue Konan Tchinda, Clémentin Tayou Djamegni	1838.79	148

Main Parallel Track UNSAT

Winning Solvers

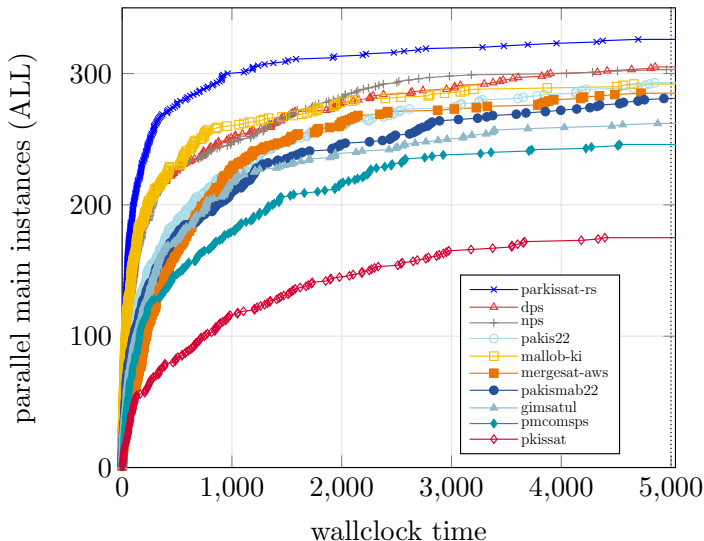
	Solver	Authors	PAR-2	Solved
1	Mallob-Ki	Dominik Schreiber	1597.21	163
2	parKissat-rs	Xindi Zhang, Zhihan Chen, and Shaowei Cai	1613.96	163
3	NPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi Inoue	2377.65	151

Main Parallel Track

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	parKissat-rs	Xindi Zhang, Zhihan Chen, and Shaowei Cai	2105.19	326
2	NPS	Hidetomo Nabeshima, Tsubasa Fukiage, Yuto Obitsu, Xiao-Nan Lu, and Katsumi	2799.64	303
	DPS	Inoue	2799.72	305
3	Mallob-Ki	Dominik Schreiber	2987.64	292

Main Parallel Track



Main Sequential Track SAT

Winning Solvers

	Solver	Authors	PAR-2	Solved
1	SeqFROST-NoExtend	Muhammad Osama and Anton Wijs	1709.42	144
	SeqFROST-ERE-All		1715.51	144
2	Kissat-inc	Zhihan Chen, Xindi Zhang, Shaowei Cai, and Pinyan Lu	1769.02	145
3	Kissat-MAB-HyWalk	Jiongzhi Zheng, Kun He, Zhuo Chen, Jianrong Zhou, and Chu-Min Li	1779.61	144

Main Sequential Track UNSAT

Winning Solvers

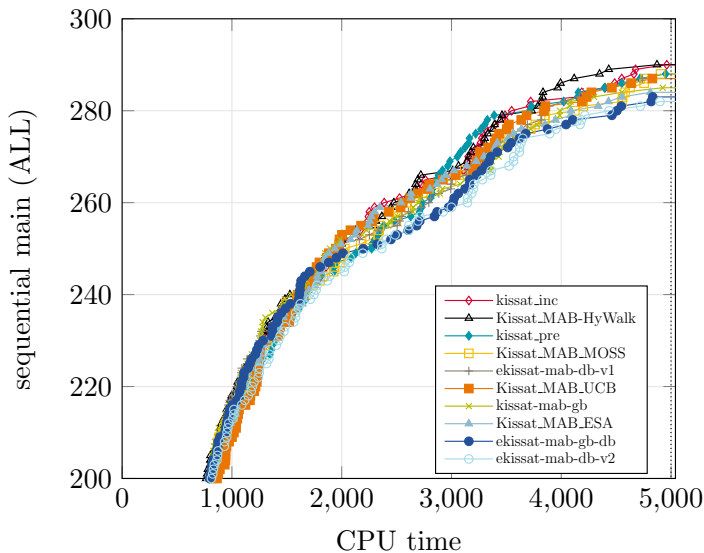
	Solver	Authors	PAR-2	Solved
1	hKis-psids	Rodrigue Konan Tchinda and	1284.38	150
	hKis-unsat	Clementin Tayou Djamegni	1484.25	145
2	Kissat-sc2022-bulky	Armin Biere and Mathias Fleury	1471.83	149
3	Kissat-MAB-UCB	Mohamed Sami Cherif, Djamal Habet and Cyril Terrioux	1524.93	147

Main Sequential Track

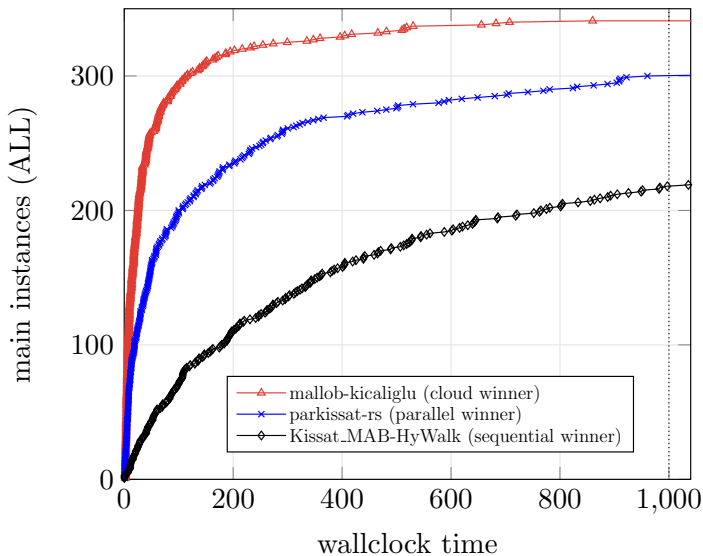
Winning Solvers

	Solver	Authors	PAR-2	Solved
1	Kissat-MAB-HyWalk	Jiongzhi Zheng, Kun He, Zhuo Chen, Jianrong Zhou, and Chu-Min Li	3334.22	290
2	Kissat-inc	Zhihan Chen, Xindi Zhang, Shaowei Cai, and Pinyan Lu	3351.93	290
	Kissat-pre		3380.17	288
3	eKissat-MAB-db-v1	Md Solimul Chowdhury	3402.95	287

Main Sequential Track



Main Track Winners: Sequential, Parallel, Cloud



Issues in 2022

Certificates

- Rules do not cover corner cases, esp. for UNSAT certificates
 - ▶ Wrong Proofs
 - ▶ Proof Checker Timeouts (45k seconds)
- Not an issue for the top solvers
- *This will change for 2023*

Result	Certificate	SAT	UNSAT (2022)	UNSAT (2023)
Wrong	Wrong	Disq.	Disq.	Disq.
Correct	Timeout	Disq.	Solved	Unsolved
Correct	Wrong	Disq.	Unsolved	Disq.

UNSAT Certificates for Parallel Solvers

UNSAT proof certificates will be enforced "sooner than you think"

- 2022: notable correctness issues with parallel solvers
- *2023 will see a new track (per discussions at PoS 2022)*
 - ▶ Incentives for developing proof certification for parallel SAT solvers
 - ▶ (Perhaps not in 2023 though... but soon enough!)

New for 2023: Open Call for Proof Checkers

Support More Powerful Proof Systems

- Call to be released by early September
- Intent to submit (incl. extended abstract): early fall
- Submission deadline: November 30, 2022 (preliminary)
- Checkers announced by January 15, 2023 (preliminary)
- **Requirement:** Checkers must be *formally verified*
- Main track UNSAT
- **Implications:**
 - ▶ Each solver must specify checker be used to check its proofs
 - ▶ Per-instance time limit on proof checking
 - ▶ "Solving" an instance requires that proof can be checked

New for 2023: Challenge Track (preliminarily planned)

Large Anniversary Track Dataset

- Benchmark set public
- Benchmarks: unsolved instances from the 2022 Anniversary track
- **Challenge:** Devise a SAT solver which can solve as many of the benchmark instances
 - ▶ "Solved": solved sequentially on StarExec within the 2022 Anniversary track time limit
 - ▶ Results checked by organizers
 - ▶ "Hall of fame": list for each instance authors who solved it and when was the certificate submitted

Thank you!

