The Results of SAT Competition 2020

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

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July 8, 2020
SAT Solver Competitions

Goals

- identify new challenging benchmarks
- promote SAT solvers and their development
- ”snapshot” evaluation of current solvers

Long tradition, starting from 1992

- 3 competitions in the 90s (1992, 1993, 1996)
- 13 SAT Competitions (2002–)
- 1 SAT Challenge (2012)
Key rules

- Certified results of unsatisfiability using DRAT proof logging
- Disqualification of buggy solvers
  - Producing an incorrect model
  - Report UNSAT on a known satisfiable instance
  - Proof checker finds inconsistency (demoted to no-limit)
- 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
What is New This Year

- We have two new tracks
  - Cloud Track – evaluate distributed solvers on the Amazon cloud. Solvers are run on 1600 virtual cores for 1000 seconds. Sponsored by Amazon. Participants received AWS credit to develop their solvers.
  - Planning Track – dedicated benchmark suite on 200 planning instances. Future competitions will have special benchmark suites for other applications.

- New formally-verified checker
  - `cake_lpr_array` by Yong Kiam Tan: very easy to install
  - available at: https://github.com/tanyongkiam/cake_lpr
Benchmark Instance Selection

**GBD Benchmark Database (GBD)**
- Collaborative Management of Attributes of Benchmark Instances
  https://pypi.org/project/global-benchmark-database-tool
- Retrieval of Benchmark Instances by their Attributes
  https://gbd.itl.iti.kit.edu

Tracks part 1

- **Main (Sequential) Track (50 solvers)**
  - 400 benchmarks, a combination of “application” and “crafted”
  - 5,000 sec limit for solving and 40,000 sec for proof checking
  - Solvers run on a single core
  - UNSAT proof logging required
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- **Parallel Track (14 solvers)**
  - The same 400 benchmarks from Main track
  - 5,000 sec limit for solving
  - 1 AWS m4.16xlarge: 64 virtual CPU cores, 256GB RAM
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- **Parallel Track (14 solvers)**
  - The same 400 benchmarks from Main track
  - 5,000 sec limit for solving
  - 1 AWS m4.16xlarge: 64 virtual CPU cores, 256GB RAM

- **Cloud Track (6 solvers)**
  - The same 400 benchmarks from Main track
  - 1,000 sec limit for solving
  - 100 AWS m4.4xlarge: total of 1600 virtual CPU cores
Tracks part 2

- Incremental Library Track (5 solvers)
  - benchmarks are SAT based applications (bones, essentials, lsp, max, ijtihad, pasar), we used same applications but with different inputs
  - combined rank for each application determines winner
  - 2,000 sec limit for solving

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Planning Track (49 solvers)

- 200 benchmarks, all coming from planning problems
- 5,000 sec limit for solving

No-Limit Track (64 solvers, superset of Main track participants)

- 300 brand new benchmarks (subset of the Main Track benchmarks)
- 5,000 sec limit for solving

Most of the solvers provided source codes and models, but not all

No awards: top solvers were open source and proof producing
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Balyo, Froleyks, Heule, Iser, Järvisalo, Suda
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The Top 3 solvers of the Planning Track are:

1. CaDiCaL-alluip-trail (PAR-2: 3406, 80 solved) by Randy Hickey, Nick Feng, and Fahiem Bacchus
2. Cryptominisat-ccnr-lsids (PAR-2: 3441, 79 solved) by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht, Arijit Shaw, and Kuldeep Meel
3. Kissat-sc2020-unsat (PAR-2: 3472, 74 solved) by Armin Biere
Planning Track – Results

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   Cryptominisat-ccnr (PAR-2: 3446, 79 solved)
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   by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht, Arijit Shaw, and Kuldeep Meel

3. **Kissat-sc2020-unsat** (PAR-2: 3472, 74 solved)
   by Armin Biere
The Top 3 solvers of the Planning Track are:

1. **CaDiCaL-alluip-trail** (PAR-2: 3406, 80 solved)
   - **CaDiCaL-alluip** (PAR-2: 3409, 80 solved)
   by Randy Hickey, Nick Feng, and Fahiem Bacchus

2. **Cryptominisat-ccnr-lsids** (PAR-2: 3441, 79 solved)
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Unfortunately, no planning specific solvers
Incremental Library Track

- 6 applications (bones, essentials, lsp, max, ijtihad, pasar)
- 50 benchmark instances per application
- Ranking by PAR-2 (2000 seconds timeout)
- Final Ranking: Number of Won Categories

<table>
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<th>Cryptominisat5</th>
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<td>513 (46)</td>
<td>631 (43)</td>
<td>390 (46)</td>
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<td>essentials</td>
<td>1333 (35)</td>
<td>1210 (37)</td>
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<td>471 (45)</td>
<td>506 (45)</td>
<td>969 (38)</td>
<td><strong>386 (46)</strong></td>
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<td>1</td>
<td><strong>3</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

Winner: **Cryptominisat5**
Parallel Track SAT – Results

The Top 3 solvers of the Parallel Track SAT are:

1. P-MCOMSPS-STR-32 (PAR-2: 2853, 153 solved) by Vincent Vallade, Ludovic Le Frioux, Souheib Baarir, Julien Sopena, and Fabrice Kordon
2. PaInleSS ExMapleLCMDistChronoBT (PAR-2: 2913, 154 solved) by Rodrigue Konan Tchinda and Clémentin Tayou Djamegni
3. Plingeling (PAR-2: 3805, 133 solved) by Armin Biere
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Parallel Track UNSAT – Results

The Top 3 solvers of the Parallel Track UNSAT are:

1. Plingeling (PAR-2: 3630, 137 solved) by Armin Biere
2. P-MCOMSPS-STR-32 (PAR-2: 3729, 131 solved) by Vincent Vallade, Ludovic Le Frioux, Souheib Baarir, Julien Sopena, and Fabrice Kordon
3. ManyGlucose-32 (PAR-2 3844, 131 solved) and ManyGlucose-64 (PAR-2: 3974, 129 solved) by Hidetomo Nabeshima and Katsumi Inoue
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Parallel Track UNSAT – Plot

![Graph showing solved instances (UNSAT) vs. wallclock time for various SAT solvers including plingeling, pmcomp, manyglucose, treengeling, painlessmaple, and maplepainless.](image)

- Solved instances (UNSAT)
- Wallclock time

Legend:
- plingeling
- pmcomp
- manyglucose
- treengeling
- painlessmaple
- maplepainless
Parallel Track ALL – Results

The Top 3 solvers of the Parallel Track ALL are:

1. P-MCOMSPS-STR-32 (PAR-2: 3291, 284 solved) by Vincent Vallade, Ludovic Le Frioux, Souheib Baarir, Julien Sopena, and Fabrice Kordon
2. Plingeling (PAR-2: 3718, 270 solved) by Armin Biere
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   by Vincent Vallade, Ludovic Le Frioux, Souheib Baarir, Julien Sopena, and Fabrice Kordon

2. Plingeling (PAR-2: 3718, 270 solved)
   by Armin Biere

3. ManyGlucose-32 (PAR-2: 3985, 260 solved)
   by Hidetomo Nabeshima and Katsumi Inoue
Parallel Track ALL – Results

The Top 3 solvers of the Parallel Track ALL are:

1. **P-MCOMSPS-STR-32** (PAR-2: 3291, 284 solved)
   **P-MCOMSPS-STR-64** (PAR-2: 3689, 272 solved)
   by Vincent Vallade, Ludovic Le Frioux, Souheib Baarir, Julien Sopena, and Fabrice Kordon

2. **Plingeling** (PAR-2: 3718, 270 solved)
   by Armin Biere

3. **ManyGlucose-32** (PAR-2: 3985, 260 solved)
   by Hidetomo Nabeshima and Katsumi Inoue
The Top 3 solvers of the Cloud Track are:

1. mallob-mono (PAR-2: 583, 299 solved) by Dominik Schreiber
2. TopoSAT2 (PAR-2: 706, 278 solved) by Thorsten Ehlers, Mitja Kulczynski, Dirk Nowotka, and Philipp Sieweck
3. Slime (PAR-2: 1057, 214 solved) by Oscar Riveros
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Cloud Track – Plot

solved instances (ALL)

wallclock time

mallob-mono  TopoSAT2  Slime
paracooba  CTSAT  paracooba-march
The Top 3 solvers of the Main Track SAT are:

1. Relaxed LCMDCBDL
2. Kissat-sc2020-sat
3. Cryptominisat-ccnr-lsids
   Cryptominisat-ccnr
   by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht, Arijit Shaw, and Kuldeep Meel
The Top 3 solvers of the Main Track SAT are:

3 **Cryptominisat-ccnr-lsids** (PAR-2: 3263, 144 solved)  
**Cryptominisat-ccnr** (PAR-2: 3317, 145 solved)  
by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht, Arijit Shaw, and Kuldeep Meel
Main Track SAT – Results

The Top 3 solvers of the Main Track SAT are:

2 **Kissat-sc2020-sat** (PAR-2: 3128, 146 solved)
   by Armin Biere

3 **Cryptominisat-ccnr-lsids** (PAR-2: 3263, 144 solved)
   **Cryptominisat-ccnr** (PAR-2: 3317, 145 solved)
   by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht,
   Arijit Shaw, and Kuldeep Meel
The Top 3 solvers of the Main Track SAT are:

1. **Relaxed_LCMDCBDL_newTech** (PAR-2: 2997, 150 solved)  
   by Xindi Zhang and Shaowei Cai

2. **Kissat-sc2020-sat** (PAR-2: 3128, 146 solved)  
   by Armin Biere

3. **Cryptominisat-ccnr-lsids** (PAR-2: 3263, 144 solved)  
   **Cryptominisat-ccnr** (PAR-2: 3317, 145 solved)  
   by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht,  
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Main Track SAT – Top 10 Plot

CPU time

solved instances (SAT)

0 1,000 2,000 3,000 4,000 5,000

0 50 100 150

- Relaxed_LCMD-CBDL_newTech
- Kissat-se2020-sat
- cryptominisat-ccnr-lsids
- cadical-alluip-trail
- abcdsat_n20
- Undominated-LC-MapleLCMDiscChronoBT-DL
- MapleLCMDistChronoBT-DL-f2trc
- optsatm20
- ExMapleLCMDistChronoBT_DL
- DurianSat
The Top 3 solvers of the Main Track UNSAT are:

1. Kissat-sc2020-unsat (PAR-2: 4315, 124 solved)
2. CaDiCaL-trail (PAR-2: 4842, 117 solved)
3. MapleLCMDistChronoBT-f2trc-s (PAR-2: 4991, 110 solved)
Main Track UNSAT – Results

The Top 3 solvers of the Main Track UNSAT are:

1. Kissat-sc2020-unsat (PAR-2: 4315, 124 solved)
2. Kissat-sc2020-default (PAR-2: 4336, 126 solved)

by Armin Biere

2. CaDiCaL-trail (PAR-2: 4842, 117 solved)

by Randy Hickey, Nick Feng, and Fahiem Bacchus

3. MapleLCMDistChronoBT-f2trc-s (PAR-2: 4991, 110 solved)

by Stepan Kochemazov

Balyo, Froleyks, Heule, Iser, Järvisalo, Suda

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   *Kissat-sc2020-default* (PAR-2: 4336, 126 solved)
   *Kissat-sc2020-sat* (PAR-2: 4725, 118 solved)
   by Armin Biere

2. **CaDiCaL-trail** (PAR-2: 4842, 117 solved)
   by Randy Hickey, Nick Feng, and Fahiem Bacchus

3. **MapleLCMDistChronoBT-f2trc-s** (PAR-2: 4991, 110 solved)
   by Stepan Kochemazov
Main Track UNSAT – Top 10 Plot

The chart shows the solved instances (UNSAT) over CPU time for various solvers. The solvers include:

- Kissat-sc2020-unsat
- cadical-trail
- MapleLCMDistChronoBT-f2trc-s
- mergesat
- Maple
- mix
- SLIME
- MapleLCMDistChronoBT-DL-v3
- ExMapleLCMDistChronoBT_DL
- Undominated-LC-MapleLCMDiscChronoBT-DL
- DurianSat

The x-axis represents CPU time, while the y-axis shows the number of solved instances.
The Top 3 solvers of the Main Track ALL are:

1. Kissat-sc2020-sat (PAR-2: 3926, 264 solved) by Armin Biere
2. Relaxed LCMDCBDL newTech (PAR-2: 4179, 253 solved) by Xindi Zhang and Shaowei Cai
The Top 3 solvers of the Main Track ALL are:

1. **Kissat-sc2020-sat** (PAR-2: 3926, 264 solved) by Armin Biere
2. **Relaxed LCMDCBDL** (PAR-2: 4179, 253 solved) by Xindi Zhang and Shaowei Cai
3. **Cryptomnisat-ccnr-lsids** (PAR-2: 4267, 248 solved) 
   **Cryptomnisat-ccnr** (PAR-2: 4278, 250 solved) by Mate Soos, Shaowei Cai, Jo Devriendt, Stephan Gocht, Arijit Shaw, and Kuldeep Meel
Main Track ALL – Results

The Top 3 solvers of the Main Track ALL are:

2. **Relaxed\_LCMDCBDL\_newTech** (PAR-2: 4179, 253 solved)
   by Xindi Zhang and Shaowei Cai

3. **Cryptominisat-ccnr-Isids** (PAR-2: 4267, 248 solved)
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Main Track ALL – Results

The Top 3 solvers of the Main Track ALL are:

1. **Kissat-sc2020-sat** (PAR-2: 3926, 264 solved)
   **Kissat-sc2020-default** (PAR-2: 4083, 260 solved)
   by Armin Biere

2. **Relaxed_LCMDCBDL_newTech** (PAR-2: 4179, 253 solved)
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Main Track ALL– Top 10 Plot

![Graph showing CPU time vs. solved instances for various SAT solvers including Kissat-sc2020-sat, Relaxed_LCMDCBDL_newTech, cadical-alluip-trail, cryptominisat-ccnr-lsids, MapleLCMDistChronoBT-DL-f2trc, Undominated-LC-MapleLCMDiscChronoBT-DL, ExMapleLCMDistChronoBT_DL, mergesat, MapleLCMDistChronoBT-DL-v3, and DurianSat.](image)
More information and Acknowledgments

Additionals Information

- The Competition Proceedings (solver and benchmark descriptions) will soon be available at https://satcompetition.github.io/2020/
- For the detailed competition results see the SAT Competition website

Acknowledgments

- Thanks to all the participants
- Thanks for all the benchmarks
- Thanks to Mike Whalen, Jonathan Eidelman, and Frankie Botero at AWS
- Thanks to Aaron Stump and StarExec
- Thanks to CAS Software Karlsruhe for the medals
- Thank You for Your attention